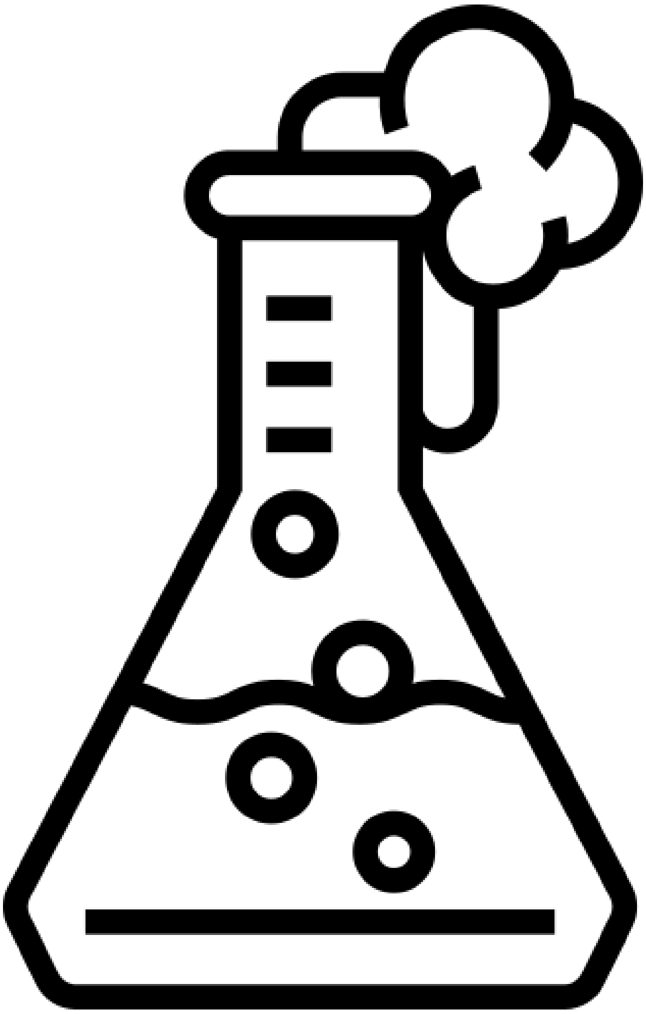
The Science Doctor KS3 Chemistry Workbook



Dr Peter Edmunds

Introduction

This is the free version of the Science Doctor KS3 Chemistry workbook. It contains the majority of the content within the paid for version, just without the answers. This is also a "draft" version and will not receive extensive proofreading and ongoing corrections.

I originally started the site sciencedoctor.school.blog to support teachers in their planning and workload. Since then, the support I have received has allowed me to turn the site into something much bigger and, somehow, nearly a million resource downloads have now occurred on the site. "Buy me a coffee" donations have made my hobby of writing a little more financially feasible and, frankly, this workbook wouldn't exist without them.

With physics & chemistry now written, I turn my eye slowly to Biology. If you would like to support my ongoing work then do consider donating or purchasing a physical copy of either of my Chemistry or Physics KS3 workbooks. The physical copies come with the benefit of including answers (and those who know me will know how much I really don't enjoy writing answers!). "Buy me a coffee" links can be found on the sciencedoctor.school.blog website.

This workbook is not yet fully proofread. It absolutely will contain some mistakes at this stage. If you do encounter a genuine mistake then please report it to @edmunds_dr on X /twitter.

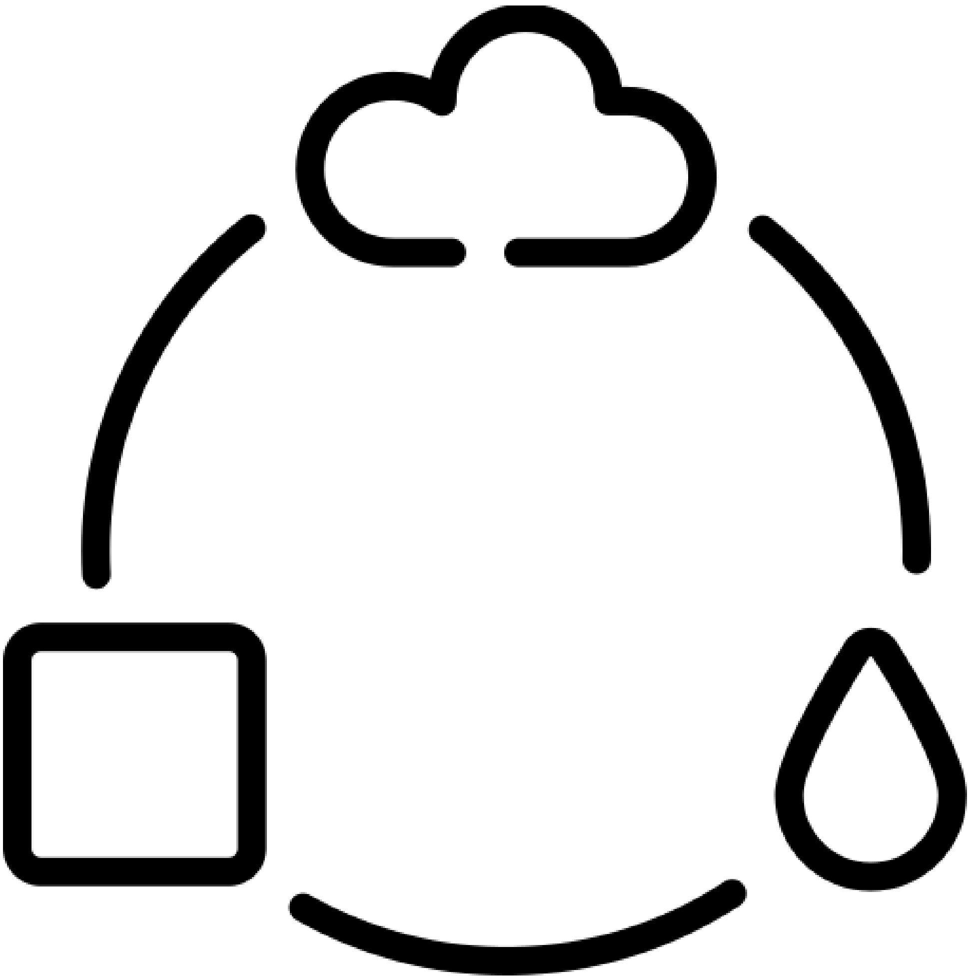
Thanks & I hope you find the resources in this workbook useful.

