IGCSE Complete Chemistry Notes

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Refined and cleared by KmQ! :D

Unit 1: *States of matter*

Everything is made of particles. Particles in solid are not free to move around. Liquids and gases can. As particles move they collide with each other and bounce off in all directions. This is called random motion.

In 2 substances, when mixed, particles bounce off in all directions when they collide. This mixing process is called diffusion. It's also the movement of particles without a force.

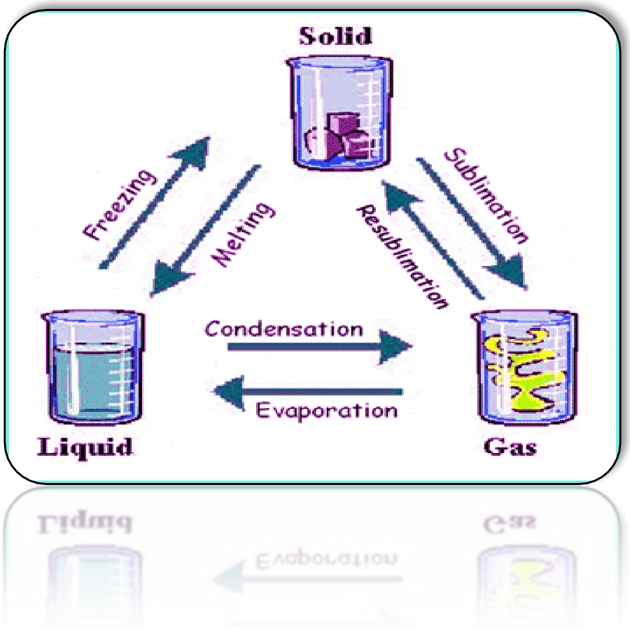
The smallest particle that cannot be broken down by chemical means is called an atom.

·In some substances, particles are just single atoms. For example the gas argon, found in air, is made up of single argon atoms.

·In many substances, particles consist of 2 atoms joined together. These are called molecules.

·In other substances, particles consist of atoms or groups of atoms that carry a charge. These particles are called ions.

Solids liquids and gases



Solid Properties:

- Definite shape and volume
- Normally hard and rigid
- Large force required to change shape
- High Density
- Incompressible

Model:

- Closely packed
- Occupy minimum space
- Regular pattern
- Vibrate in fixed position
- Not free to move

Liquid Properties:

- Definite volume but no shape.
- High Density
- Not compressible

Model:

- Occur in clusters with molecules slightly further apart compared to solids
- Free to move about within a confined vessel

Gas Properties:

- No Fixed volume and no fixed shape
- Low density
- Compressible

Model:

- Very far apart
- Travel at high speed
- Independent and random motions
- Negligible forces of attraction between them

Diffusion in Gases

Gases diffuse in different rates. Those rates depend on their factors:

1. <u>Mass of the particles</u>

The lower the mass of its particles the faster a gas will diffuse.
Why?
Because the lighter the molecules...the faster it will travel (obviously...)

2. <u>The temperature</u>

The higher the temperature, the faster a gas will diffuse.
Why?
Because particles gain energy as they are heated

Mixtures, Solutions, and Solvents

Mixture: Contains more the one substance. They are just mixed together and not chemically combined.

<u>Example</u>: Sand and water.

Solution: It is when a solute and a solvent mix. The solute dissolves in the solvent making a solution.

<u>Example</u>: sugar (solute) dissolves in water (solvent) making a solution of sugar and water.

The solubility of every substance is different.

To help a solute dissolve you could:

- Stir it
- Rise the temperature

If you add excess amount of sugar in a small amount of water...it won't dissolve as there is no space for it. The solution becomes <u>saturated</u>.

Solvent: A substance that allows solutes to dissolve in

Example: Water, Ethanol

Pure substances and impurities

A pure substance is a substance that has no particles of any other substance mixed with it.

An unwanted substance, mixed with a wanted substance, is called an **impurity**.

To check if a substance is pure, you have to check its melting and boiling points.

A pure substance has a definite, sharp, melting point. When a substance is impure, the melting point falls and its boiling point rises. So the more impurity present, the wider and bigger the change in melting and boiling point.

Separation methods:

Filter ------------------------- Solid from liquid
Centrifuge ------------------ Solid from liquid
Evaporation ---------------- Solid from its solution
Crystallization -------------- Solid from its solution
Distillation ------------------ Solvent from a solution
Fractional distillation ----- Liquid from each other
Chromatography ---------- Different substances from a solution

Separation methods

1. Filtering

Example:

A mixture of chalk and water...

1. A filter paper is placed in a funnel, the funnel placed on a flask.
2. The mixture is poured on the filter paper.

The chalk (the residue) will remain in the filter paper and the water (the filtrate) will fall down in the flask.

2. Centrifuging

This method is used to separate small amounts of solid and liquid. Inside a centrifuge (it's a machine), test tubes are spun very fast so the solid gets flung to the bottom.

3. Evaporation

This method is used to separate a solution in which the solid is dissolved in the liquid.

1. The solution is heated so that the liquid evaporates and the solid remains in the bottom of the evaporating dish.

4. Crystallization

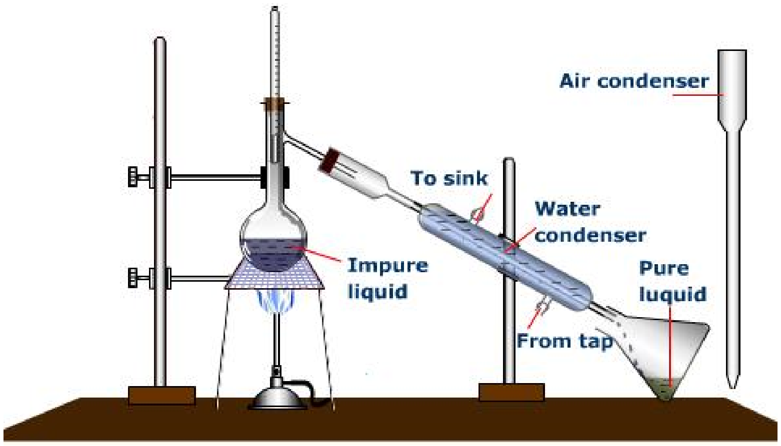
This method is similar to evaporation but here the solid forms crystals then the crystals are left to dry.

Separating a mixture of two solids

1. This can be done by dissolving one in an appropriate solvent.
2. Then filtering one and extracting the other from the solution by evaporation.

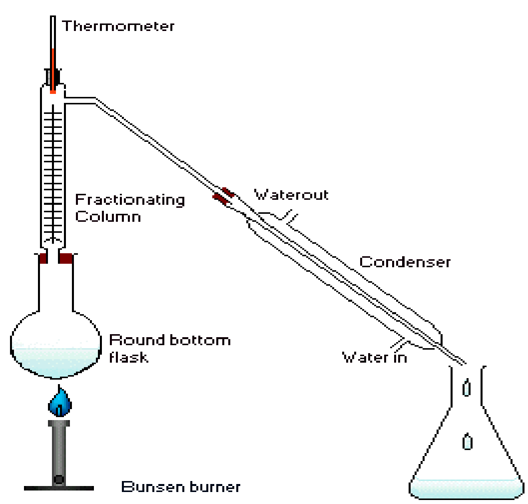
5. Simple distillation

1. The impure liquid is heated.
2. It boils, and steam rises into the condenser.
3. The impurities are left behind.
4. The condenser is cold so the steam condenses to the pure liquid and it drops out on the beaker.



6. Fractional distillation

1. The mixture is heated.
2. The wanted substance boils and evaporates (some of the unwanted liquid will evaporate too) and rises up the column.
3. The substance will condense on the beads in the column causing them to heat.
4. When the beads reach a certain temperature when the wanted liquid wont condense anymore (That's the boiling point) it will rise while the unwanted liquid will condense and drop. The wanted liquid will make its way through the condenser where it will condense and drop down in the beaker.



7. Chromatography

This method is used to separate a mixture of substances. For example you can use it to find how many coloured substances there are in black ink.

Steps:

1. Drop the black ink on to the center of a filter paper and allow it to dry.

2. Drop water on to the ink spot, one drop at a time.

3. Suppose there are three rings: yellow, red and blue. This shows the ink contains 3 coloured substances.

The substances travel across the paper at different rates. That's why they separate into rings. The filter paper showing the separate substances is called a **chromatogram**. This method works because different substances travel at different speeds because they have different levels of attraction to it.

Uses of chromatography:

- Separate mixtures of substances
- Purify a substance by separating the impurities from it
- Identify a substance

Unit 2: *The Atom*

Atoms are the smallest particles. Each atom consists of a nucleus and a cloud of particles called electrons that whizz around the nucleus.

