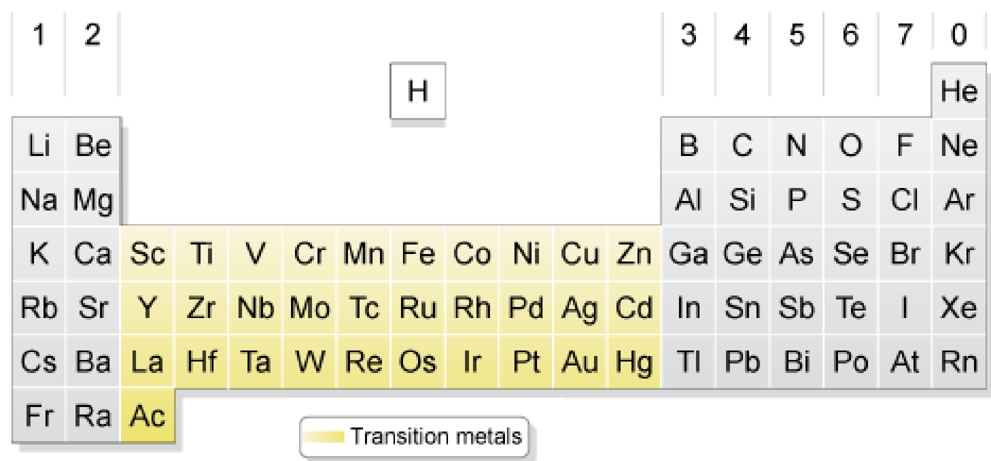
SC13a Transition Metals

- Most metals are transition metals.
- The metals used in the home are typically transition metals such as copper and iron.
- Most transition metals have high melting and boiling points and form coloured compounds.
- Transition metals are in the central block of the periodic table.



SC13a Questions on Transition Metals

- Where would you find the transition metals?
- Would transition metals have high or low melting points?
- Transition metals form compounds that are …………….
- Give a use of a transition metal and suggest why it has been chosen for this purpose.

SC13b Corrosion

Corrosion is a process where something is slowly damaged or destroyed by a chemical process. Rusting is a type of corrosion. You see it all over the place but why does it actually happen? Let's find out...

Rusting of Iron is a Redox Reaction

1) If iron comes into contact with air and water, after a while, it will rust.
   Rusting only happens when the iron's in contact with both oxygen (from the air) and water.
2) Rust is a form of hydrated iron(III) oxide.
3) This equation shows the formation of rust:

   iron + oxygen + water → hydrated iron(III) oxide

   Only iron can form rust, but other metals can be oxidised and corrode.

4) Rusting of iron is a redox reaction. Iron loses electrons when it reacts with oxygen.
   Each Fe atom loses three electrons to become Fe^{3+}, so iron's oxidised.
   Simultaneously, oxygen gains electrons when it reacts with iron.
   Each O atom gains two electrons to become O^{2-}. Oxygen's reduced.
5) Other metals can corrode in the presence of oxygen and water to form their metal oxides.

Oil, Grease and Paint Prevent Corrosion

1) You can prevent corrosion by coating the metal with a barrier.
   This keeps out the water, oxygen or both.
2) Painting is ideal for large and small structures. It can also be nice and colourful.
3) Oiling or greasing has to be used when moving parts are involved, like on bike chains.

SC13b Corrosion - question

A Coat of Tin Will Protect Steel from Corroding

1) Tin plating is where a coat of tin is applied to the object, e.g. food cans.
2) The tin acts as a barrier, stopping water and oxygen in the air from reaching the surface of the metal.
3) This only works as long as the tin coating remains intact.
   If the tin is scratched to reveal some of the metal below, it will start to corrode.

More Reactive Metals Can Prevent Metals Corroding

You can also prevent corrosion using the sacrificial method. You place a more reactive metal with whatever you don't want to corrode. The water and oxygen then react with this 'sacrificial' metal instead of with the metal you're protecting.

This method is known as sacrificial protection.

1) Galvanising is where a coat of zinc is put onto an iron object to prevent rusting. The zinc acts as sacrificial protection — it's more reactive than iron so it'll lose electrons in preference to iron. The zinc also acts as a barrier. Steel buckets and corrugated iron roofing are often galvanised.
2) Blocks of metal, e.g. magnesium, can be bolted to less reactive metals to prevent corrosion. Magnesium loses electrons in preference to the less reactive metal. It's used on ship hulls, or on underground pipes.

How does painting a metal prevent it from corroding?

Evaluate the suitability of sodium for the sacrificial protection of an off shore oil rig .

SC13c Electroplating

- Electroplating
- Electroplating is when a thin coat of valuable (or unreactive) metal is applied to a cheaper (more reactive) metal.
- Silver and Gold are metals that are commonly used for electroplating.

Metal added by electroplating	Applications
silver	cutlery, sports trophies
gold	jewellery
chromium	wheel rims, jewellery
tin	steel food cans
zinc	iron nails, steel railings

SC13c Electroplating Questions

- What is electroplating?
- How is electroplating done?
- Suggest two reasons that explain why a gold medal may consist of silver electroplated with gold.

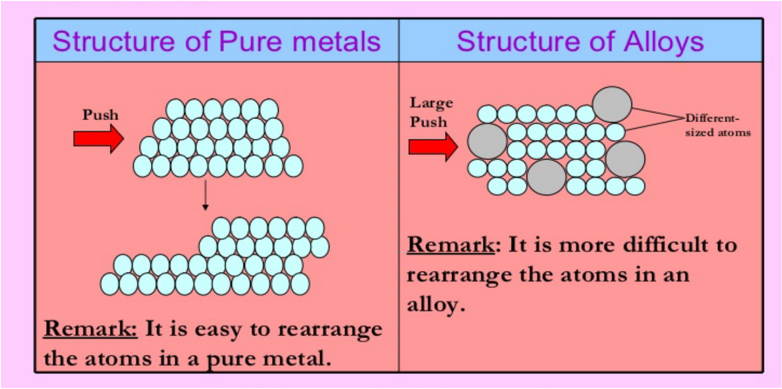
SC13d/e Uses of metals and their alloys

Alloys

Many metals are mixed with small amounts of other metals to improve their properties for a particular use and such a mixture of metals is called an alloy.

Converting pure metals into alloys often increases their strength: In a pure metal structure all the atoms are the same size and are packed closely together in a regular arrangement. When a force is applied, the layers of atoms slide over each other, making the metal soft

In an alloy each metal in the mixture has different sized atoms and when force is applied, the atoms can't slide past each other as easily so the alloy is harder and stronger.



Examples of alloys:

- Iron: A big problem with iron is that it rusts however, iron can be made into the alloy stainless steel (mixture of iron and small amounts of chromium and nickel) which doesn't corrode
- Gold: Pure gold is too soft to be used in jewellery and other metals, e.g copper and silver, are added to make a harder and stronger alloy. The purity of gold is measured in carats, or as fineness:
  - Pure gold is 24-carat and has a fineness of 1000 parts per thousand
  - The lower the carat and fineness, the lower the purity of gold

Shape memory alloys:

Nitinol is an alloy of nickel and titanium and it is a smart material – i.e it has a property that changes with a change in conditions (usually temperature). Nitinol is a shape memory alloy which means if the shape of something made of nitinol is altered, it returns to its original shape when heated. Nitinol is used in the repair of a collapsed artery:

- Doctors slide a squashed nitinol tube into the damaged artery.As it warms up in the body, the nitinol returns to its original size and holds the artery open.
- Spectacles can be made from nitinol and if they get sat on they will reform there shape when heated.

SC13d/e Questions on uses of metals and their alloys

- Define an alloy.
- Why is an alloy stronger than a pure metal?
- What is the advantage of stainless steel over iron?
- What is a shape memory alloy?
- Name a Shape memory alloy and give an example of where it may be used.