Peter Edmunds

Contents

Tick each ☐ once the topic is completed.

The particle

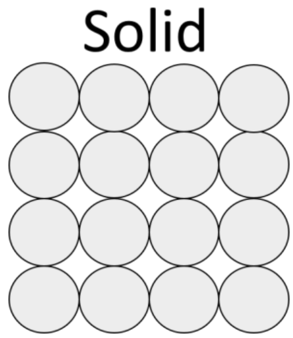


model

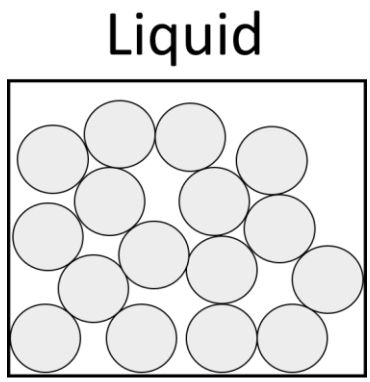
Solids, liquids and gases

All matter is made of **particles**. Depending on the substance, the particles could be **atoms** or **molecules**.

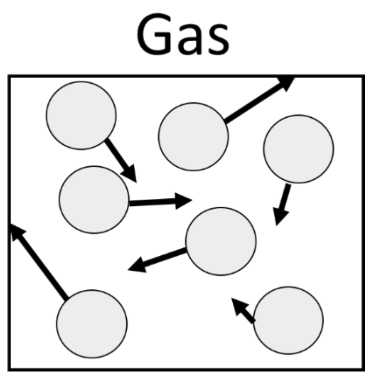
The three **states of matter** are **solid**, **liquid**, and **gas**. They all have different properties due to the arrangement and movement of their particles.



Solids have particles that are held tightly together, this means that they are **dense**. The particles are arranged in a regular pattern and **vibrate around fixed positions.** Solids have a definite shape and volume and **cannot be compressed** easily because the particles are already packed closely together. Solids have the least amount of energy.



In a **liquid** the particles are held closely together but the particles can also move past each other. This means that a liquid has a changing shape and can **flow**. Liquids are **dense** and **cannot be compressed** easily. A liquid can change its shape but not its volume.



There are only **very weak forces** between **gas** particles, which are far apart. Because of this gases can be **compressed**, and so they have no fixed volume. The particles move around quickly in random directions, at a range of different speeds. They cause pressure when they collide with the walls of a container. Gases have a **low density** and they do not have a fixed shape or volume. Gases have the most energy. As you heat a gas, the particles move more quickly.

While solids are usually the most dense state of matter; water and ice are an exception. Water (a liquid) is more dense than ice (a solid). That’s why ice cubes float in a drink.

Q1. In the spaces below, draw the particle arrangement for solids liquids and gases.

Solids	**Liquids**	**Gases**

Q2. Name the state of matter that can be compressed. ....

Q3. Name the state of matter that can change its shape but not its volume. ....

Q4. Name the state of matter that has no fixed volume. ....

Q5. Name the state of matter that has a low density. ....

Q6. Name the state of matter that has particles that vibrate around fixed positions. ....

Q7. Name the state of matter that is used in hydraulics. ....

Q8. Name the state of matter that has particles that flow but are still close together. ....

Q9. State what happens to the speed of gas particles when the temperature of a gas is increased.

....

Q10. Describe the movement of gas particles.

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....

Q11. Describe how the particle arrangement changes as a material changes from a solid into a liquid.

....

....

....

....

Q12. Describe how the particle arrangement changes as a material changes from a liquid into a gas.

....

....

....