An element is a substance that contains only one kind of atom.

The periodic table is the “map/address book” for elements where each element is given a symbol (E.g. K for potassium). The group of elements that have similar properties are put in a numbered column. For example, if you know how one element in group 1 behaves, you can easily guess how the others in the same group will behave.

The rows are called periods. The zig-zag line separates metals from non-metals, with the non-metals on the right. So most elements are metals.

A compound contains atoms of different elements joined together where the atoms are chemically combined. For example carbon dioxide is a compound of carbon and oxygen (1 carbon and 2 oxygen molecules).

The symbol for compound is made from the symbols of the elements in it. So the formula for carbon dioxide is CO2.

Isotopes and Radioactivity

You can identify an atom by the number of protons in it. For example, only sodium atoms have 11 protons.

Isotopes are atoms of the same element, with different numbers of neutrons.

Some isotopes are radioactive. That means its nucleus is unstable, sooner or later the atoms breaks down or decays, giving out radiation in the form of rays and tiny particles, as well as large amount of energy.

Like carbon-14, a number of other elements have radioisotopes that occur naturally and eventually decays. But the other two isotopes of carbon (like most natural isotopes) are non-radioactive.

You can know when radioisotopes decay by looking at there half life.
Radiation affects humans as it may causes them radiation sickness but radiation also has some uses.

Uses of radiation:

1. Check for leaks in pipes (industry)
This is done by adding a radioisotope to the oil or gas. At a leak, the radiation is detected using an instrument. Radioisotopes used in this way are called tracers.

2. in cancer treatment (Medical)
Radioisotopes can cause cancer but yet also can cure it. Using radiotherapy the radioisotope will decay and give out rays that can kill cancer cells. These rays will be aimed exactly at the cancer cells.

3. To find the age of old remains
A tiny percentage of a living thing contains carbon-14 atoms. When living thing dies it no longer takes in new carbon atoms. But existing carbon-14 atom decay over time - we can measure the faint radiation from them.

How electrons are arranged

The electrons in an atom circle fast around the nucleus, at different levels from it. These energy levels are caller electron shells. The further the shell is from the nucleus, the higher the energy level.

Each shell can hold a limited number of electrons.

First shell can hold up to 2 electrons
Second shell can hold up to 8 electrons
The third shell can also hold up to 8 electrons

Electronic configuration means the arrangement of electrons in an atom.

Example:
- Argon has the electronic configuration : 2,8,8
- Magnesium has the electronic configuration : 2,8,2

Important points:

- The shells fill in order, from lowest energy level to highest energy level
- All the elements in a group have the same number of electrons in their outer shells. These are called Valency electrons.
- The group number is the same number of outer shell electrons
- The period number shows how many shells there are.
- If an element posses a full outer shell, the element become unreactive

Unit 3: *Atoms combining*

Most elements form compounds because they want a full outer shell and to achieve that they must react with other atoms. For example, sodium has just one electron in its outer shell. It can obtain a full outer shell by losing this electron to anther atoms and by that it becomes a sodium ion. Now because sodium lost a electron...it now has 10 electrons but 11 protons...so it has a 1 positive charge.

An ion is a charged particle. It is charged because it has an unequal number of protons and electrons.

The ionic bond

Example:

Sodium and chlorine react together; sodium gives its electron to chlorine. Now both elements have a full outer shell, but with a charge. Now they are ions.

Sodium now has 10 electrons but 11 protons so it has a positive charge.
Chlorine now has 18 electrons but 17 protons so it has a negative charge.

The two ions have opposite charges, so they attract each other. The force of attraction between them is strong. It is called an ionic bond.

When sodium reacts with chlorine, billions and billions of sodium and chlorine ions form and they attract each other. But the ions don't stay in pairs. They cluster together so that each ion is surrounded by 6 ions of opposite charges. The pattern grows until a giant structure of ions is formed. The overall charge of the structure is 0 since 1 positive charge and 1 negative charge neutralize each other.

The ionic bonding is only between metals and non-metals.

Important notes:

- Hydrogen and the metals form positive ions
- Non-metals form negative ions, and their names end in -ide
- Group 4 and 5 do not usually form ions because they would have to lose or gain several electrons and that takes too much energy
- Group 0 elements do not form ions; they already have full outer shells
- Some of the transition metals form more than one ion.
- Some ions can be formed from groups of joined atoms. These are called compound ions.

Properties of ionic compound

1. **Ionic compounds have high melting and boiling points.**

This is because ionic bonds are very strong, so it takes a lot of heat energy to break up the lattice.

2. **Ionic compounds are usually soluble in water.**

The water molecules can attract the ions away from the lattice. The ions can then move freely, surrounded by water molecules.

3. **Ionic compounds can conduct electricity when they are melted or dissolved.**

When melted the lattice breaks up and the ions are free to move. Since they are charged, this means they can conduct electricity. The solutions of ionic compounds conduct electricity too because they are also free to move.

The covalent bond

Giving and losing an electron is not the only way to gain full outer shells since atoms can also share electrons.

Covalent bonding is for non-metals only since only non-metals need to gain electrons.

A molecule is a group of atoms held together by covalent bonds.

When a pair of electrons is shared, it is called a single covalent bond, or just single bond.

When 2 pairs of electrons are shared, it is called a double covalent bond, or just double bond.

When 3 pairs of electrons are shared, it is called a triple covalent bond, or just triple bond.

Covalent compounds

A covalent compound is when atoms of *different* elements share electrons with each other.

The molecules in a covalent compound isn't flat because each electron repel each other and try to get as far apart from each other.

Molecular substances

Most molecular substances are gases or liquids at room temperature. Molecular solids are held in a lattice but the forces between the molecules are weak. All molecular solids have similar structure. The molecules are held in regular pattern in a lattice. So the solids are crystalline.

When you cool down a molecular liquid or gas the molecules lose energy so they start moving slowly and at the freezing point, they form a lattice (a good example would be ice)

Properties of covalent bonding

1. **Covalent compounds have low melting and boiling point**
   This is because the forces between the molecules are weak.

2. **They do not conduct electricity**
   This is because molecules are not charged, so they cannot conduct, even when melted

Giant covalent structures

A giant covalent structure, or macromolecules are made of billions of atoms bonded together in a covalent structure.

Diamond – a giant covalent structure

Diamond is made of carbon atoms held in a strong lattice. Each carbon atom forms a covalent bond to four others. Eventually billions of carbon atoms bond together to form a crystal of diamond.

Diamond properties:

1. It is very hard because each atom is held by four strong bonds.
2. It has a very high melting point because of the strong bonds.
3. It can’t conduct electricity because there are no free electrons to carry the charge.

Silica is similar to diamond.

Graphite – a very different giant structure

Like diamond graphite is made only of carbon atoms. So diamond is and graphite are allotropes of carbon (means they are two forms of the same element)

Graphite, unlike diamond, is one of the softest solids on earth.

In graphite, each carbon atom forms a covalent bond to three others. This gives rings of six atoms.

Graphite properties:

1. Is soft and slippery because the sheets can slide over each other
2. Is a good conductor of electricity because each carbon atom has four outer electron and graphite bonds 3 only so the fourth electron is free to move carrying a charge.

Substance	Properties	Uses
Diamond	-Hardest known substance and does not conduct -Sparkles when cut	In tools for drilling and cutting For jewellery
Silica	-Hard, can scratch things -Hard, lets light through -High melting point	-In sandpaper -For making glass and lenses -In bricks for lining furnaces
Graphite	-Soft and slippery -Soft and dark in color -Conduct electricity	-As a lubricant for engines -For pencil 'lead' (mixed with clay) -For electrodes, and connecting brushes in generators.

Properties of Diamond:

- Hard substance
- High MP / BP
- Cant conduct electricity

Properties of Graphite:

- Soft and slippery
- Good Conductor

Properties of Silica:

- High BP / MP
- Hard

Comparing Bonds

Differences in STRUCTURE

Covalent	Ionic
Molecular	ionic
Shares electrons	Exchange electrons
Simple molecules	Giant lattices
Non metal only	Metals and non metals

Differences in PROPERTIES

Dissolves in organic liquid (not water)	Dissolves in water
Low Boiling and melting point	High boiling and melting point
Does no conduct electricity	Conducts electricity

Metallic bonding

Metals form giant structures in which electrons in the outer shells of the metal atoms are free to move. The metallic bond is the force of attraction between these free electrons and metal ions. Metallic bonds are strong, so metals can maintain a regular structure and usually have high melting and boiling points.

Properties of metals:

1. **Metals have high melting points**

This is because it takes a lot of heat energy to break up the lattice.

2. **Metals are malleable and ductile.**

Malleable: They can be bent and pressed into shapes.