SC14a YIELDS

The amount of useful product that is obtained from a chemical reaction is called the yield. In theory one might expect all the reactants to turn into products – this is the 'theoretical yield'

The theoretical yield can be calculated from the balanced equation of a reaction and assumes all the reactants are turned into products.

Calculating the theoretical yield

e.g. $2H_2 + O_2 \rightarrow 2H_2O$

1. Calculate the relative formula masses

- $2H_2$ – 4 hydrogen atoms: A_r of H = 1 → A_r of $2H_2$ = 2 x 2 = 4g
- O_2 – 2 oxygen atoms: A_r of O = 16……→ A_r of O_2 = 32g
- $2H_2O$ – 4 hydrogen atoms, 2 oxygen atoms 32 + 4 = 36g

So 36g of water should theoretically be produced when 4g of hydrogen reacts with 32g of oxygen

In practice, however, the 'actual yield' obtained is less than the predicted 'theoretical yield' because

1. reaction may be incomplete – i.e not all reactants are used up
2. some of the product is lost during the practical preparation – e.g when transferring liquids from one container to another
3. there may be other unwanted reactions taking place – e.g some of the reactants may react in different ways to make a different product

The percentage yield compares the actual yield to the theoretical yield (i.e it compares the actual amount of product formed to the predicted amount of product formed calculated from the balanced chemical equation).

Percentage yield = (actual yield / theoretical yield) x 100

e.g. if in the reaction above the actual yield (i.e the amount of water produced) was in fact 30g → percentage yield = (30/36) x 100 = 83.3%

SC14a Questions on Yields

- What is the theoretical yield?
- Give three reasons why you never get 100% yield?
- If you predict that you will make 12g of propane but only make 4g what is the percentage yield?
- A company makes a drug in a very efficient process which gives 95% yield. If the theoretical yield is 20 g what mass is actually made?

SC14b Atom Economy

It's important in industrial reactions that as much of the reactants as possible get turned into useful products. This depends on the atom economy and the percentage yield of the reaction.

Atom Economy is the % of Reactants Changed to Useful Products

1) A lot of reactions make more than one product. Some of them will be useful, but others will just be waste.
2) The atom economy of a reaction tells you what percentage of the mass of the reactants has been converted into your desired product when manufacturing a chemical. Here's the formula:

$$\text{Atom Economy} = \frac{\text{total } M_r \text{ of desired products}}{\text{total } M_r \text{ of all products}} \times 100$$

3) 100% atom economy means that all the atoms in the reactants have been turned into useful (desired) products. The higher the atom economy the 'greener' the process.

High Atom Economy is Better for Profits and the Environment

1) Reactions with low atom economies use up resources very quickly. At the same time, they make lots of waste materials that have to be disposed of somehow. That tends to make these reactions unsustainable — the raw materials will run out and the waste has to go somewhere.
2) For the same reasons, low atom economy reactions aren't usually profitable. Raw materials can be expensive to buy and waste products can be expensive to remove and dispose of responsibly.
3) One way around the problem is to find a use for the waste products rather than just throwing them away. There's often more than one way to make the product you want — so the trick is to come up with a reaction that gives useful 'by-products' rather than useless ones.

SC14b Atom Economy Questions

- Give two reasons why a high atom economy is important in industrial reactions.

State was is meant by the atom economy of a reaction.

Calculate the atom economy for producing hydrogen in the following reaction $CO + H_2O \longrightarrow CO_2 + H_2$

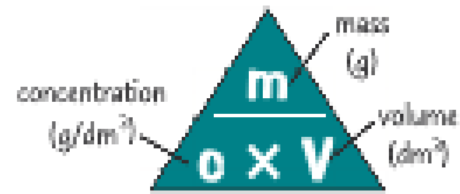
SC14c Concentrations

Concentration is a Measure of How Crowded Things Are

1 dm^3
= 1 litre
= 1000 cm^3

1) The more solute (the solid you're dissolving) you dissolve in a given volume, the more crowded the molecules are and the more concentrated the solution.
2) Concentration can be measured in grams per dm^3 — so 1 gram of stuff dissolved in 1 dm^3 of solution has a concentration of 1 gram per dm^3.
3) Here's the formula for finding concentration from the mass of solute:

concentration = mass of solute ÷ volume of solution



EXAMPLE: 25 g of copper sulfate is dissolved in 500 cm^3 of water. What's the concentration in g/dm^3?

1) Make sure the values are in the right units. The mass is already in g, but you need to convert the volume to dm^3.
   1000 cm^3 = 1 dm^3, so
   500 cm^3 = (500 ÷ 1000) dm^3 = 0.5 dm^3
2) Now just substitute the values into the formula:
   concentration = 25 ÷ 0.5 = 50 g/dm^3

EXAMPLE: What mass of sodium chloride is in 300 cm^3 of solution with a concentration of 12 g/dm^3?

1) Rearrange the formula so that mass is by itself. mass = concentration × volume
2) Put the volume into the right units. 300 cm^3 = (300 ÷ 1000) dm^3 = 0.3 dm^3
3) Substitute the values into the rearranged formula. mass = 12 × 0.3 = 3.6 g

4) Concentrations are often given in moles per dm^3 instead. To convert from g/dm^3 to mol/dm^3, you just divide the concentration in g/dm^3 by the relative formula mass of the solute.

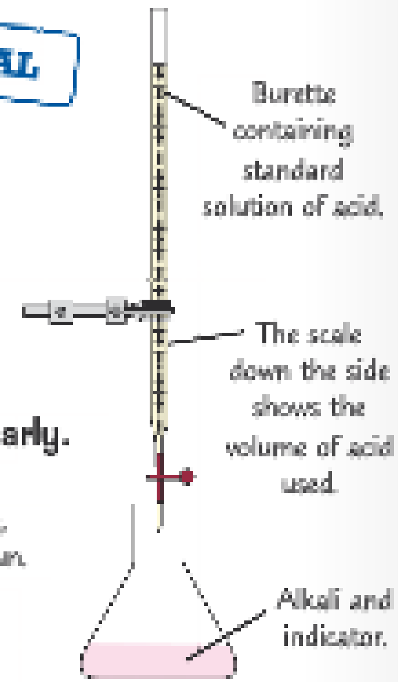
SC14c Concentrations Questions

- What mass of sodium hydroxide would you need to make up 200cm^3 of a 55g/dm^3 solution?
- Calculate the concentration in g dm^{-3} , of the solute in these solutions: a) 15g of sodium chloride in 3.0dm^3 of a solution. b) 0.25g of sodium hydroxide in 100cm of solution.
- Calculate the concentration in g dm $^{-3}$ of a solution of nitric acid HNO_3 with a concentration of 0.4 mol dm^{-3}

SC14d Titrations and Calculations

Titrations are Used to Find Out Concentrations

PRACTICAL



1) Titrations allow you to find out exactly how much acid is needed to neutralise a given quantity of alkali (or vice versa).
2) Using a pipette, measure out a set volume of the alkali into a flask. Add a few drops of an indicator — usually phenolphthalein or methyl orange.
   You can't use Universal indicator — it changes colour gradually and you want a single colour change.
3) Fill a burette with a standard solution (a known concentration) of acid.
   Keep the burette below eye level while you fill it — you don't want to be looking up if any acid spills.
4) Use the burette to add the acid to the alkali a bit at a time. Swirl the flask regularly. Go slowly (a drop at a time) when the alkali's almost neutralised.
   To work out when this is, do a rough titration first. Don't worry about recording the exact end point first time, just note the approximate amount of acid you need, then go slowly as you get near this amount on the next run.
5) The indicator changes colour when all the alkali has been neutralised (this is called the end point) — phenolphthalein is pink in alkalis but colourless in acids, and methyl orange is yellow in alkalis but red in acids.
6) Record the volume of acid used to neutralise the alkali (called the titre).
7) Repeat this process a few times, making sure you get very similar results each time. You can then take the mean (of your results.