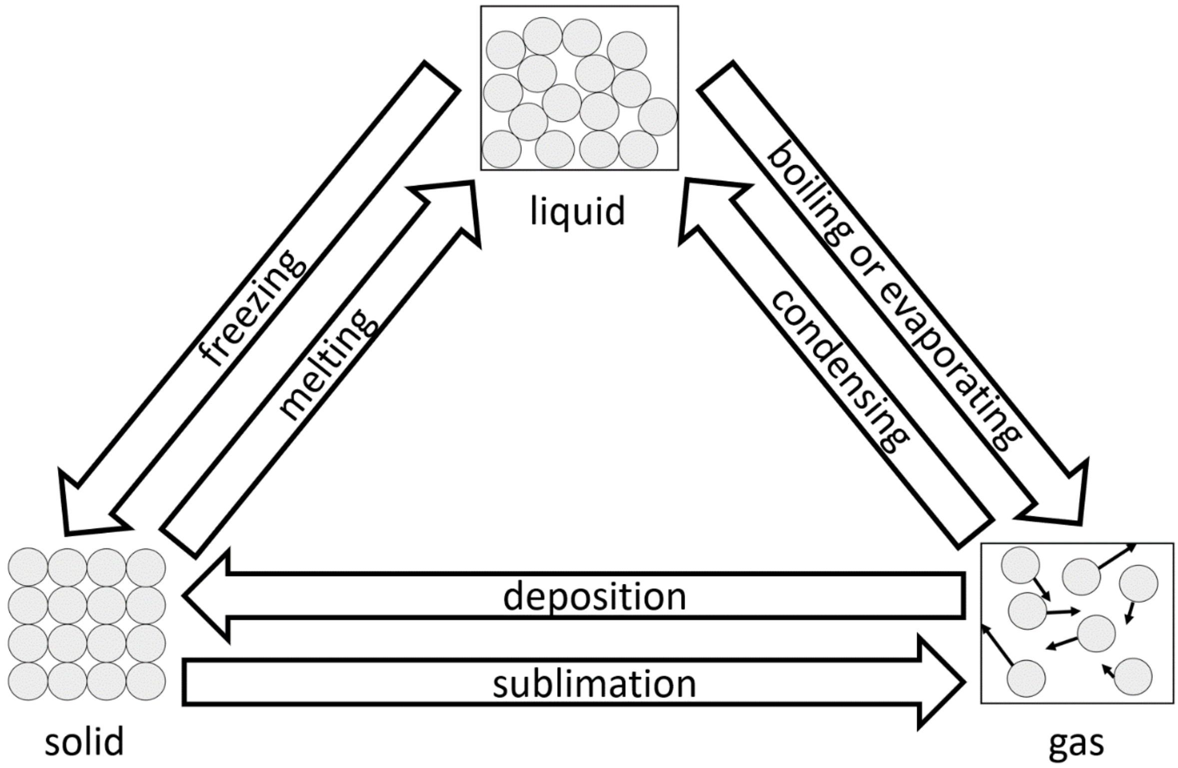
....

Q13. State the reason why ice cubes float in water.

....

Changes of state

As the temperature of particles changes, they **change state**. In the process of changing state, the overall number of particles stays the same. This means the mass before a state change is the same as the mass after a state change. This is called the **conservation of mass**. The different state changes are shown in the diagram below:



A **solid** has particles that are held together in a regular pattern. The particles vibrate around their fixed positions. As the solid is heated, these vibrations increase until it reaches its **melting point**. One example of a melting point is that of water at 0°C.

While the solid is melting, it stays at the same temperature. The particles start to be freed from their fixed positions until they are free to move past each other. Particles are still in contact. When the process of melting is complete, all the particles are in the **liquid** state.

If we continue heating the liquid, the particles again move more quickly. When the liquid reaches its **boiling point**, it starts boiling and turning into a **gas**. Here, the particles are moving quickly enough so they separate from one another. Particles in a gas are far apart and move around quickly in random directions. One example of a boiling point is that of water at 100°C.

When a gas is cooled to its boiling point, it **condenses** into a liquid. If a liquid is cooled to its melting point, it **freezes** to form a solid.

If cooled enough, gases can also undergo **deposition** so they are turned directly into a solid. If heated enough, solids can undergo **sublimation** so they are turned directly into a gas.

Q1. During a state change, mass is conserved. Describe what conservation of mass means.

....

....

Q2. Name the state change in going from solid to liquid. ....

Q3. Name the state change in going from gas to liquid. ....

Q4. Name the state change in going from liquid to gas. ....

Q5. Name the state change in going from gas to solid. ....

Q6. Name the state change in going from solid to gas. ....

Q7. Name the state change in going from liquid to solid. ....

Q8. State the melting point of water. ....

Q9. State the boiling point of water. ....

Q10. Describe the particle arrangement in a solid.

....

....

Q11. Describe the particle arrangement in a gas.

....

....

Q12. The following statements are either true or false. State which are true and which are false.

a) As a solid melts, the temperature increases.

....

b) As a gas is heated, the particles move more quickly.

....

c) Regardless of temperature, particles in a solid vibrate the same amount.

....

d) If particles in a liquid evaporate into a gas, the gas has less mass than the liquid.

....

Q13. Some water is at a temperature of −10°C. State which state of matter the water is in. Explain why.

....

Q14. Some water is at a temperature of 200°C. State which state of matter the water is in. Explain why.

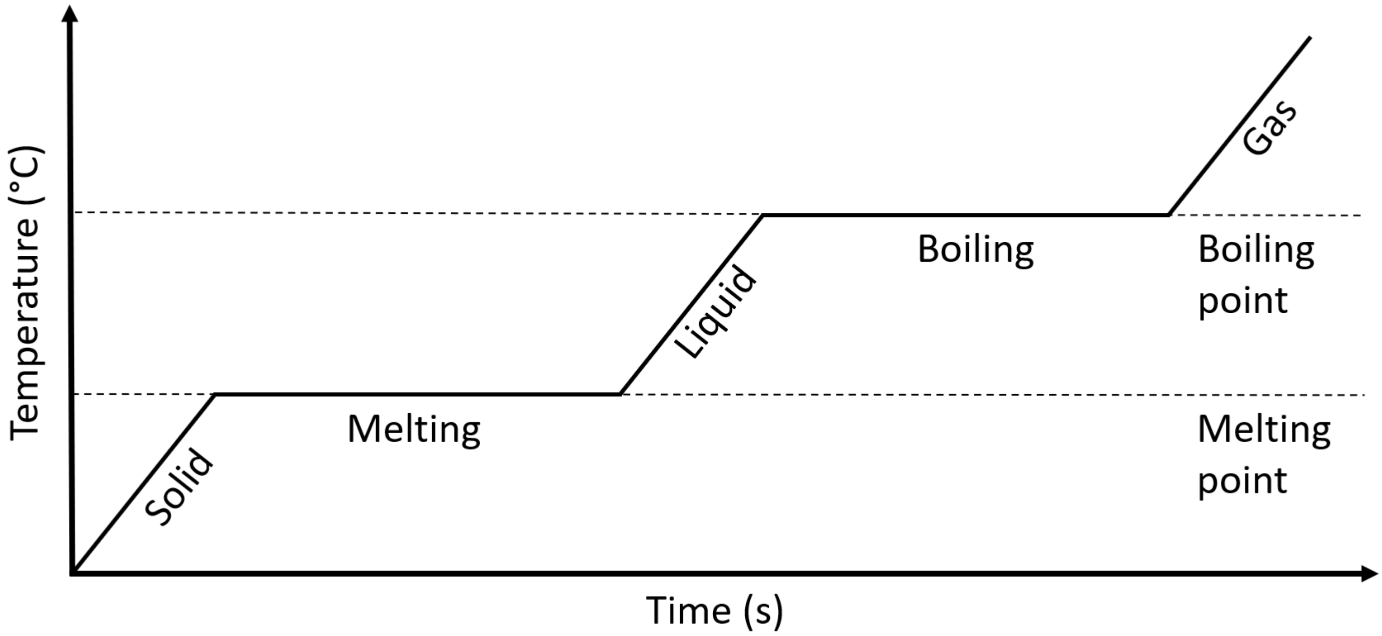
....