Ductile: They can be drawn out into wires.

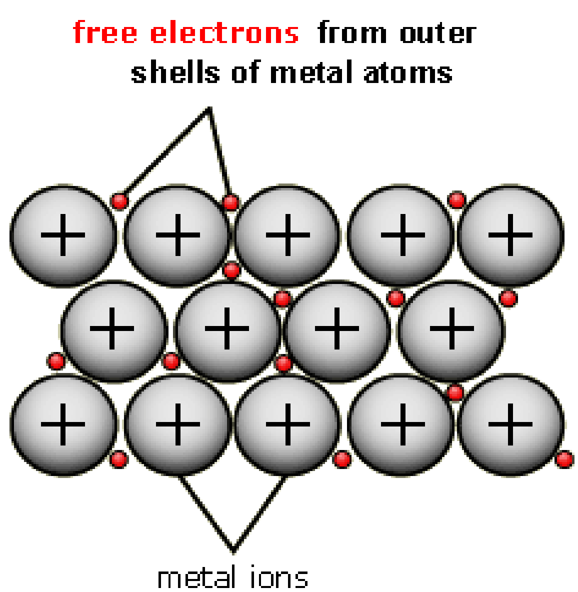
This is because the layers can slide without the metallic bond breaking, because the electrons are free to move too.

3. **Metals are good conductors of heat**

That's because the free electrons take in heat energy, which makes them move faster and they quickly transfer the heat through the metal structure.

4. **Metals are good conductors of electricity**

This is because the free electrons can move through the lattice carrying the charge.



Unit 4: *The Periodic Table*

The periodic table is a list of all the elements, <u>in order of increasing atomic number</u>.

The columns are called <u>groups</u>.

The rows are called <u>periods</u>.

Groups

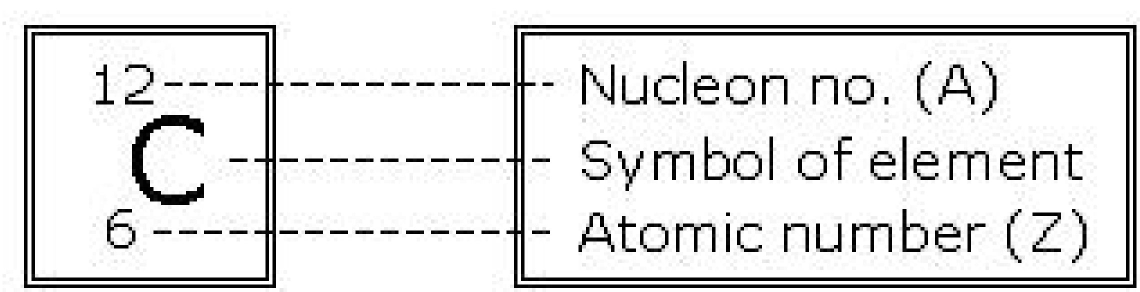
- The group number tells you how many electrons there are in the outer shell of the atoms.
- The outer-shell electrons are also called <u>valency electrons</u> and their number shows how the elements behave.
- All elements in a group have similar properties.
- Group 0 elements have a *full outer shell*. This makes them unreactive.
- Some of the groups have special names:

Group 1 – **The alkali metals**

Group 2 – **The alkaline earth metals**

Group 7 – **The halogens**

Group 0 – **The noble gases**



Periods

The period number gives information about the number of electron shells that are available in that period.

Hydrogen

Hydrogen sits alone in the table because it's the only element with one electron shell.

Trends in the periodic table

The elements in each numbered group shows trends in their properties. For example as you go down group 1, the elements become more reactive or as you go down group 7 the elements become less reactive and so on.

Group 1: *The alkali metals*

Their physical properties:

1. Like all metals, they are good conductors of heat and electricity.
2. They are softer than most other metals and they have low density.
3. They have low melting and boiling points, compared to most metals.

Their chemical properties:

1. All alkali metals react vigorously with water, releasing hydrogen gas and forming hydroxides. The hydroxides give alkaline solutions.
2. They react with non-metals. With chlorine they react to make chlorides and with oxygen they make oxides.

They form ionic compounds in which the metal ion has a charge of 1+. The compounds are white solids, which dissolve in water to give a colorless solution.

The trend in physical properties

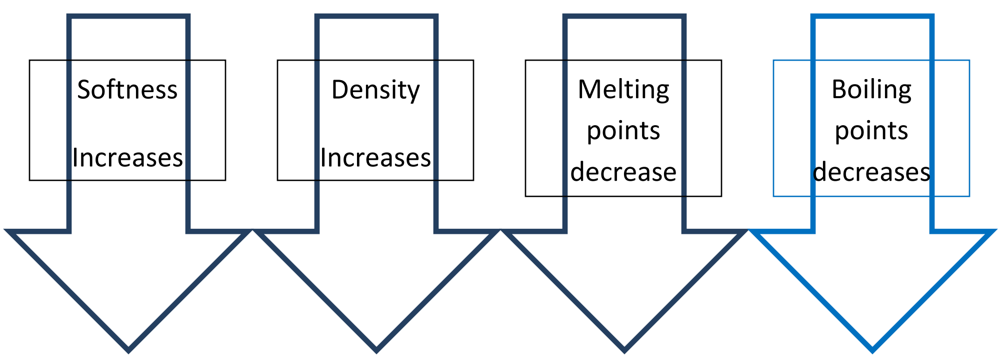
Lithium

Sodium

Potassium

Rubidium

Caesium



Why they have similar properties?

Because atoms with the same number of valency electrons react in a similar way.

As you go down the group reactivity increase.

Why?

Because the atoms get larger down the group because they add electron shells.

Group 7: *The halogens*

A non-metal group.

- Form colored gases.
- Are poisonous
- Are brittle and crumbly in their solid form, and do not conduct electricity.
- Form diatomic molecules (means they exist as 2 atoms)

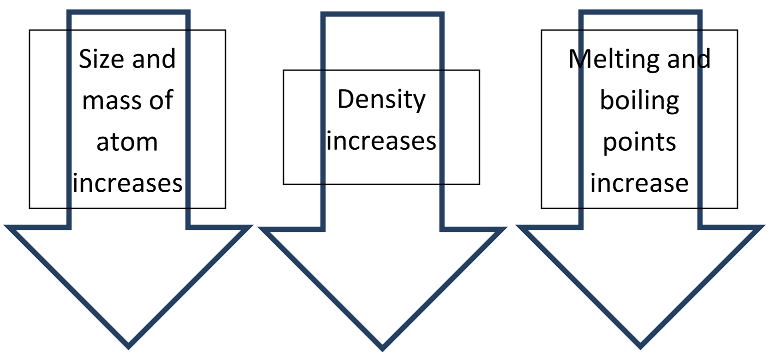
Trends in their physical properties

Fluorine

Chlorine

Bromine

iodine



Trends in their chemical properties

Reactivity increases as you go up group 7.

Why?

Because the smaller the atom, the easier it is to attract the electron – so the more reactive the element will be.

Why are they so reactive?

Because their atoms are only one electron short of a full shell.

Group 0: *The noble gases*

A non-metal group

- Contains colorless gases, which occur naturally in air
- Monatomic – they exist as single atoms
- Unreactive because they have a full outer shell.

Trends in their physical properties

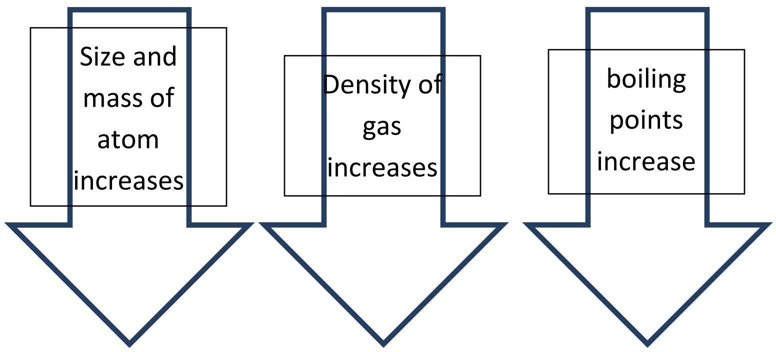
Helium

Neon

Argon

Krypton

Xenon



Uses of noble gases

Noble gases are unreactive, making them safe to use. They also glow when current is passed through them at low pressure.

Gas	**Use**
Helium	-Used to fill balloons and airships, because it is much lighter than air and will not catch fire
Neon	-Used in advertising signs. It glows red, but the color can be changed by mixing it with other gases.
Argon	-Used as a filler in ordinary tungsten light bulbs. (oxygen would make the tungsten filament burn away) -Used to protect metals that are being welded. It won't react with the hot metals (unlike oxygen)
Krypton	-Used in lasers. For example for eye surgery and in car headlamps
Xenon	-Used in lighthouse lamps, lights for hospitals operating theatres, and car headlamps.