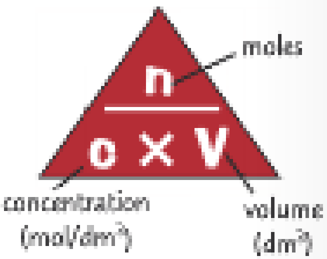
SC14d Titrations and Calculations question

You Can Calculate the Concentration Using Your Titration Results

1) You saw on the last page that concentration can be measured in g/dm^3. The concentration of a solution can also be measured in moles per dm^3 — so 1 mole of a substance dissolved in 1 dm^3 of solution has a concentration of 1 mole per dm^3 (or 1 mol/dm^3).

2) The formula for finding concentrations in mol/dm^3 is similar to the one for g/dm^3:

concentration = number of moles ÷ volume of solution



3) You can use the results of a titration experiment to calculate the concentration of the alkali when you know the concentration of the acid (or vice versa).

4) You might also need to convert a concentration in mol/dm^3 into g/dm^3. To do this, you just multiply the concentration in mol/dm^3 by the relative formula mass of the solute.

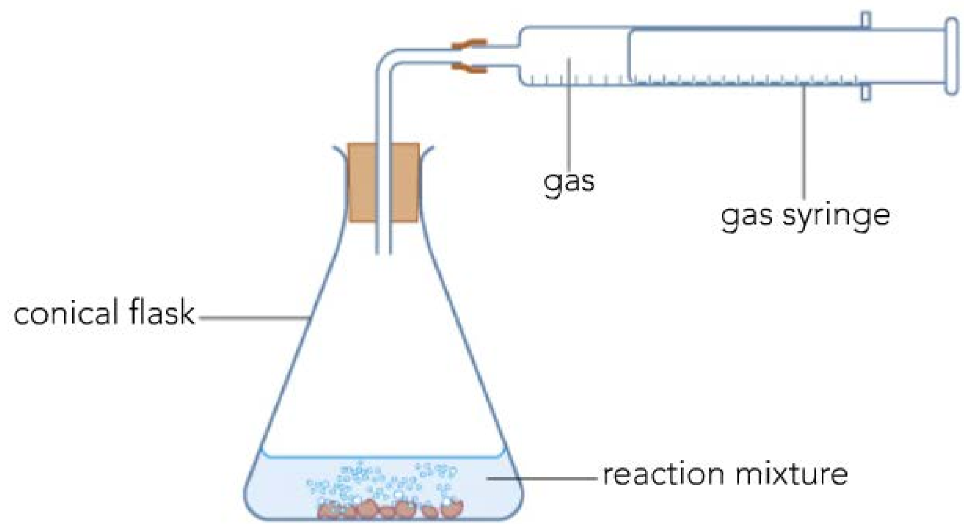
27cm^3 of 0.50mol/dm^3 hydrochloric acid neutralises 15cm^3 of sodium hydroxide solution. The equation is : $HCl + NaOH \longrightarrow NaCl + H_2O$. Find the concentration of the sodium hydroxide in mol/dm^3

SC14e Molar volume of gases

- **1 mole of a gas = 24dm^3** *(at room temperature and atmospheric pressure)*

$$\text{number of moles} = \frac{\text{mass (grams)}}{\text{relative atomic (or formula) mass}}$$

A GAS SYRINGE is used to collect gases during reactions to allow molar gas calculations to be performed

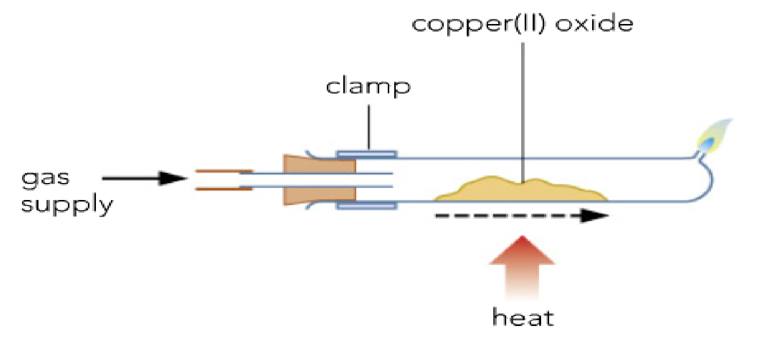


SC14e Molar volume of gases

e.g.

Using the idea of 'molar volume' means that we can calculate volumes of gases.

For example, how much hydrogen is needed to obtain 2.54 g of copper by reducing copper oxide?



D *Apparatus for reducing copper oxide to copper*

Step 1: Write out the balanced symbol equation for the reaction:

$$H_2 + CuO \rightarrow Cu + H_2O$$

Step 2: Work out the number of moles in 2.54 g of copper:

$$\text{moles} = \frac{\text{mass}}{\text{relative atomic mass}} = \frac{2.54}{63.5} = 0.04 \text{ moles}$$

Step 3: Use the balanced symbol equation to work out the number of moles of hydrogen needed:
To make 1 mole of Cu needs 1 mole of H_2 so 0.04 moles of H_2 are needed.

Step 4: Calculate the volume of hydrogen:
1 mole of hydrogen has volume 24 dm^3 so

$$0.04 \text{ moles} = 24 \times 0.04 = 0.96\, dm^3$$

0.96 dm^3 of hydrogen will be needed to produce 2.54 g of copper.

SC15a Fertilisers and the Haber Process

Fertilisers Help Plants Grow

1) The three main essential elements in fertilisers are nitrogen, phosphorus and potassium. Plants absorb these nutrients from the soil.
2) If plants don't get enough of these elements, their growth and life processes are affected.
3) Fertilisers replace these missing elements in the soil, or provide more of them. This helps to increase the crop yield, as the crops can grow faster and bigger.

Ammonia Can be Neutralised with Acids to Produce Fertilisers

Ammonia is a base and can be neutralised by acids to make ammonium salts.
Ammonia is really important to world food production, because it's a key ingredient of many fertilisers.

1) If you neutralise nitric acid with ammonia you get ammonium nitrate. It's an especially good fertiliser because it has a high percentage of nitrogen, the ammonia and the nitric acid — kind of a double dose.
2) Ammonium sulfate can also be used as a fertiliser. You make it by neutralising sulfuric acid (from the Contact process, with ammonia (formed in the Haber Process .
3) Ammonium phosphate is a fertiliser made by neutralising phosphoric acid with ammonia.
4) Potassium nitrate is also a fertiliser — it can be made by neutralising nitric acid with potassium hydroxide.

A fertiliser factory will carry out several integrated processes to make fertilisers. E.g. it may make ammonia using the Haber process phosphoric acid from phosphate rock, sulfuric acid (made using the Contact process, r nitric acid. These chemicals are then used to make ammonium phosphates, ammonium sulfate and ammonium nitrate.

SC15a Fertilisers and the Haber process questions

Preparing Ammonium Sulfate in the Lab

You can make most fertilisers using this titration method — just choose the right acid (nitric, sulfuric or phosphoric) and alkali (ammonia or potassium hydroxide) to get the salt you want. You'll need ammonia and sulfuric acid to make ammonium sulfate.

- Name three elements that are important components in fertilisers.
- What is the role of the fertilisers?
- State and explain the type of reaction involved in making ammonium nitrate.