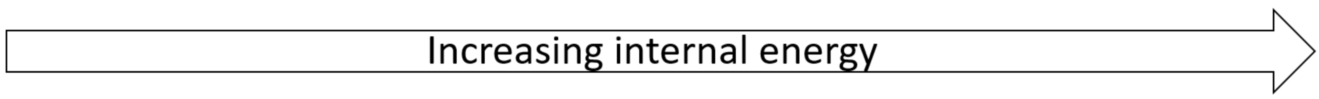
Q15. Some water is at a temperature of 50°C. State which state of matter the water is in. Explain why.

....

Heating and cooling curves

The graph below shows the heating curve of a **pure** substance. A pure substance is made from only one element or compound. Note how the temperature of the substance remains constant during a state change.





As thermal energy is transferred to the substance, the **internal energy** of the particles in the substance increases. The internal energy consists of the **kinetic energy** and **potential energy** stores of the particles.

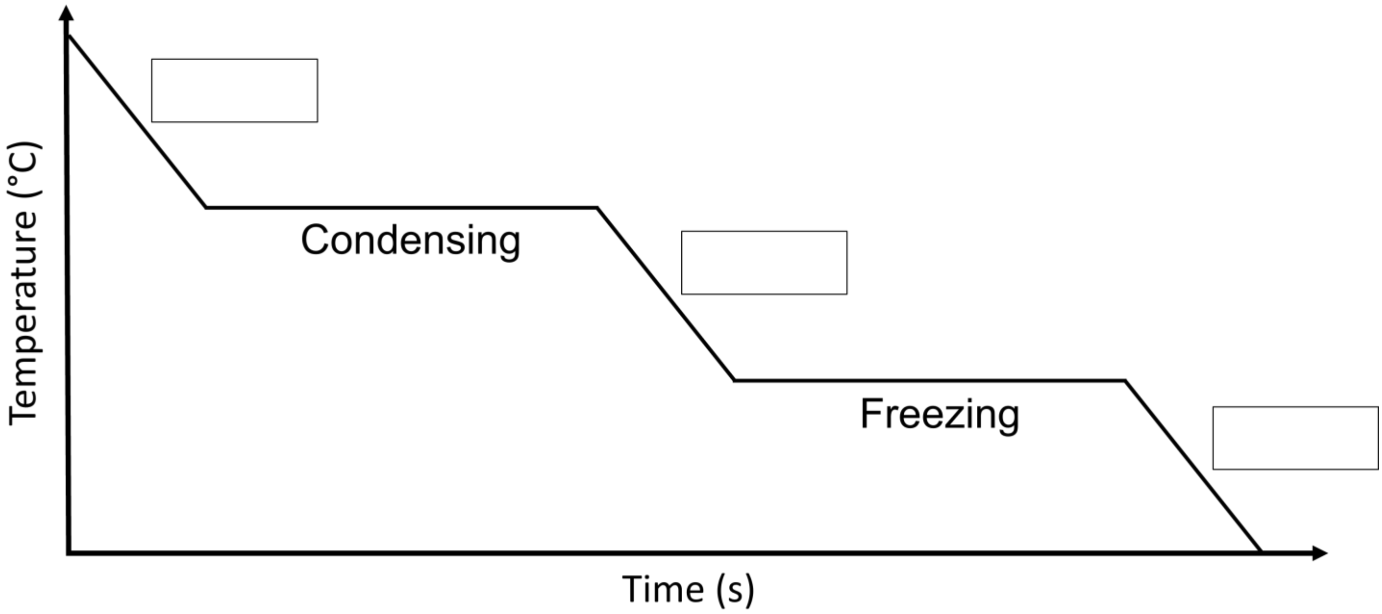
While the substance is increasing in temperature, the kinetic energy store of the particles in the substance increases. As a solid increases in temperature, the vibrations of the particles in the solid increase.

Eventually, the solid start melting. During this time, some bonds are broken but the temperature remains constant. The potential energy store of the particles in the substance increases. The thermal energy supplied to the material is called "latent" here. Latent comes from the Latin for "hidden".

Similar happens with liquids and gases. As a liquid or gas increases in temperature, particles move more quickly and their kinetic energy store increases. As a liquid is boiled, bonds are broken and the potential energy store of particles increases.

An **impure** substance contains more than one element or compound. We could also say the substance contains **impurities**. For an impure substance, there is not a single temperature for melting and boiling. Instead, this happens over a range of temperatures.