The transition elements

The transition elements are the block of 30 elements in the middle of the periodic table. They are all metals.

Their physical properties

- Hard, tough and strong
- High melting points (mercury is an exception)
- Malleable and ductile
- Good conductors of heat and electricity
- High density

Their chemical properties

1. They are much less reactive than the metals of group 1.
2. They show no clear trend in reactivity, unlike the metals of group 1.
3. Most transition metals form colored compounds
4. Most can form ions with different charges (they have variable valency)
5. They can form more than one compound with another element
6. Most transition metals can form complex ions

Uses of transition metals

- The hard strong transition metals are used in structure such as bridges, buildings, cars etc.
- Many transition metals are used in making alloys.
- Transition metals are used as conductors of heat and electricity.
- Many transition metals and their compounds act as catalysts

Unit 6: *Chemical equations*

Physical and chemical change

A substance can be changed by heating it, adding water to it, mixing another substance with it, and so on. The change that takes place will be either ***chemical*** change or a ***physical*** change.

Chemical change

In a chemical change, a new chemical substance is produced.

The difference between a mixture and a compound

Mixture: 2 substances are mixed together but not chemically bonded.

Compound: 2 substances are chemically bonded together

The signs of a chemical change

A chemical change is usually called a chemical reaction. You can tell when a chemical reaction has taken place by these signs:

1. **Once or more new chemical substances are formed**

The new substance usually looks different from the starting substances.

2. **Energy is taken in or given out during the reaction.**

A change that gives out heat energy is called ***exothermic***

A change that takes in heat energy is called ***endothermic***

3. **The change is usually difficult to reverse.**

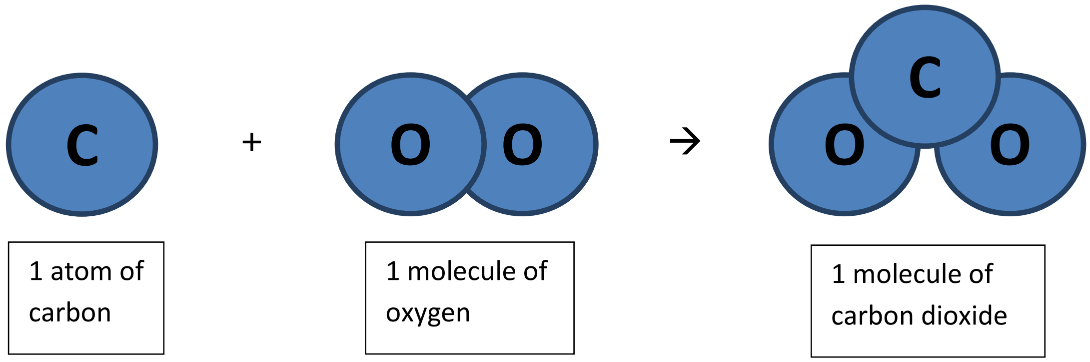
This means it will be hard to get back the raw materials of the reaction.

Physical change

If no new chemical substance is formed, a change is a physical change.

Equations for chemical reactions

The reaction between carbon and oxygen. When they react together, they form carbon dioxide. Carbon and oxygen are the reactants. Carbon dioxide is the product of the reaction.

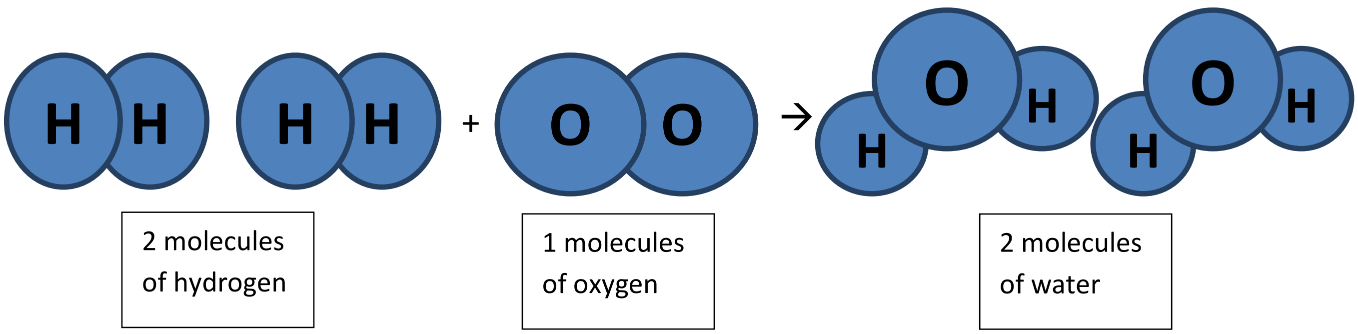


Or in a shorter way, using symbols and numbers like this:

$$C + O^2 \rightarrow CO^2$$

This short way to describe the reaction is called a chemical equation.

The reaction between hydrogen and oxygen:



And the equation is:

$$2H^2 + O^2 \rightarrow 2H^2O$$

On the left same as on the right, so:

On the left:		**On the right:**
4 hydrogen atoms	→	4 hydrogen atoms
2 Oxygen atoms		2 Oxygen atoms

You can show the state of the reactants and products by adding state symbols to the equation:

- *(s)* for solid
- *(l)* for liquid
- *(g)* for gas
- *(aq)* for aqueous solution (solution in water)

Unit 8: *Acids and alkalis*

Acids

You can tell if something is acid, by its effect on litmus.

Litmus is a purple dye. It can be used as a solution, or on paper.

Acids turn litmus red

Alkalis

You can tell if something is alkali, by its effect on litmus.

Alkali turn litmus blue

Indicators

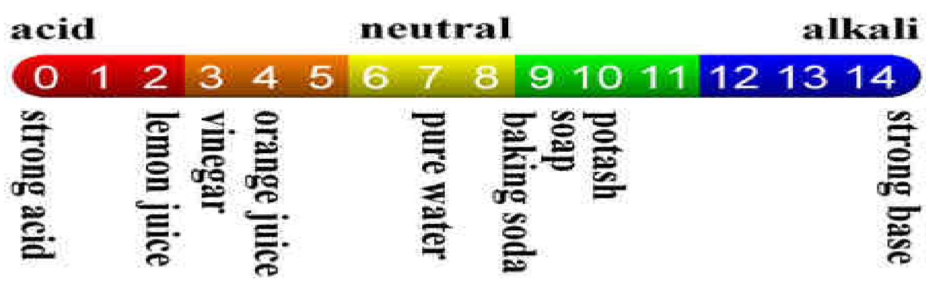
Litmus is called an indicator, because it indicates whether something is an acid or an alkali.

Neutral substances

Many substances are not acids or alkalis. They are neutral. Example is pure water.

The pH scale

You can say how acidic or alkaline a solution is using a scale of numbers called pH scale. The numbers go from 0 to 14:



On this scale:

An acidic solution has a pH number less than 7

An alkaline solution has a pH number greater than 7

A neutral solution has a pH number of exactly 7

Acids produce hydrogen ions

Acidic solutions contain hydrogen ions, this what makes them ‘acidic’

The difference between strong and weak acids

In solution of strong acids, all molecules become ions.

In solution of weak acids, only some do.

The higher the concentration of hydrogen ions, the lower the pH, the stronger the acid.

Alkalis produce hydroxide ions

Alkaline solutions contain hydroxide ions, this is what makes them alkaline.

The difference between a strong alkali and weak alkali

In solution of strong alkali, it contains more hydroxide ions.

In solution of weak alkali, it contains less hydroxide ions.

The higher the concentration of hydroxide ions, the higher the pH.

To tell if the solution is a weak or strong acid. You can also measure there conductivity. A strong acid will show high conductivity and low pH. A weak acid does not conduct well, and has a higher pH.

For alkali's, a strong alkali will show high conductivity and high pH. A weak acid will show low conductivity and low pH.

Reaction of acids with metals

When an acid reacts with a metal, hydrogen is displaced, leaving a salt in solution. It's a redox reaction.

Reaction of acids with bases

Bases are a group of compound that reacts with acids, and neutralize them, giving a salt and water. Bases include alkalis, and insoluble metal oxides, hydroxides and carbonates.

1. **With alkalis**

Acid + alkali → salt + water

2. **With metal oxides**

Acid + metal oxide → salt + water

3. **With carbonates**

Acid + metal carbonate → salt + water + carbon dioxide

Reactions of bases

1. Neutralizing acids, giving salt and water. With carbonates carbon dioxide is produce too.
2. All the alkalis (except ammonia) will react with ammonium compounds, giving ammonia out.