SC15b Factors affecting equilibrium

- Reversible reactions may reach equilibrium this only happens when they are in a ***closed system*** such as a stoppered flask in which no substances can enter or leave. In a **dynamic equilibrium**:
- The forward and backward reactions still happen at the same rate.
- The concentrations of all reacting substances do not change.

The position of a dynamic equilibrium and how quickly equilibrium is reached are affected by changes in conditions.

An increase in temperature, an increase in pressure in a reaction involving gases, an increase in concentration of a reacting substance or the addition of a catalyst all lead to a decrease in the time taken to reach equilibrium.

SC15b Factors affecting equilibrium questions

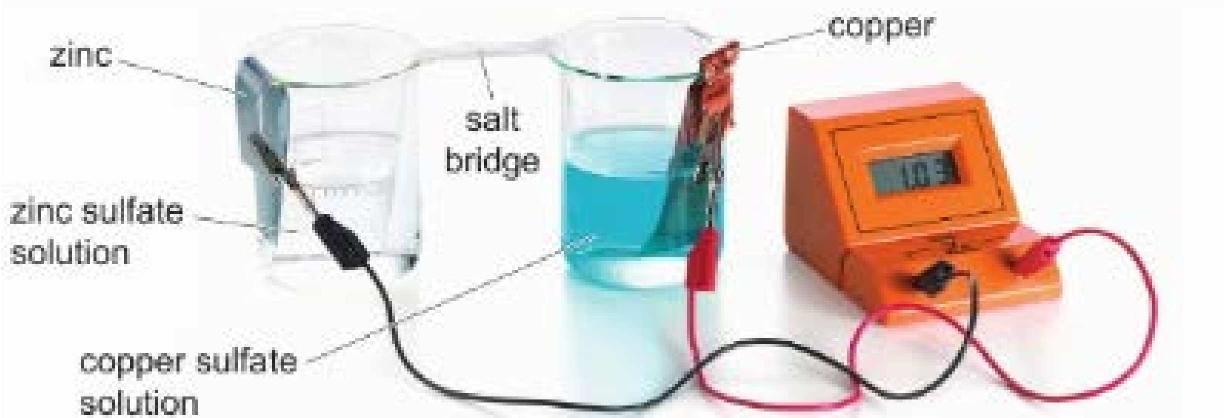
- How does the time taken for a reversible reaction to reach equilibrium depend on the reaction conditions?
- How are the reaction conditions chosen for the industrial processes?

SC16a Chemical Cells and Fuel Cells

The everyday batteries used in mobile phones and torches are **chemical cells**. A simple chemical cell has these components:

- two different metals, each dipped into a solution of one of their salts
- a 'salt bridge' to allow dissolved ions to pass from one solution to the other.

A voltage (potential difference) is produced between the two metals. In general, the further apart in the reactivity series the two metals are, the greater the voltage. A current flows if the cell is connected to an external circuit. Photo B shows a simple chemical cell, invented in 1836 by John Daniell (1790–1845). The salt bridge is filter paper soaked with concentrated potassium nitrate solution.



SC16a Chemical Cells and Fuel Cells Questions

Fuel Cells Use Fuel and Oxygen to Produce Electrical Energy

1) A fuel cell is an electrical cell that's supplied with a fuel and oxygen and uses energy from the reaction between them to produce electrical energy efficiently.
2) Chemical cells produce a potential difference across the cell, until all the reactants have been used up.
3) There are a few different types of fuel cells, using different fuels and different electrolytes.
4) For example, the hydrogen-oxygen fuel cell combines hydrogen and oxygen to release heat energy and nice clean water. That means there are no nasty pollutants to worry about.

Give one advantage and one disadvantage of using fuel cells for energy.

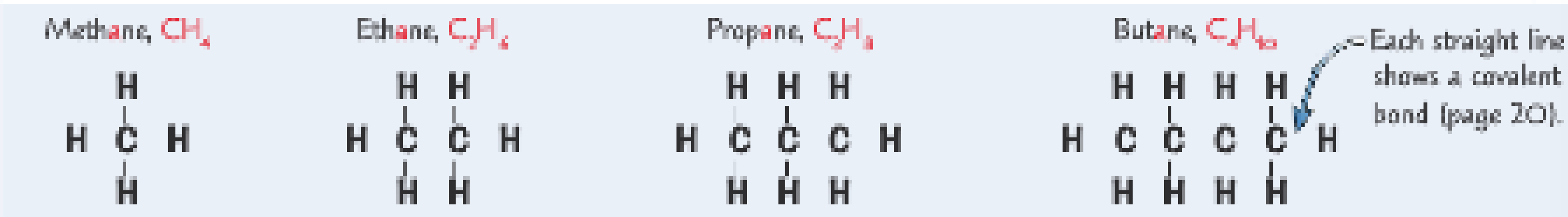
How are chemical reactions used to produce electricity?

Some fuel cells use ethanol C_2H_5OH. When in use all the carbon atoms are converted to carbon dioxide. Write a balanced equation for the overall reaction in an ethanol oxygen fuel cell.

SC22a/b Alkanes and Alkenes

Alkanes are Saturated Hydrocarbons

1) A homologous series is a group of chemicals that have similar chemical structures.
2) Alkanes are a homologous series of hydrocarbons — they contain just carbon and hydrogen atoms.
3) Different alkanes have chains of different lengths. These are the first four alkanes:



4) The diagrams above show that all the atoms have formed bonds with as many other atoms as they can — this means they're saturated.

Carbon atoms tend to make four bonds, but hydrogen atoms can only make one.

5) Alkanes all have the general formula C_nH_{2n+2}. So if an alkane has 5 carbons, it's got to have $(2 \times 5) + 2 = 12$ hydrogens.
6) Alkanes (and other hydrocarbons) take part in combustion reactions. During a complete combustion reaction, they burn in oxygen to form carbon dioxide and water.

$$C_2H_6 + 3\tfrac{1}{2}O_2 \rightarrow 2CO_2 + 3H_2O$$

ethane + oxygen → carbon dioxide + water

$$C_2H_6 + 2\tfrac{1}{2}O_2 \rightarrow 2CO + 3H_2O$$

ethane + oxygen → carbon monoxide + water

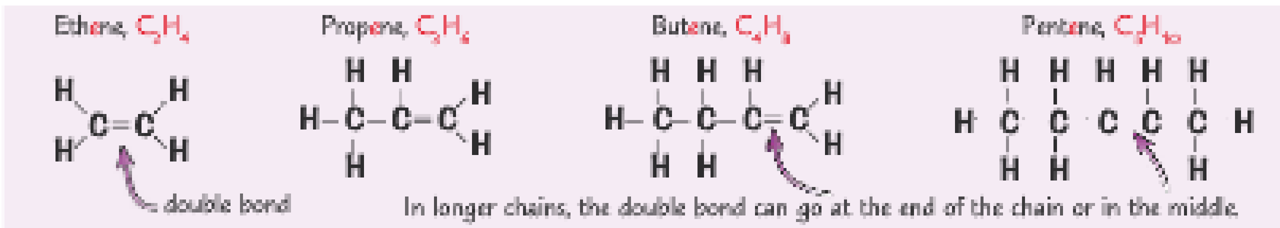
7) Incomplete combustion happens in a limited supply of oxygen. During incomplete combustion, carbon monoxide is produced. Carbon, in the form of soot, can also be given out.

These two combustion reactions can happen at the same time, giving a mixture of combustion products.