Q1. The diagram below shows the cooling curve of a pure substance. Label the three states of matter that are missing from the diagram.



Q2. Describe what a pure substance is.

....

....

Q3. Describe what happens to the motion and kinetic energy of gas particles as they cool.

....

....

Q4. Describe what internal energy is.

....

....

Q5. Describe what an impure substance is.

....

....

Q6. Describe how the heating curve for an impure substance is different to that of a pure substance.

....

....

Q7. Describe why the temperature of a pure substance stays constant while it melts.

....

....

Q8. State what happens to the internal energy of a substance as it increases in temperature.

....

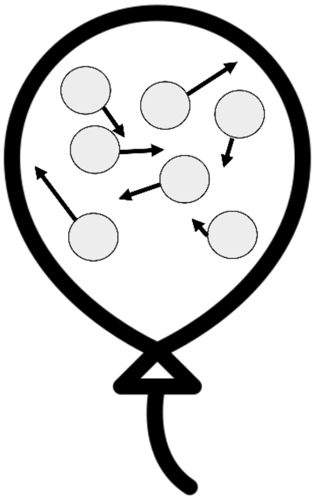
Pressure in gases

Particles in a gas move **in random directions** and at a range of different speeds.

We know this because of something called **Brownian motion**. In 1827, Robert Brown (which Brownian motion is named after) noticed that pollen particles moved around in a random way. Smoke particles move in a similar way in air. This is because of collisions with air particles that are moving in random directions and at a range of different speeds.

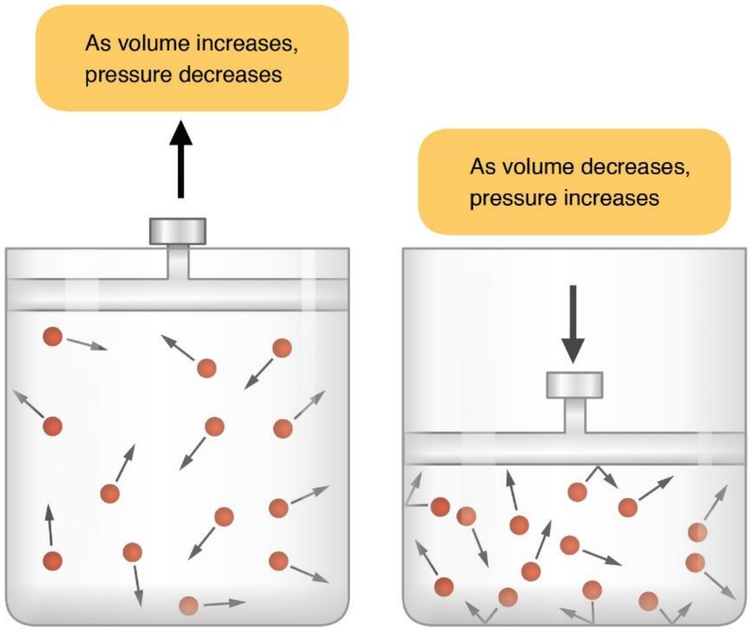
While the smoke particles are much larger than the air particles, the air particles are moving much faster and so they affect how the smoke particles move when they collide.

When a gas particle collides with a surface, **pressure** is exerted on that surface.



The reason balloons get bigger when you blow them up is because you are adding air into the balloon.

More air means **more particles** inside the balloon. In turn, this leads to **more collisions** between air particles and the walls of the balloon. More collisions cause a **higher force** on the walls, which then leads to a **higher pressure**. This makes the balloon **expand**.



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If we reduce the volume of a container, a similar thing happens. This is shown in the diagram to the left.

If the volume of a container is reduced, gas particles collide with the walls of the container more often.

This leads to a higher force on the walls of the container, and therefore a higher pressure.

If we increase the temperature of a gas in a container, the **kinetic energy** and speed of the gas particles also increase. This also means the gas particles collide with the walls of the container more often (again leading to a higher force and a higher pressure on the walls of the container). This is why a balloon expands if we heat it.

Q1. Smoke particles are observed to move in a random way in air. State the name of this process and explain why this happens.

....

....

Q2. Air is being pumped into a balloon.

a) State what happens to the number of air particles inside the balloon.

....

b) State what happens to the number of collisions between the air particles and the walls of the balloon.

....

c) State what happens to the force exerted by the air particles on the walls of the balloon.

....

d) State what happens to the pressure inside the balloon.

....

e) State what happens to the size of the balloon.

....

Q3. Some gas is inside a container. The volume of the container is slowly increased.

a) State what happens to the force exerted by the air particles on the walls of the container.

....

b) State what happens to the pressure inside the container.

....

Q4. State what happens to the average speed of gas particles as the temperature of the gas is increased.

....

Q5. Two containers have the same amount of gas particles inside them. Container A is smaller than container B. State and explain which container has the higher pressure.

....

....

Q6. Two containers have the same amount of gas particles inside them. Container A is at a lower temperature than container B. State and explain which container has the higher pressure.

....

....

Q7. A balloon is cooled. State and explain what happens to the size of the balloon.

....

....

Diffusion

Particles in liquids and gases move with a **random motion**. Particles in a liquid are in contact with each other and free to flow past each other. Particles in a gas are separate from one another and move quickly in random directions at a range of speeds. We also know that this causes **Brownian motion**.