The ionic equation

An ionic equation shows only the ions that actually take part in a reaction. It leaves out the rest.

1. First write down all the ions present in the equation
2. Now cross out any ions that appear, unchanged, on both sides of the equation
3. What's left is the ionic equation for the reaction

Proton donors and acceptors

Acids donate its protons to bases and bases accept them.

For example:

Magnesium oxide is a insoluble base. The acid donates its H^+ protons and the oxygen from magnesium oxide react with it to make water molecules.

Acidity in soil

Most crops grow best when the pH of the soil is near 7. If soil is too acidic or too alkaline, crops grow badly or not at all.

Usually acidity is the problem. Why? Because of a lot of vegetation rotting in it or because too much fertilizer was used in the past.

To reduce the acidity, the soil is treated with a base like limestone or quicklime or slaked lime.

Acid rain

Acid rain is caused by factories, power stations, homes who burn fossil fuels to make electricity. The waste gases from all these reactions include sulphur dioxide, and oxides of nitrogen. They go into the air and react with air and water to produce sulphuric acid and nitric acid which are strong acids.

Making salts

You can make salts by reacting metals, insoluble bases, or soluble bases with acids.

With metals:

Example:

1. **Add the zinc to the sulphuric acid in a beaker**

It will start to dissolve and hydrogen bubbles are given off. Stops when all the acid is used up.

2. **Excess zinc is removed by filtering. This leaves a aqueous solution of zinc sulphate.**

3. **The solution is heated to evaporate some water. Then it is left to cool and crystals of zinc sulphate start to form.**

With insoluble base:

It's the same method as the one above but, the metal wont react with the acid. So you must start with a metal oxide.

With an alkali (soluble base):

1. Put the alkali into a flask and add some drops of indicator
2. Add the acid from a burette, just a little at a time. Swirl the flask to help the acid and alkali mix.
3. When the indicator turns green stop adding acid.
4. Calculate how much acid was used.
5. Carry out the experiment again without the indicator and add same amount of acid that was used before. This is because the indicator will make the salt impure.
6. Heat the solution from the flask and crystals will start to form.

Making insoluble salts by precipitation

Not all salts are soluble.

Soluble	Insoluble
All sodium, potassium, and ammonium salts	
All nitrates	
Chlorides…	*Except* silver and lead chloride
Sluphates…	*Except* calcium, barium and lead sulphate
Sodium, potassium, and ammonium carbonates…	But all other carbonates are insoluble.

Insoluble salts can be made by precipitation

Preparing barium sulphate

Barium sulphate is a insoluble salt. You can make it by mixing solutions of barium chloride and magnesium sulphate.

1. Make up solutions of barium chloride and magnesium sulphate.
2. Mix them. A white precipitate of barium sulphate forms at once.
3. Filter the mixture. The precipitate is trapped in the filter paper.
4. Rinse the precipitate by running distilled water through it.
5. Then place it in a warm oven to dry

To precipitate an insoluble salt, you must mix a solution that contains its positive ions with one that contains its negative ions.

Unit 10: *How fast reactions are?*

Rates of reaction

Some reaction are fast and some are slow.

What is rate?

Rate is a measure of how fast or slow something is.

Rate is a measure of the change that happens in a single unit of time.

To find rate of a reaction, you should measure:

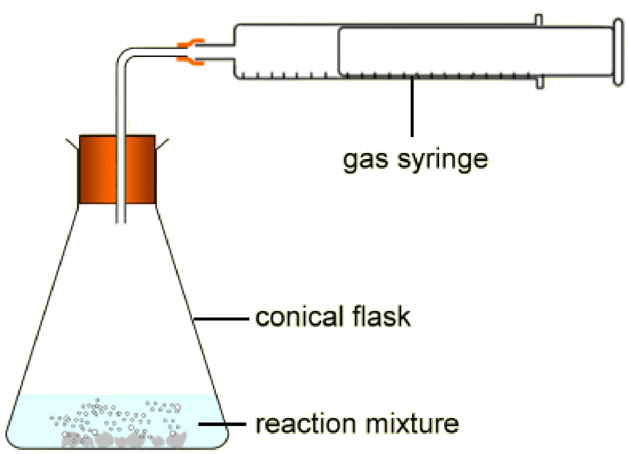
- The amount of a reactant used up per unit of time

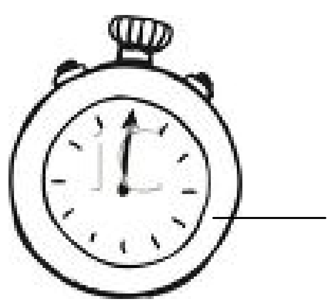
Or

- The amount of a product produced per unit of time

A reaction that produces a gas

When you react magnesium and hydrochloric acid, it produces hydrogen gas. To measure the rate of this reaction this method is set up:





Using this you can measure the amount of hydrogen produced in a period of time.

Collisions

For a chemical reaction to occur, the **reactant** particles must collide. But collisions with too little energy do not produce a reaction.

The particles must have enough energy for the collision to be successful in producing a reaction.

The rate of reaction depends on the rate of successful collisions between reactant particles. The more successful collisions there are, the faster the rate of reaction.

Changing the temperature

If the temperature is increased:

- the reactant particles move more quickly
- they have more energy
- the particles collide more often, and more of the collisions result in a reaction
- the rate of reaction increases

Changing the concentration or pressure

If the concentration of a dissolved reactant is increased, or the pressure of a reacting gas is increased:

- the reactant particles become more crowded
- there is a greater chance of the particles colliding
- the rate of reaction increases

Changing the surface area

If a solid reactant is broken into small pieces or ground into a powder:

- its surface area increases
- more particles are exposed to the other reactant
- there are more collisions
- the rate of reaction increases

The effect of light

Some chemical reactions obtain the energy from light. They are called photochemical reactions. For example:

1. Silver bromide is pale yellow, but darkens on exposure to light because the light causes it to decompose to silver:

   Light

$2AgBr \rightarrow 2Ag + Br^2$

2. Plants use carbon dioxide from the air to make sugar called **glucose**, in a reaction called **photosynthesis**. This uses the energy in sunlight. The green substance – **chlorophyll** – in leaves speeds up the reaction:

$6CO^2 + 6H^2O \rightarrow C6\ H12\ O6 + 6O^2$

chlorophyll

Carbon dioxide + water → glucose + oxygen

In both these reaction, the stronger the light, the more energy it provides so the faster the reaction goes.

<u>Effect of catalysts</u>

A **catalyst** is a substance that can increase the rate of a reaction. The catalyst itself remains unchanged at the end of the reaction it catalyses. Only a very small amount of catalyst is needed to increase the rate of reaction between large amounts of reactants.

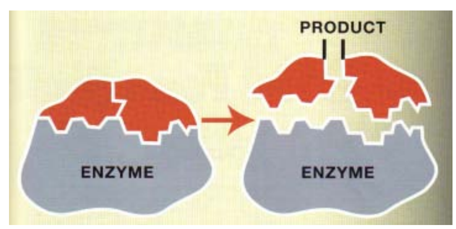
A catalyst works by lowering the activation energy for the reaction.

<u>Enzymes: biological catalysts</u>

Enzymes are proteins that act as catalysts. So they are often called **biological catalysts**.

<u>How enzymes work</u>

First the enzyme and the reactant molecule fit together like jigsaw pieces. The reactant molecule has to be the right shape. The enzyme breaks down the molecule to smaller pieces and so on.



Important notes:

- An enzyme works best in conditions that match those in the living cells it came from.
- This means most enzymes work best in the temperature range 25-45ºC
- If the temperature is too high, an enzyme loses its shape and it becomes <u>denatured</u>.
- An enzyme also works best in a particular pH range.

Uses of enzymes

1. In making ethanol
2. In making bread
3. In biological detergents

Unit 12: *The behavior of metals*

Most elements are metals.

Properties of metals:

1. They are strong.
2. They are malleable
3. They are ductile
4. They are sonorous (They make a ringing noise when you strike them)
5. They are shiny when polished
6. They are good conductors of electricity and heat
7. They have high melting and boiling points (they are all solid at room temperature, except mercury)
8. They have high density (they are heavy)
9. They react with oxygen to form oxides
10. When they react, metals form positive ions.

The last two properties are <u>chemical properties</u>, the others are <u>physical properties</u>.

Metals reactivity

A reactive element has a strong drive to become a compound. So it reacts readily with other elements and compounds.

If a metal is more reactive than another metal, then it displaces it and takes it place.

For example:

When a metal is heated with a oxide of a less reactive metal, it acts as a reducing agent. The reaction always gives out heat – it is exothermic. (reducing agent: a substance which brings about the reduction of another substance.)