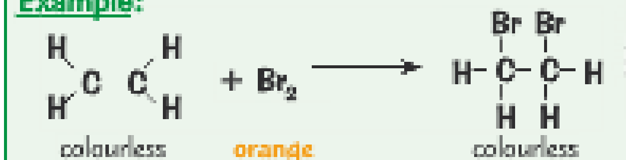
SC22a/b Alkanes and Alkenes question

Alkenes Have a C=C Double Bond

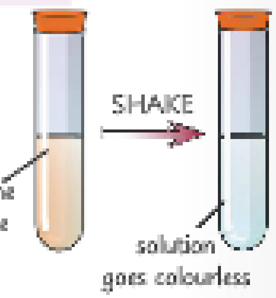
1) Alkenes are a homologous series of hydrocarbons with at least one carbon-carbon double bond.
2) They are known as unsaturated because they can make more bonds — the double bond can open up, allowing the two carbon atoms to bond with other atoms.
3) The first four alkenes are ethene, propene, butene and pentene (see below).
4) Alkenes have the general formula C_nH_{2n} — they have twice as many hydrogens as carbons.



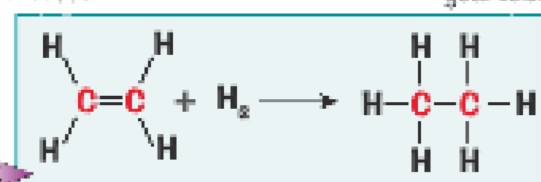
5) You can test for an alkene using bromine water. When added to bromine water, an alkene will decolourise the bromine water, turning it from orange to colourless. This is because the double bond can open up and form bonds with the bromine.



Alkanes don't react with bromine water as they don't contain double bonds.



6) Alkenes can also be reacted with hydrogen in a process called hydrogenation. The hydrogen reacts with the double-bonded carbons and adds across the double bond.



Explain the difference between a saturated and an unsaturated hydrocarbon.

SC23a Ethanol Production

Alcoholic drinks have been made for thousands of years. These drinks contain a chemical substance called ethanol (although people often call it 'alcohol'). Its formula is C_2H_5OH. Ethanol can also be used as a fuel for vehicles and as a raw material for the chemical industry.

The ethanol in alcoholic drinks is made from **sugars**. Sugars are small, soluble substances that belong to a group called **carbohydrates** (compounds made of carbon, hydrogen and oxygen). Many fruits (such as grapes) contain a lot of sugars.

Plant material containing sugars is mixed with water and yeast. Enzymes in the yeast turn the sugars into ethanol and carbon dioxide, in a process called **fermentation**:

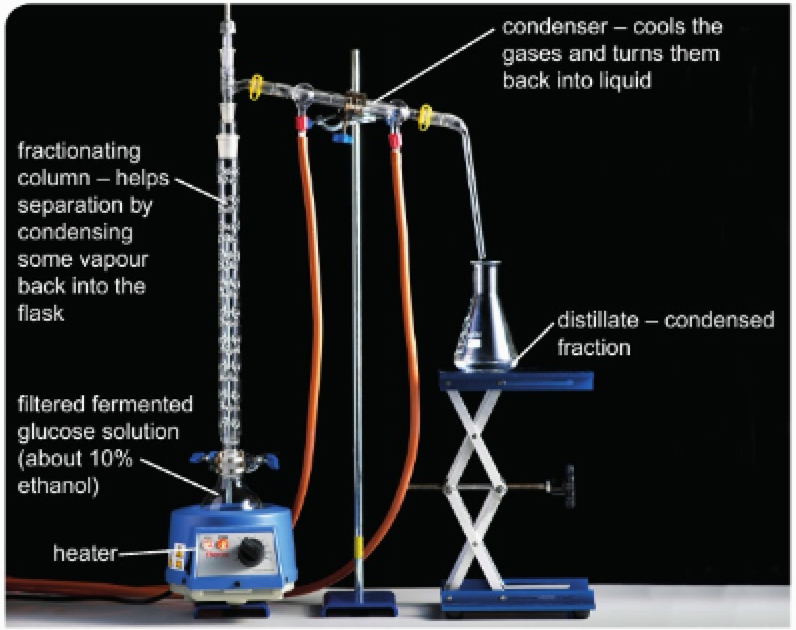
glucose → ethanol + carbon dioxide

SC23a Ethanol Production question

The fermentation process only produces alcohol concentrations up to 15%, as higher concentrations kill the yeast cells. More concentrated solutions of ethanol are formed by **fractional distillation**, as shown in photo D. This works because the boiling point of ethanol (78 °C) is lower than the boiling point of water (100 °C). The heated liquids evaporate and their vapours cool as they rise up the fractionating column. As the ethanol has a lower boiling point, it remains as a gas for longer, and separates from the water. As a result, the first **fraction**, or **distillate**, that is collected contains a higher percentage of ethanol.

Explain how fractional distillation can be used to increase the concentration of an alcohol solution. Include the following words in your explanation:

boiling point; concentrated; condense; dilute; ethanol; evaporate; heated; water

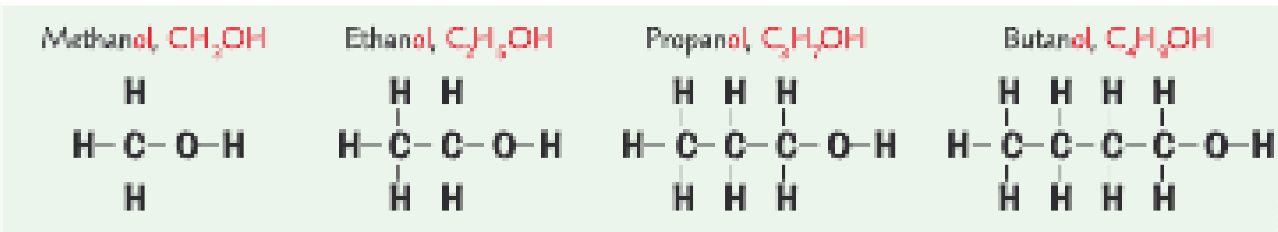


D fractional distillation of an ethanol solution

SC23b Alcohols

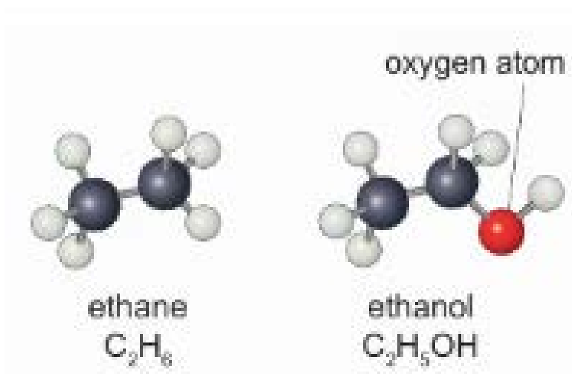
Alcohols Have an '-OH' Functional Group and End in '-ol'

1) The general formula of an alcohol is $C_nH_{2n+1}OH$. So an alcohol with 2 carbons has the formula C_2H_5OH.
2) All alcohols contain an -OH functional group. Here are the first four alcohols in the homologous series:



A functional group's a group of atoms that determines how a molecule reacts. Members of a homologous series all contain the same functional group (e.g. alcohols all contain -OH and alkenes contain C=C).

3) The basic naming system is the same as for alkanes — but replace the final '-e' with '-ol'.
4) Don't write CH_4O instead of CH_3OH — it doesn't show the functional -OH group.
5) It is possible to get alcohols where the -OH group is attached to different carbon atoms in the carbon chain, or alcohols with more than one -OH group



SC23b Alcohols Questions

- Describe the difference in molecular structure between propanol and butanol.
- Hexanol has 6 carbon atoms. How many hydrogen atoms does hexanol have?
- Pentanol is an alcohol with 5 carbon atoms. A) state its molecular formula. B) draw a structural formula for pentanol and circle the functional group.

SC23c Carboxylic Acids

Alcohols Can Be Oxidised to Form Carboxylic Acids

1) When something's oxidised, it gains oxygen.
2) Alcohols can be oxidised to form carboxylic acids. You need an oxidising agent, such as potassium manganate(VII), for this.