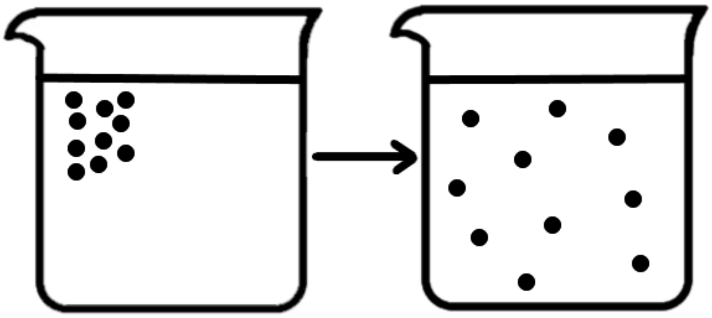
Diffusion happens in fluids (liquids and gases). Diffusion is the movement of particles from a high concentration (of those particles) to a lower concentration.

The diagram below shows some dye being introduced to a glass of water. Because the water particles are moving in random directions, this leads to diffusion of the dye.

Immediately after the dye has been dropped it is at a high concentration in that area. Diffusion means that particles move from this high concentration to the surrounding areas (where there is a low concentration). Eventually the dye is evenly spread throughout the water.

BruceBlaus, CC BY 3.0, via Wikimedia Commons

The diagram to the right also shows the initial and final stages in terms of particles. If we leave the water and dye for long enough then the dye particles are evenly distributed throughout the water.



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If we wanted to speed this process up, then we could heat the water. Particles move faster in a hotter liquid or gas. Therefore diffusion would also be faster. We could also speed up diffusion by stirring the liquid.

Q1. The following statements are either true or false. State which are true and which are false.

a) In diffusion, particles move from a low concentration to a high concentration.

....

b) Diffusion happens at the same rate, regardless of the temperature of the liquid.

....

c) Diffusion happens only in liquids.

....

d) Diffusion in a liquid can be sped up by stirring the liquid.

....

Q2. Describe how particles move in liquids.

....

....

Q3. Describe how particles move in gases.

....

....

Q4. Describe what diffusion is.

....

....

Q5. State what happens to the average speed of particles in a liquid as the temperature of the liquid is increased.

....

Q6. Two beakers are full of water. Some red dye is dropped in each. Beaker A contains water at 20 °C, Beaker B contains water at 50 °C. State and explain in which beaker diffusion will be fastest.

....

....

Q7. Some deodorant is sprayed in a room. Explain how the deodorant spreads throughout the room.

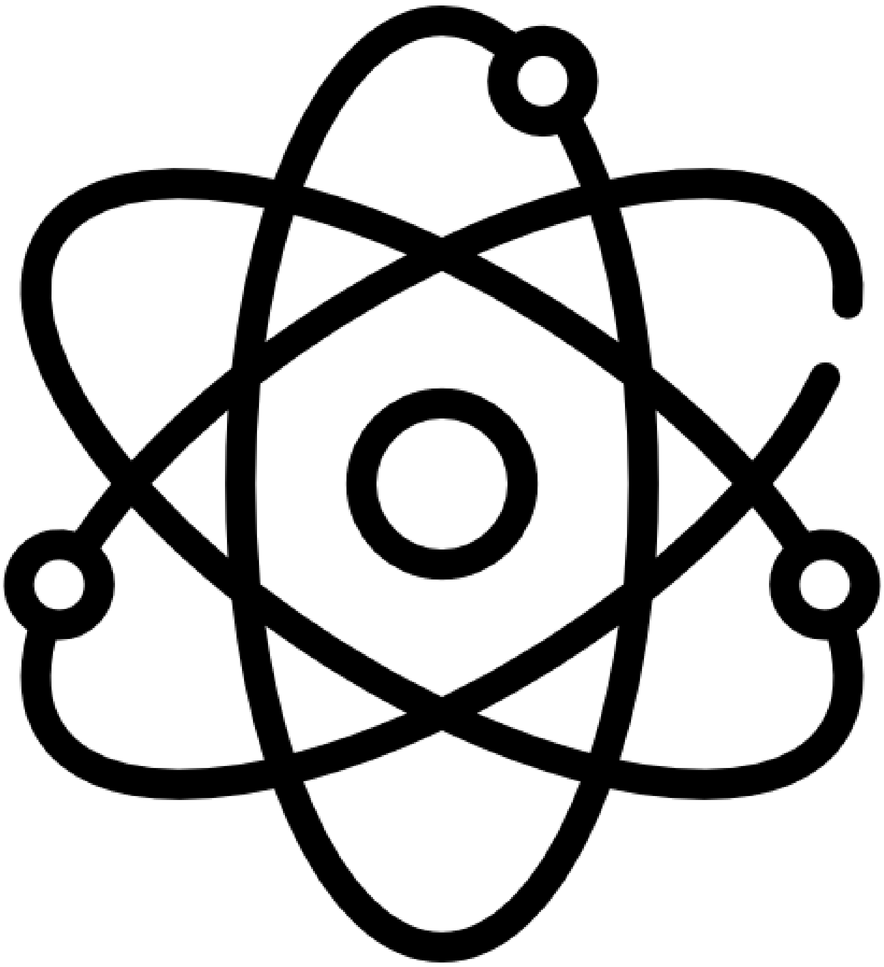
....

....

Q8. A fan is on in the same room. State what this would do to the rate of diffusion.

....

Atoms, elements



and compounds

The atom

We have already learnt about the **particle model**, where matter is made of particles. This is one example of a **scientific model**.

Scientific models are usually simplified versions of an object or a phenomenon. This makes them easier to understand, while still representing the key features.