<u>A metal will always displace a less reactive metal from solutions of its compounds.</u>

The reactivity series

Potassium, K

Sodium, Na

Calcium, Ca

Magnesium, Mg

Aluminum, Al

Carbon

Zinc, Zn

Iron, Fe

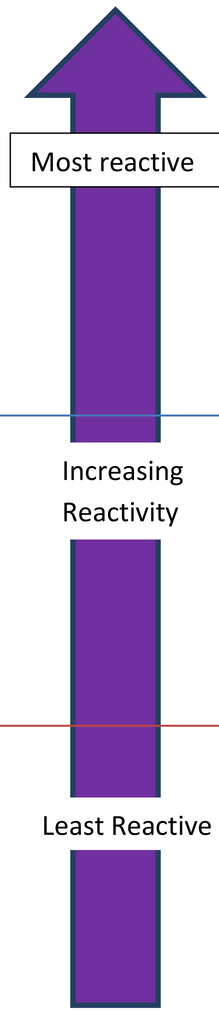
Lead, Pb

Hydrogen

Copper, Cu

Silver, Ag

Gold, Au



Metals above the blue line: Carbon can't reduce their oxides.

Metals above the red line: They displace hydrogen from acids, and hydrogen can't reduce their oxides.

Things to remember about the reactivity series

- The reactivity series is a list of metals in order of their drive to form positive ions. The more reactive the metal, the more easily it gives up electrons to form positive ions.
- A metal will react with a compound of a less reactive metal (for example an oxide) by pushing the less reactive metal out of the compound and taking its place, as ions.
- The more reactive the metal, the more **stable** its compounds are.
- The more reactive the metal, the more difficult it is to extract it from ores.
- The less reactive the metal, the less it likes to form compound.

The stability of some metal compounds

Many compounds break down easily on heating. In other words, they undergo thermal decomposition.

(Thermal decomposition is the breakdown of a compound by heating it)

1. **Carbonates**

Most decompose to oxide and carbon dioxide, on heating.

- But the carbonates of potassium and sodium do not decompose.
- Strong heating is needed to break down calcium carbonate and the reaction is reversible.
- The further down the series, the more easily the other carbonates break down. For example Copper(II) carbonate breaks down very easily, like this:

$CuCO^3$ (s) $\rightarrow$ CuO (s) + CO^2 (g)

2. **Hydroxides**

Most decompose to oxide and water on heating, like this:

$Zn(OH)^2$ (s) $\rightarrow$ ZnO (s) + H^2O (l)

- But the hydroxide of potassium and sodium do not decompose.
- The further down the series, the more easily the others break down.

3. **Nitrates**

All decompose on heating – but not all the same products.

- Potassium and sodium nitrates break down to nitrites, releasing only oxygen, like this:

$2NaNO^3$ (s) $\rightarrow$ $2NaNO^2$ (s) + O^2 (g)

- But the nitrates of the other metals break down further to oxides, releasing the brown gas nitrogen dioxide as well as oxygen:

$2Pb(NO^3)^2$ $\rightarrow$ 2bO (s) + $4NO^2$ (g) + O^2 (g)

- The further down the series, the more easily they break down

Uses of reactivity series

- The thermite process
- The sacrificial protection of iron
- Galvanizing
- Making cells (batteries)

Unit 13: *Making use of metals*

<u>Metal Ores</u>

Sodium = rock salt

Aluminum = bauxite

Iron = hematite

<u>Extraction</u> Method of extraction

Potassium, K

Sodium, Na

Calcium, Ca

Magnesium, Mg

Aluminum, Al

Carbon

Zinc, Zn

Iron, Fe

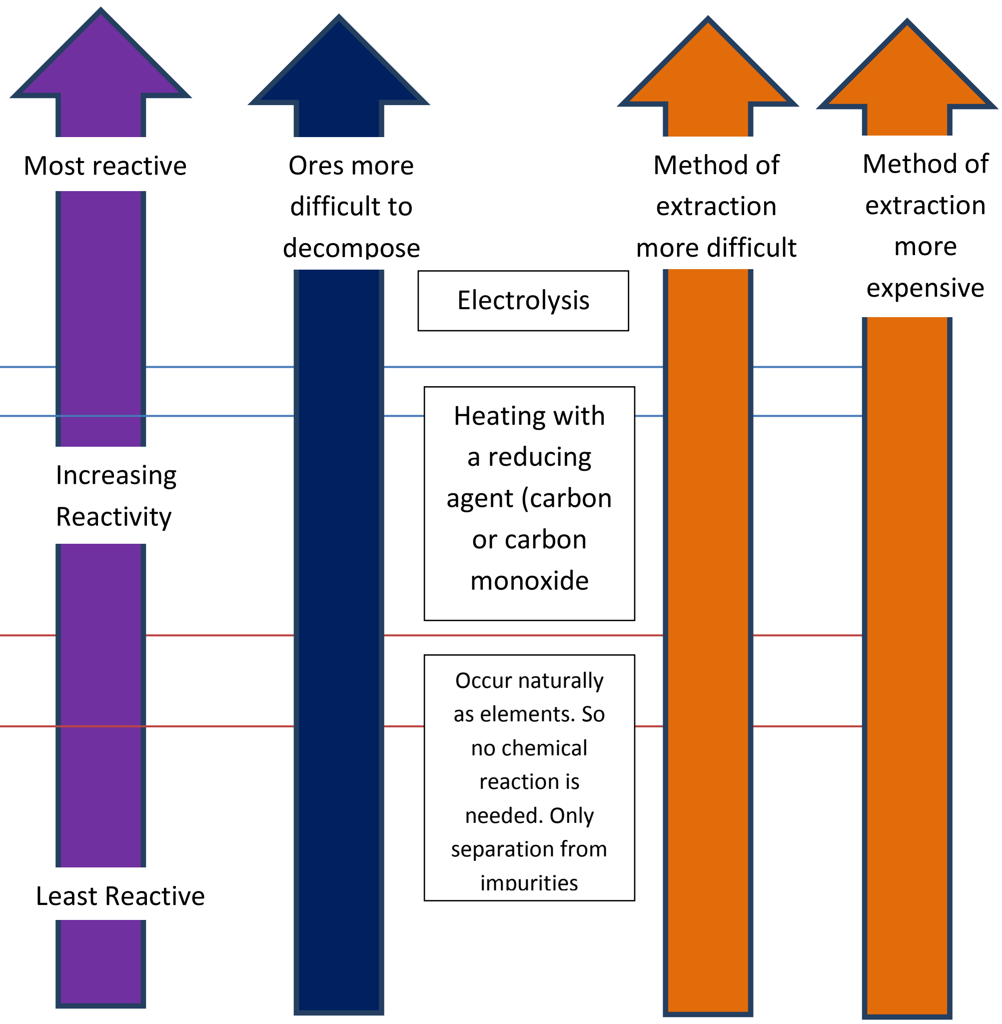
Lead, Pb

Hydrogen

Copper, Cu

Silver, Ag

Gold, Au



Extraction of zinc from zinc blende

Zinc blende is mainly zinc sulphide, ZnS. First it is roasted in air, giving zinc oxide:

Zinc sulphide + Oxygen → Zinc oxide + Sulphur dioxide

$2ZnS$ (s) $3O^2$ $2ZnO$ (s) $2SO^2$

Then the oxide is reduced in one of the two ways below:

1. **Using carbon monoxide.** This is carried in a furnace:

Zinc oxide + Carbon monoxide → Zinc + Carbon dioxide

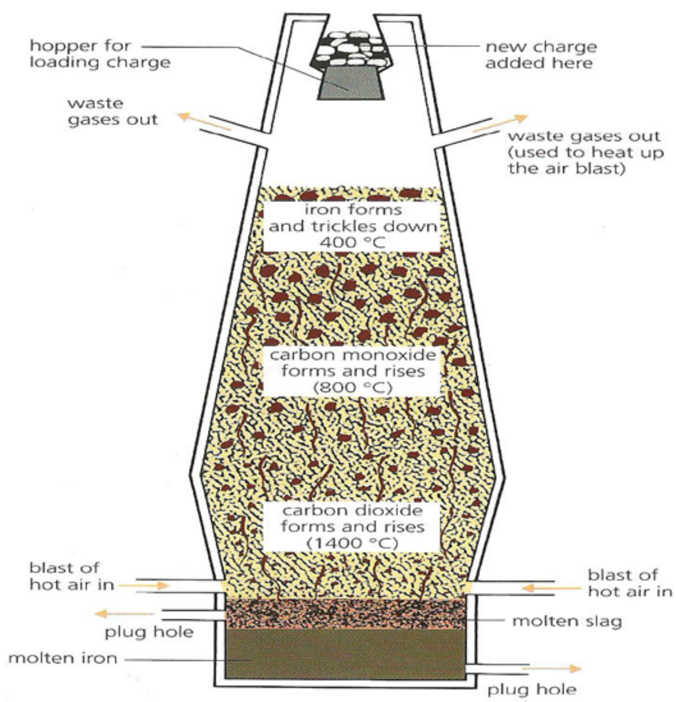
ZnO (s) CO (g) Zn (s) CO^2 (g)

The final mixture contains zinc and a slag of impurities. The zinc is separated from it by fractional distillation. (It boils at 907ºC)

2. **Using electrolysis**

Extraction of iron

<u>The blast furnace</u>



A mixture called the **charge**, containing the iron ore, is added through the top of the furnace. Hot air is blasted in through the bottom. After a series of reactions, liquid iron collects at the bottom of the furnace.