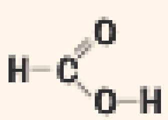
Alcohols can only form carboxylic acids in this way if the -OH group is attached to a carbon that's only attached to one carbon itself.

Example: Ethanol + potassium manganate(VII).

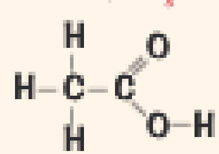
This reaction's accompanied by a colour change — the reaction mixture goes from purple to colourless.

3) The basic naming system for carboxylic acids is the same as for alkanes — but replace the final '-e' with '-oic acid'.
4) Carboxylic acids are another homologous series of molecules. They have the general formula $C_{n-1}H_{2n-1}COOH$ and they have a -COOH functional group.
5) Here are the first four carboxylic acids in the homologous series. They can each be formed by oxidising the alcohol which contains the same total number of carbons (i.e. methanol is oxidised to methanoic acid, ethanol is oxidised to ethanoic acid, and so on).

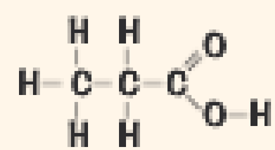
Methanoic acid, $HCOOH$



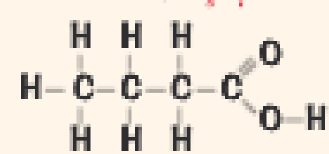
Ethanoic acid, CH_3COOH



Propanoic acid, C_2H_5COOH



Butanoic acid, C_3H_7COOH



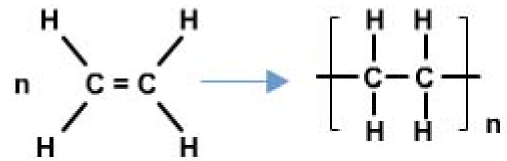
SC23c Carboxylic Acids questions

- What substance produces the sharp taste of vinegar?
- Describe the loss and gain of atoms when an ethanol molecule is oxidised.
- The fifth carboxylic is called pentanoic acid. Draw its structural formula and circle its functional group.

SC24a & b Additional Polymerisation

Polymers are substances made up of thousands of simple repeating units. Monomers are substances whose molecules react together to form polymers. This process is called polymerisation.

e.g. poly(ethene) (a polymer) is made from lots of ethene monomers. The number of ethene molecules that join together to make one molecule of poly(ethene) is very large (thousands/millions). n is used to indicate a large number (i.e ‘n’ lots of ethene molecules join to form a polymer made up of ‘n’ number of ethene repeating units). *Note polymers lose the C=C double bond*



Some polymers are natural e.g cellulose (found in plant cell walls) and other polymers are manufactured e.g plastics.

Properties and uses of (manufactured) polymers

Poly(ethene) : made from ethene monomers.

- Properties: Flexible, cheap, good insulator
- Uses: carrier bags, plastic bottles, insulation for electrical wires, cling film

- Poly(propene) – made from propene monomers:
  - Properties: flexible, shatterproof, strong, long lasting, high softening point
  - Uses: plastic bags, buckets, ropes, washing up bowls, carpets
- Poly(chloroethene) – PVC made from chloroethene monomers:
  - Properties: tough, cheap, long-lasting, good insulator
  - Uses: window frames, gutters, pipes, insulation for electrical wires

- Poly(tetrafluoroethene) – PTFE or Teflon……made from tetrafluoroethene monomers:
  - Properties: tough, slippery, resistant to corrosion, good insulator
  - Uses: non-stick coatings for saucepans.

SC24a/b Questions on Additional Polymerisation

- Define polymerisation.
- What do mono, poly and mer mean?
- What is polyethene made from?
- What does the ‘n’ indicate in a polymerisation equation?
- Why is the polymer still called polyethene if it no longer has a double bond?
- Give an example of a naturally occurring polymer.
- Give a use of polyethene, polypropene, pvc and PTFE and explaine the properties of each polymer that make it suitable for each use.

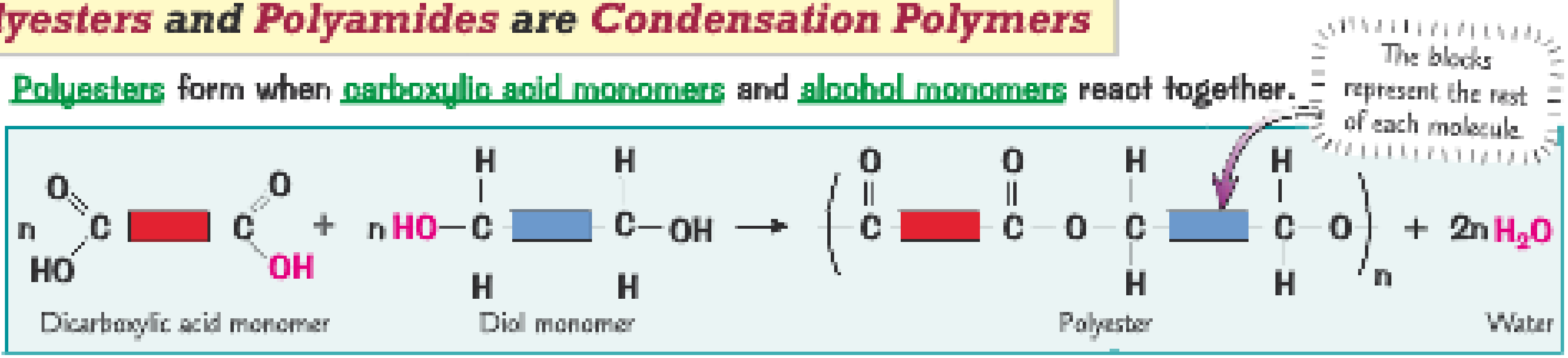
SC24c Condensation Polymerisation

Polymers can be Made by Condensation Polymerisation

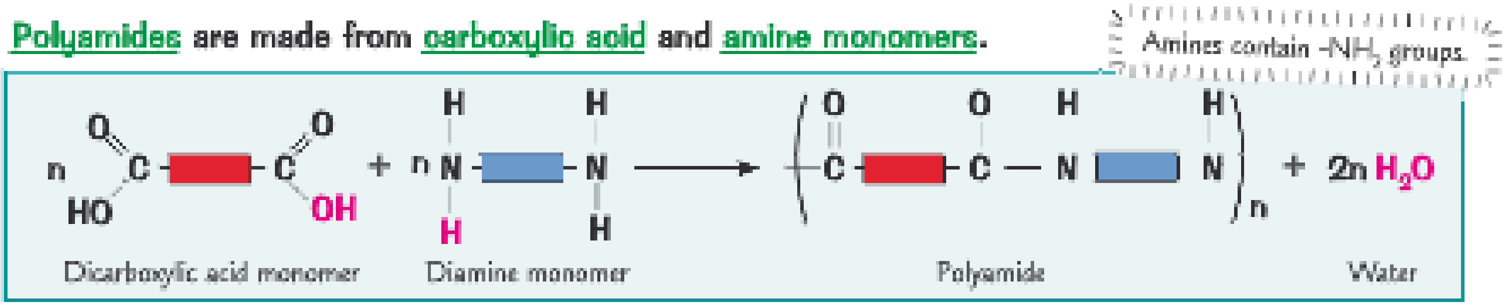
1) Condensation polymerisation usually involves two different types of monomer.
2) The monomers react together and bonds form between them, making polymer chains.
3) Each monomer has to contain at least two functional groups, one on each end of the molecule.
4) Each functional group can react with the functional group of another monomer, creating long chains of alternating monomers. For each new bond that forms, a small molecule (e.g. water) is lost.