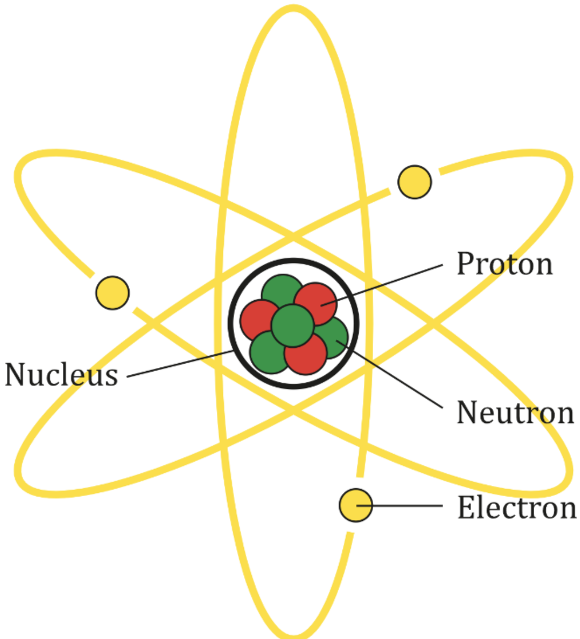
The particle model is used to explain and predict the behaviour of solids, liquids and gases. This is a simplification, as we know that particles are made of atoms and molecules (which, in turn, consist of smaller parts).

Models are also changed and updated over time, and the atomic model is one example of this. Previously, it was thought that atoms were indivisible (could not be broken down into anything smaller). This is the **Dalton model** of the atom.

However, newer evidence from experiments suggested the atom was made of **sub-atomic particles**. They are called sub-atomic because they are smaller than the atom itself.

In the current model of the atom, there are three subatomic particles:

1. **Protons**. These have a positive charge and are contained in the centre of atom. The centre of the atom is called the **nucleus**.
2. **Neutrons** are also contained in the nucleus, but neutrons are neutral. Something that is neutral has no charge.
3. **Electrons** orbit around the nucleus. They have a negative charge.



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Most of the mass of an atom is contained in the nucleus, with neutrons and protons having around 2000 times more mass than an electron.

Overall an atom is **neutral** as there are equal numbers of electrons and protons.

Generally, evidence is required to change a scientific model. New evidence and research go through a process called **peer review**.

Peer review is when other scientists look at the new evidence and decide whether or not it is valid. This is important as otherwise incorrect models and theories could be spread. After peer review, new research can be published. After this, other scientists may decide to try and **reproduce** the research to check whether the results are repeatable.

Q1. Describe the Dalton model of the atom.

....

....

Q2. The following questions are asking about the current model of the atom.

a) Describe where the nucleus of an atom is.

....

b) Name the two sub-atomic particles that are in the nucleus.

....

c) Name the sub-atomic particle that orbits around the nucleus.

....

d) State the charge on a proton.

....

e) State the charge on an electron.

....

f) State the charge on a neutron.

....

g) Name the sub-atomic particle that has the least mass.

....

Q3. Describe what a scientific model is.

....

....

Q4. Describe an advantage of using scientific models.

....

....

Q5. Describe what peer review is.

....

....

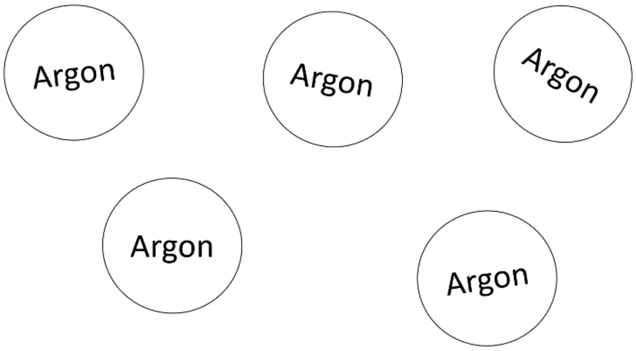
Q6. Describe the difference between the Dalton model and the current model of the atom.

....

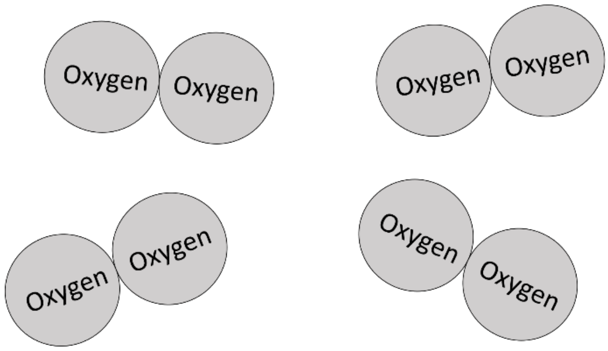
....

Elements, compounds and mixtures.

An **element** is made from only one type of **atom**. There are over 100 known elements and they are listed on the **periodic table**. For example, argon and oxygen are both elements as they both contain only one type of atom.

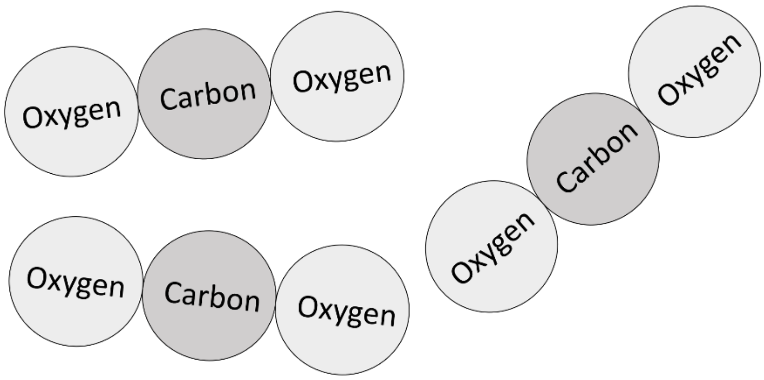


Here, we have the element argon. We know that we have an element because there is only one type of atom.