What's in the charge?

The charge contains three things:

1 **Iron ore.** The chief ore of iron is called **haematite**. It is mainly iron(III) oxide, Fe_2O_3, mixed with sand.

2 **Limestone.** This common rock is mainly calcium carbonate, $CaCO_3$.

3 **Coke.** This is made from coal, and is almost pure carbon.

The reactions in the blast furnace

Stage 1: The coke burns giving off heat

The blast of hot air starts the coke burning. It reacts with the oxygen in the air, giving carbon dioxide:

Carbon + Oxygen $\rightarrow$ Carbon dioxide

C (s) O^2 (g) CO^2

Explanation: It's a combustion reaction which means it's a redox reaction. The carbon is oxidized to carbon dioxide. The blast of air provides the oxygen for the reaction.

The reaction is exothermic – it gives off heat, which helps to heat the furnace.

Stage 2: Carbon monoxide is made

The carbon dioxide reacts with more coke, giving carbon monoxide:

Carbon + Carbon dioxide $\rightarrow$ Carbon monoxide

C (s) CO^2 (g) $2CO$ (g)

Explanation: In this redox reaction, the carbon dioxide loses oxygen. It is reduced.

The reaction is **endothermic** – it takes in heat from the furnace. This is good because stage 3 needs a lower temperature.

Stage 3: The iron(III) oxide is reduced

This is where the actual extraction occurs. Carbon monoxide reacts with the iron ore giving liquid iron:

Iron(III) oxide + Carbon monoxide $\rightarrow$ Iron + Carbon dioxide

Fe^2O^3 (s) $3CO$ (g) $2Fe$ (l) $3CO^2$ (g)

The iron trickles to the bottom of the furnace.

Explanation: In this redox reaction, carbon monoxide acts as the reducing agent. It reduces the iron(III) oxide to the metal.

At the same time the carbon monoxide is oxidized to carbon dioxide.

What is the limestone for?

The limestone reacts with the sand (silica) in the ore, to form calcium silicate or slag.

Limestone + Silica → Calcium silicate + Carbon dioxide

$CaCO^3$ (s) SiO^2 (s) $CaSiO^3$ (s) CO^2 (g)

The slag runs down the furnace and floats on the iron.

Explanation: The purpose of this reaction is to remove impurities from the molten iron.

Silica is an acidic oxide. Its reaction with limestone is neutralization (because limestone is a base), giving calcium silicate, a salt.

The waste gases

These are carbon dioxide and nitrogen. They come out at the top of the furnace.

Explanation: The carbon dioxide is from the reduction reaction in stage 3. The nitrogen is from the air blast. It has not taken part in the reactions so has not been changed.

The molten iron is tapped from the bottom. It is impure with carbon as the main impurity. Some is run into moulds to give **cast iron**. This is hard but brittle. But most of the iron is turned into **steel**.

Uses of some metals

Metal	Used for ...	Properties that make it suitable
aluminium	overhead electricity cables (with a steel core for strength)	a good conductor of electricity (not as good as copper, but cheaper and much lighter); ductile, resists corrosion
	coating CDs and DVDs	shiny surface reflects the laser beam that 'reads' a CD or DVD
	cooking foil and food cartons	non-toxic, resistant to corrosion, can be rolled into thin sheets
	drinks cans	light, non-toxic, resistant to corrosion
copper	electrical wiring	one of the best conductors of electricity, ductile
	roofing	malleable, develops an attractive protective coating
	saucepan bases	conducts heat well, unreactive, tough
lead	holding the glass in stained-glass windows, and sealing joins in roofs	easy to bend at room temperature, unreactive
	car batteries	gives a current when connected to lead(II) oxide in an electrolyte (dilute sulphuric acid)
zinc	protecting steel from rusting	offers sacrificial protection
	coating or **galvanising** iron and steel	resists corrosion, offers sacrificial protection if coating cracks
	for torch batteries	gives a current when connected to a carbon electrode, in an electrolyte
silver	electrical connections inside mobile phones, keyboards, and photovoltaic (PV) cells	the best metal of all at conducting electricity, ductile
	mirrors, and mirrored sunglasses	reflects light very well, even in a very thin coat
	jewellery	looks good, and resists corrosion
titanium	tooth implants, and replacement hip and knee joints	light, strong, very resistant to corrosion, non-toxic, malleable, and ductile
	exhaust pipes for planes	light, very resistant to corrosion, ductile, high melting point
	pipes and tanks in chemical factories	strong, very resistant to corrosion

Steel and other alloys

An alloy is a mixture of metals that changes there properties or increase them. Turing a metal into an alloy increases its range of uses.

Pure iron is too soft and stretches easily and rusts.

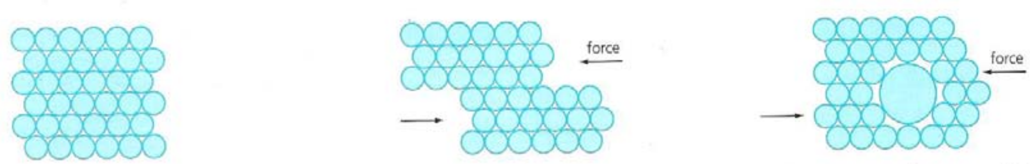
When carbon (0.5%) is mixed with it, the result is mild steel. This is hard and strong.

Uses of mild steel (MUST KNOW): buildings, ships, car bodies and machinery

When nickel and chromium are mixed with iron, the result is stainless steel. This is hard and rustproof.

Uses of stainless steel (MUST KNOW): car parts, kitchen sinks and cutlery.

Why an alloy has different properties



This shows the atoms in a pure metal. They are arranged in a regular lattice. (In fact they are metal ions in a sea of electrons, as you saw on page 52.)

When pressure is applied, for example by hammering the metal, the layers can slide over each other easily. That is why a metal is malleable and ductile.

But when the metal is turned into an alloy, new atoms enter the lattice. The layers can no longer slide easily. So the alloy is stronger than the original metal.

Making steels

This is how steels are made:

1. **First, unwanted impurities are removed from the iron.**

The molten iron from the blast furnace is poured into an oxygen furnace. Calcium oxide is added, and a jet of oxygen is turned on. The calcium oxide neutralizes any acidic impurities, forming a slag that is skimmed off. The oxygen reacts with the others burning them away.

2. **Then other elements may be added**

This is measured out carefully, to give steels with the required properties.

Alloy	Made from	Special properties	Uses
stainless steel	70% iron 20% chromium 10% nickel	does not rust	car parts, kitchen sinks, cutlery, tanks and pipes in chemical factories, surgical instruments
aluminium alloy number 7075 TF	90.25% aluminium 6% zinc 2.5% magnesium 1.25% copper	light but very strong	aircraft
brass	70% copper 30% zinc	harder than copper, does not corrode	musical instruments, ornaments, door knobs and other fittings
bronze	95% copper 5% tin	harder than brass, does not corrode, chimes when struck	statues, ornaments, church bells

Look at the alloy of aluminium above. Aircraft need materials that are light but very strong, and resistant to corrosion. Pure aluminium is light, but not strong enough. So *hundreds* of aluminium alloys have been developed, for aircraft parts.

Corrosion

Corrosion is when a metal is attacked by air, water, or other substances in its surroundings, the metal is said to corrode.

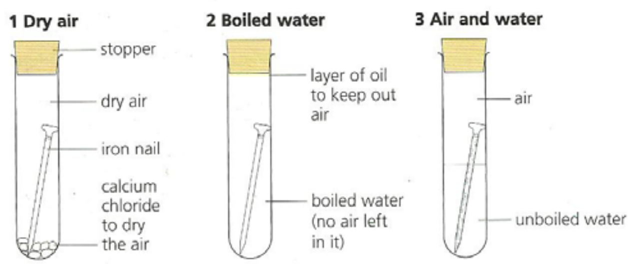
The more reactive a metal is, the more readily it corrodes.

What does rusting involve?