Polyesters and Polyamides are Condensation Polymers

1) Polyesters form when carboxylic acid monomers and alcohol monomers react together.



2) Polyamides are made from carboxylic acid and amine monomers.



SC24c Condensation Polymerisation Questions

- What is meant by condensation polymerisation?
- What two types of monomers react together to form polyesters?
- Name three biologically important condensation polymers.

SC24d PROBLEMS WITH POLYMERS

Materials such as wood and paper are biodegradable which means they will naturally breakdown or rot because microbes can feed on them. Most manufactured polymers have many uses because they are not biodegradable so last for a long time. When thrown away in landfill sites, these polymers stay there for a long time. When burned ('incinerated'), they release energy that can be used to generate electricity, however most also produce toxic products

Overcoming problems associated with disposal of polymers

1. Developing biodegradable polymers
    - Biodegradable polymers would rot after only a few years if they ended up in a landfill site however, this is still quite a long time and best option is to reduce the amount of plastic sent to landfill sites in the first place.

2. Reusing and recycling materials
    - One way to reduce the amount of plastic sent to landfill sites is by reusing materials e.g reusing plastic bags rather than throwing them away after just a single use
    - If an item can't be reused anymore then the material it is made from can be recycled (i.e. processed and used to make new objects). Paper, glass and metal waste is already recycled in the UK. Polymers are more difficult to recycle because the waste needs to be sorted into different types of polymer before each type can be made into new objects.

SC24d Questions on Problems with Polymers

- Define biodegradable.
- Manufactured polymers are not biodegradable. Give two problems associated with trying to dispose of these polymers.
- Describe two ways that we can overcome the problems caused by disposing of polymers.
- Why is recycling polymers more time consuming than recycling paper, glass and metal?

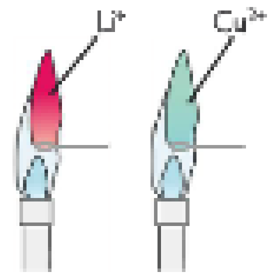
SC25a Flame Tests and Photometry

You Can Use Flame Tests to Identify Metal Ions

Compounds of some metals produce a characteristic colour when heated in a flame.

1) You can test for various metal ions by putting your substance in a flame and seeing what colour the flame goes.

- Lithium, Li^{+}, gives a crimson red flame.
- Sodium, Na^{+}, gives a yellow flame.
- Potassium, K^{+}, gives a lilac flame.
- Calcium, Ca^{2+}, gives a brick red flame.
- Copper, Cu^{2+}, gives a blue-green flame.



Remember — metals always form positive ions.

2) To carry out a flame test in the lab, first clean a nichrome wire loop by dipping it into hydrochloric acid and then rinsing it in deionised water.
3) Then dip the wire loop into a sample of the metal compound and put the loop in the clear blue part of a Bunsen flame (the hottest bit). Record what colour the flame goes.

This test only works if the mystery compound contains just one type of metal ion — otherwise you'll get a confusing mixture of colours.

Flame photometry

Machines can also be used to analyse substances. Compared to simple lab tests such as flame tests, using scientific instruments may improve sensitivity, accuracy or speed .

SC25a Flame Tests and Photometry Questions

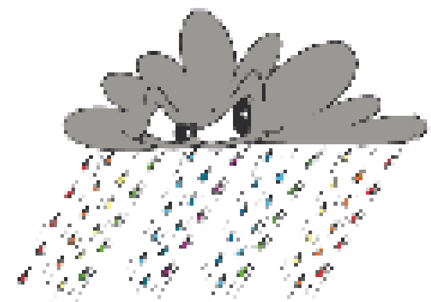
- Wooden splints may be used instead of a wire loop. Suggest two reasons that explain why the splints are soaked in distilled water before use.
- Explain potassium chloride and potassium iodide both produce lilac flame test colours.
- In a flame test if a compound gives a brick red flame, what would this tell you?
- What are the advantages of using a flame photometer over basic flame tests?

SC25b Test for positive ions.

Some Metal Ions Form a Coloured Precipitate with Sodium Hydroxide

This is also a test for metal ions, but it's slightly more complicated:

1) Many metal hydroxides are insoluble and precipitate out of solution when formed. Some of these hydroxides have a characteristic colour.
2) For this test, you add a few drops of sodium hydroxide solution to a solution of your mystery compound.
3) If a hydroxide precipitate forms, you can use its colour to tell which metal ion was in the compound.



Metal ion	Colour of precipitate	Ionic equation
Calcium, Ca^{2+}	White	$Ca^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Ca(OH)_{2(s)}$
Copper, Cu^{2+}	Blue	$Cu^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Cu(OH)_{2(s)}$
Iron(II), Fe^{2+}	Green	$Fe^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Fe(OH)_{2(s)}$
Iron(III), Fe^{3+}	Brown	$Fe^{3+}_{(aq)} + 3OH^-_{(aq)} \rightarrow Fe(OH)_{3(s)}$
Zinc, Zn^{2+}	White at first, but then redissolves in excess NaOH to form a colourless solution.	$Zn^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Zn(OH)_{2(s)}$ Then: $Zn(OH)_{2(s)} + 2OH^-_{(aq)} \rightarrow Zn(OH)_4{}^{2-}_{(aq)}$

SC25b Test for positive ions questions

- A student adds a few drops of sodium hydroxide solution to another solution. A green precipitate forms. What does this tell you about the solution?
- For the reaction between sodium hydroxide solution and iron (ii) chloride solution write the word equation and the balanced equation, including state symbols.

SC25c Tests for Negative Ions

Test for Carbonates Using Hydrochloric Acid

1) To test for carbonate ions in solution, first add some barium chloride solution.
   If there are carbonate ions present, this will produce a white precipitate of barium carbonate.
2) Then you add some dilute hydrochloric acid.
3) If there are carbonate ions present, the mixture will fizz — this is because the carbonate will react with the acid to produce carbon dioxide gas:

barium carbonate + acid → barium ions + carbon dioxide + water

$$BaCO_{3(s)} + 2H^+_{(aq)} \rightarrow Ba^{2+}_{(aq)} + CO_{2(g)} + H_2O_{(l)}$$

4) If you collect the gas and pass it through limewater, the limewater should turn cloudy
5) Once all of the barium carbonate has reacted, you'll end up with a colourless solution containing Ba^{2+} ions.

Test for Sulfate Ions Using Barium Chloride Solution

1) The test for sulfate ions in solution is similar to the test for carbonate ions.
2) First you add some barium chloride solution.
   If there are sulfate ions in the solution, a white precipitate, of barium sulfate will form:

barium ions + sulfate ions → barium sulfate

$$Ba^{2+}_{(aq)} + SO_4^{2-}_{(aq)} \rightarrow BaSO_{4(s)}$$

3) Then you add some dilute hydrochloric acid to the test sample.
4) Barium sulfate will not react with dilute hydrochloric acid, so the white precipitate will not dissolve.
   (That's how you know you've got sulfate ions and not carbonate ions.)

SC25c Tests for Negative Ions Questions

Test for Halide Ions Using Silver Nitrate Solution

To test for chloride ions (Cl^-), bromide ions (Br^-) or iodide ions (I^-), add some dilute nitric acid (HNO_3), followed by a few drops of silver nitrate solution ($AgNO_3$).

The nitric acid is added first to get rid of any carbonate ions — they produce a pale precipitate with silver nitrate too, which would confuse the results. You can't use hydrochloric acid, because you'd be adding chloride ions.

A chloride gives a **white** precipitate of silver chloride.