Rusting needs both air and water, as these tests show

What does rusting involve?

Rusting needs both air and water, as these tests show.



Nails 1 and 2 do not rust. Nail 3 does. The iron is oxidised, like this:

$$4Fe\,(s) + 3O_2\,(g) + 2H_2O\,(l) \rightarrow 2Fe_2O_3.H_2O\,(s)$$

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

How to prevent rusting

1. Coat the metal with something to keep out air and moisture.

You could use:

- **Paint**
- **Grease**
- **Plastics**
- **Another metal**. For example:

Zinc: by dipping iron into molten zinc. This is called **galvanizing**.

Tin: deposited on the steel by electrolysis, in a process called **tin plating**.

Chromium: coating with chromium. The **chromium** is deposited by electrolysis.

2. Use sacrificial protection

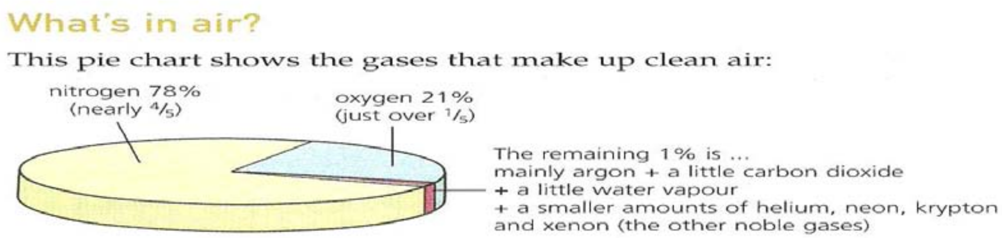
This is when a more reactive metal is attached to the metal and it corrodes instead of the steel. This is called **sacrificial protection**.

Does aluminum corrode?

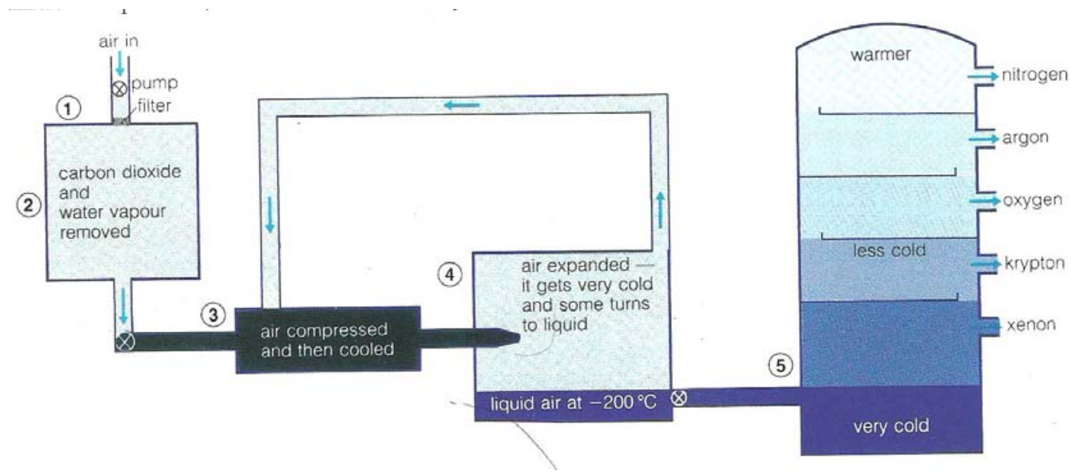
No, because a coat of aluminum oxide forms on the aluminum which acts as a seal preventing corrosion.

Unit 14: *Air and water*

Air is a mixture of gases.



These can be separated by fraction distillation. This works because the gases in air have different boiling points.



Uses of oxygen

1. In hospitals

People with breathing problems are given oxygen through oxygen tanks covering the nose and mouth, they also use oxygen tents.

2. Welding metals

A mixture of oxygen and ethanol is used in oxy-acetylenes torches for that are used in welding metals.

Air pollutants

The main air pollutants

This table shows the main pollutants found in air, and the harm they do:

Pollutant	How is it formed?	What harm does it do?
Carbon monoxide, CO colourless gas, insoluble, no smell	Forms when the carbon compounds in fossil fuels burn in too little air. For example inside car engines and furnaces.	Poisonous even in low concentrations. It reacts with the **haemoglobin** in blood, and prevents it from carrying oxygen around the body – so you die from oxygen starvation.
Sulphur dioxide, SO_2 colourless acidic gas, sharp smell, soluble	Sulphur occurs naturally in the fossil fuels (mainly in coal and oil) and forms sulphur dioxide when it burns.	Irritates the eyes and throat, and causes **respiratory** (breathing) problems. Dissolves in rain to form **acid rain** (page 123), which damages buildings, trees, and plants, and kills fish and other river life.
Nitrogen oxides, **NO and NO_2** acidic gases	Form when the nitrogen and oxygen in air react together inside hot car engines, and in hot furnaces.	Cause respiratory problems. Dissolve in rain to form acid rain.
Lead compounds	A compound called tetra-ethyl lead was added to petrol to help it burn smoothly in engines. On burning, it produced particles of other lead compounds, mainly lead halides such as $PbBrCl$.	Lead damages children's brains. It damages the kidneys and nervous system in adults.

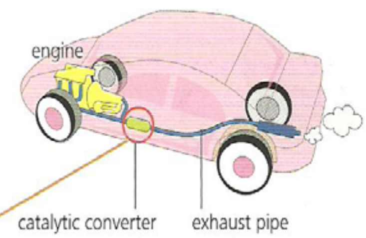
Ways to reduce pollution

- Use less fossil fuels
- Switch to clean sources of power
- Try to find ways to store CO^2 and not let it escape to the atmosphere

Catalytic converters

A exhaust pipe is a pipe where waste gases are disposed off. In it, harmful gases are present:

- oxides of nitrogen (NO and NO_2), which form when nitrogen and oxygen from the air react in the hot engine. These cause acid rain.
- carbon monoxide, CO, which forms when carbon compounds burn in insufficient oxygen. It is poisonous.
- unburnt hydrocarbons from the petrol. These can cause cancer.

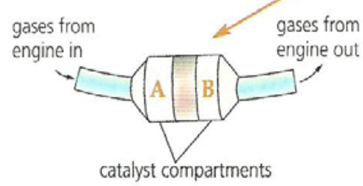


To tackle this problem, modern car exhausts contain a **catalytic converter**. In this, the harmful gases are adsorbed onto catalysts, and react to produce harmless gases. The converter usually has two catalyst compartments, marked A and B below.

In A, harmful compounds are **reduced**. For example:

$2NO\ (g) \longrightarrow N_2\ (g) + O_2\ (g)$

The nitrogen and oxygen from this reaction then flow into B.



In B, harmful compounds are **oxidised**, using the oxygen from A. For example:

$2CO\ (g) + O_2\ (g) \longrightarrow 2CO_2\ (g)$

The harmless products then flow out the exhaust pipe.

The usual catalysts are the transition metals platinum, palladium, and rhodium. They are coated onto a ceramic support. This is in the form of beads, or a honeycomb, to give a large surface area for adsorbing the gases. The harmless products flow out the exhaust pipe.

Water

Uses of water:

- At home for drinking, cooking, washing things and flushing toilet waste away.
- On farms it is needed as a drink for animals, and to water crops.
- In industry, they use it as a solvent, and to wash things, and to keep hot reaction tanks cool.
- Power stations use it to make steam. The steam then drives the turbines that generate electricity.

Purifying water

1 Find a clean source – a river or aquifer – to pump water from.

↓

2 Remove as many solid particles from the water as you can.
- You could make fine particles stick together and skim them off.
- You could filter the water through clean gravel or sand.

↓

3 Add something to kill the microbes in it. (Usually chlorine.)

↓

4 Store the water in a clean covered reservoir, ready for pumping to taps.

Chemical tests for water

1. It turns white anhydrous copper(II) sulphate blue.
2. It turns blue cobalt chloride paper pink.

Unit 17: *Organic chemistry*

Organic chemistry is a branch of chemistry connected with compounds of hydrogen and carbon (hydrocarbons).

Hydrocarbons

It is a class containing only hydrogen and carbon bonded together covalently. They can form very long chains, and can form chains linked by one double bond or triple bond. Hydrocarbons are devided into two groups **Alkanes C-C** & **Alkenes C=C**

Naming of organic substances

1C -> meth	3C -> prop	5C -> pent	7C-> hept
2C -> eth	4C -> but	6C -> hex	8C -> hex

Alkanes

General molecular formula = $C_n H_{2n+2}$

The alkanes are a homologus series which means that all of the compound have the same

- functional group
- same general formula
- same chemical properties
- show a gradual change in chemical properties
- Khalid mafee zeb