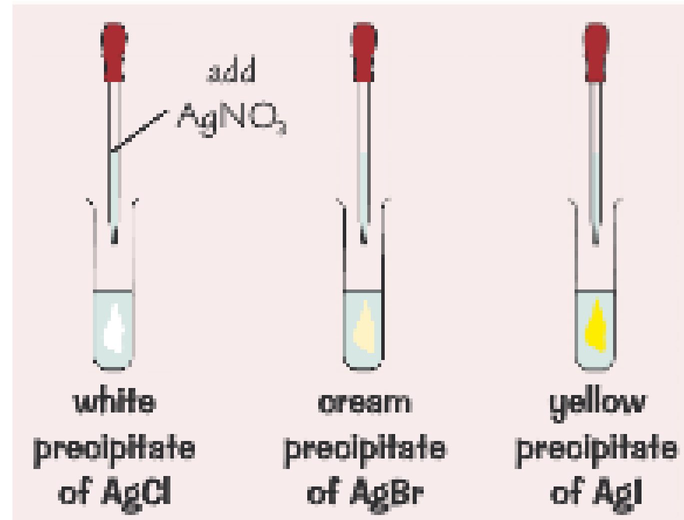
$$Ag^+_{(aq)} + Cl^-_{(aq)} \longrightarrow AgCl_{(s)}$$

A bromide gives a **cream** precipitate of silver bromide.

$$Ag^+_{(aq)} + Br^-_{(aq)} \longrightarrow AgBr_{(s)}$$

An iodide gives a **yellow** precipitate of silver iodide.

$$Ag^+_{(aq)} + I^-_{(aq)} \longrightarrow AgI_{(s)}$$



- Describe how you would test a solution to see if it contained sulphate ions.
- Some dilute nitric acid is added to a solution, followed by some silver nitrate solution. A cream precipitate forms, what does this tell you about the solution?
- Silver carbonate is an insoluble yellow solid. Suggest an explanation for why dilute acid must first be added when testing solutions for halide ions using silver nitrate solution.

SC26a Choosing Materials

Polymers are really adaptable — for example, they're often flexible, so they can be bent without breaking, and can be easily moulded into almost any shape. They're often cheaper than most other materials, and they also tend to be less dense than most metals or ceramics, so they're often used when designing products that need to have a low mass. They're also thermal and electrical insulators. But, polymers can degrade and break down over time, so polymer products don't always last as long as those made from other materials.

Ceramics, like polymers, are insulators of heat and electricity. They're much more brittle and stiff than most other materials, but they're also strong and hard wearing. They don't degrade or corrode like other materials can, so they last a lot longer — that's why we still use glass in windows instead of clear plastic.

Metals are good conductors of heat and electricity — which can be an advantage or a disadvantage, depending on what the material is needed for. They're malleable, so like polymers they can be formed into a variety of shapes. Some metals corrode easily, but products made from corrosion resistant metals can last for a very long time. Metals are usually less brittle than either ceramics or polymers, so they're likely to deform but stay in one piece where other materials may shatter.

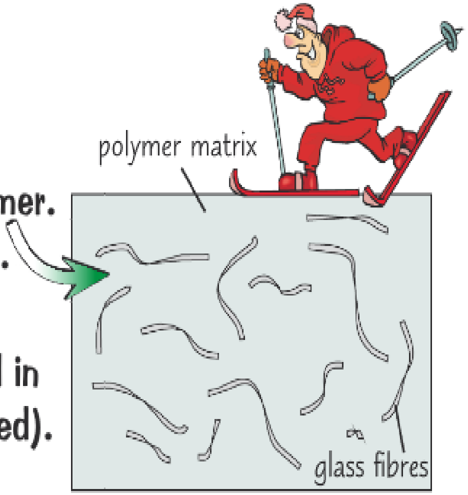
SC26a Choosing Materials Questions

- State the typical physical properties of ceramic materials.
- Describe two properties of glazed clay ceramics that make them suitable for toilet bowls.
- Describe two properties of glass that make it suitable for shower screens .
- Describe two properties of PVC that make it suitable for toilet seats.

SC26b Composite Materials

Composites are Made of Different Materials

Composites are made of one material (the reinforcement) embedded in another (the matrix/binder). The properties of a composite depend on the properties of the materials it is made from. For example:



1) Fibreglass consists of fibres of glass embedded in a matrix made of a polymer. It has a low density (like the polymer matrix) but is very strong (like glass). These properties mean fibreglass is used for things like skis and boats.

2) Concrete is made from aggregate (a mixture of sand and gravel) embedded in cement. It has a high compressive strength (it doesn't break if it's squashed). This makes it ideal for use as a building material, e.g. in skate parks.

3) KEVLAR®-based composites are made from KEVLAR® (a man-made polymer that's really strong) embedded in another material. KEVLAR® is often used as an ingredient in composite materials, as it adds a lot of strength without adding much weight. It's used in cycling helmets, tennis racquets and ropes.

4) Recently, carbon fibre composites have been made using carbon atoms bonded together to make carbon fibres or carbon nanotubes held together in a polymer resin matrix. These polymers are expensive to make but are very strong and light making them ideal for use in aerospace and sports car manufacturing.

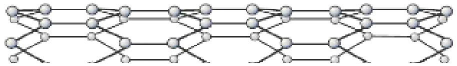
SC26b Composite Materials Questions

- Explain the meaning of the term ‘composite material’.
- What are the advantages of building a road bridge from steel reinforced concrete rather than from steel or concrete alone ?
- Name the reinforcement and matrix in a carbon fibre reinforced polymer.
-

SC26c Nanoparticles

Nanoparticles Are Really Really Really Really Tiny

1) Really tiny particles, 1–100 nanometers across, are called 'nanoparticles' (1 nm = 0.000 000 001 m). Nanoparticles contain roughly a few hundred atoms — so they're bigger than atoms and simple molecules, but smaller than pretty much anything else.
2) Fullerenes are nanoparticles.



Nanoparticles Have a High Surface Area to Volume Ratio

surface area to volume ratio = surface area ÷ volume

1) As particles decrease in size, the size of their surface area increases in relation to their volume — so their surface area to volume ratio increases.
2) Nanoparticles have a really high surface area to volume ratio.
3) This gives them different properties from larger particles, because a much greater proportion of their atoms are available to interact with substances they come into contact with.

The Effects of Nanoparticles on Health Aren't Fully Understood

1) Although nanoparticles are useful, the way they affect the body isn't fully understood, so it's important that any new nanoparticle products are tested thoroughly to minimise the risks.
2) Some people are worried that products containing nanoparticles have been made available before any possible harmful effects on human health have been investigated properly — in other words, we don't know what the side effects or long-term impacts on health could be.

SC26c Nanoparticles Questions

Nanoparticles Can Modify the Properties of Materials

Using nanoparticles is known as nanoscience. Many new uses of nanoparticles are being developed:

- They have a huge surface area to volume ratio (see above), so they can make good catalysts .
- New cosmetics, e.g. sun creams and deodorants, have been made using nanoparticles. The small particles do their job but don't leave white marks on the skin.
- Nanomedicine is a hot topic. The idea is that tiny fullerenes are absorbed more easily by the body than most particles. This means they could deliver drugs right into the cells where they're needed.
- New lubricant coatings are being developed using fullerenes. These coatings reduce friction a bit like really tiny ball bearings and could be used in all sorts of places from artificial joints to gears.
- Nanotubes conduct electricity, so they can be used in tiny electric circuits for computer chips.
- Nanoparticles are added to plastics in sports equipment, e.g. tennis rackets, golf clubs and golf balls. They make the plastic much stronger and more durable, without adding much mass (hardly any in fact).
- Silver nanoparticles are added to the polymer fibres used to make surgical masks and wound dressings. This gives the fibres antibacterial properties.

Give three examples of uses of nanoparticles.

Some socks are treated with anti bacterial silver particles, stopping the socks from becoming smelly. Describe a possible environmental hazard caused by these nanoparticles.