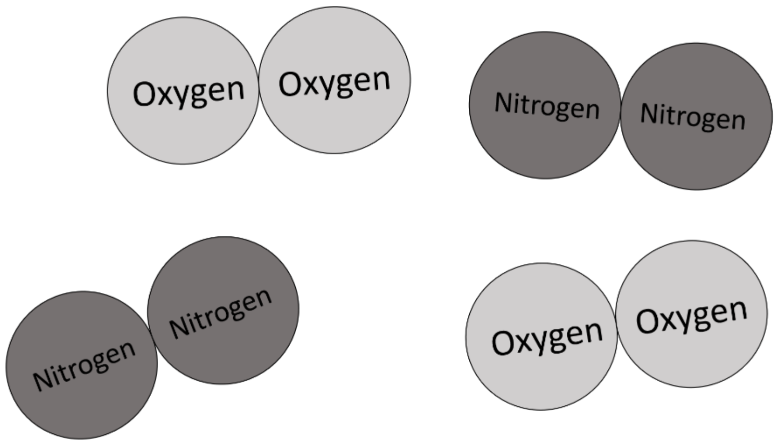
Here, we have the element oxygen. Oxygen is a diatomic gas as it contains two atoms that are chemically joined. A monatomic gas contains only single atoms that are not chemically joined.

A **compound** is a substance where two or more atoms (of different elements) are **chemically joined**. For example, carbon dioxide is a compound as it contains the elements carbon and oxygen.



Carbon dioxide is a compound; it has two different types of atom that are chemically joined.

A **mixture** is a substance that contains two or more elements or compounds that are not chemically joined together. For example, nitrogen gas mixed with oxygen gas is a mixture of elements. Carbon dioxide mixed with carbon monoxide is a mixture of compounds.



Here we have a mixture of two different elements; nitrogen and oxygen.

Q1. Describe what an element is.

Q2. Describe what a compound is.

Q3. Describe what a mixture is.

Q4. Below is a list of substances. State which are elements and which are compounds.

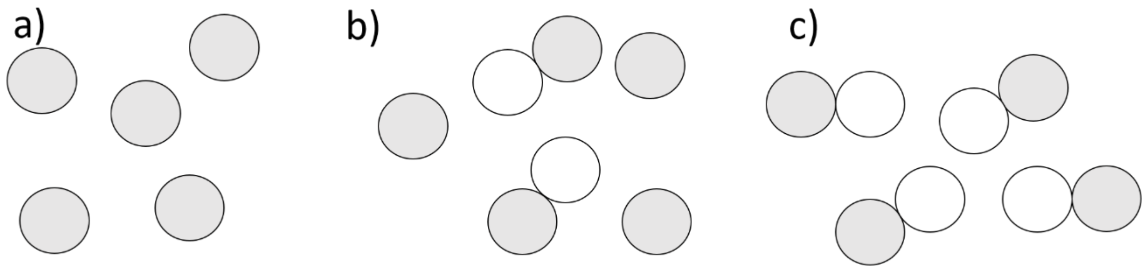
Iron	Iron Oxide	Nitrogen	Oxygen
Carbon dioxide	Aluminium	Hydrochloric acid	Water

Elements:

Compounds:

Q5. For the compounds you've listed in Q4. State what elements each compound contains.

Q6. Below are diagrams of three different substances. State which is an element, which is a compound and which is a mixture.

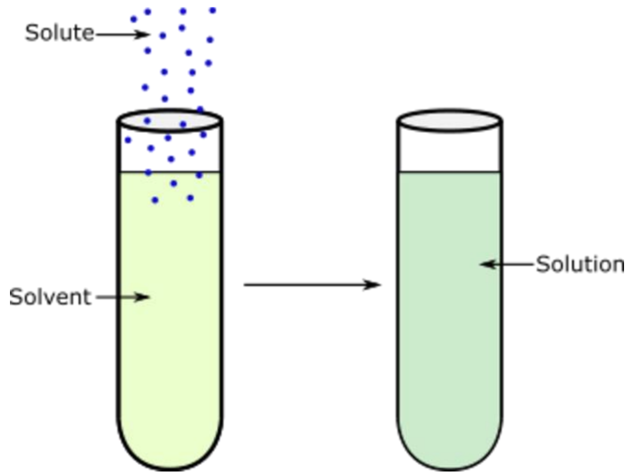


Q7. Describe the difference between an element and a compound.

Q8. Describe the difference between a compound and a mixture.

Making and separating solutions

If we add a sugar cube to water, the sugar **dissolves**. It looks like the sugar has disappeared, but the particles are just mixed in with the water.



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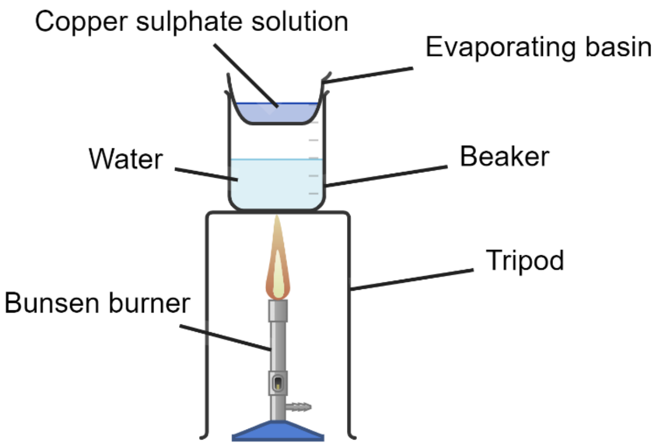
To make the sugar dissolve faster, we could heat the water and stir it.

A substance that dissolves is called the **solute**, while something that dissolves other substances is called a **solvent**.

In the example above, sugar is the solute and water is the solvent. Once a solute is dissolved in a solvent, a **solution** is formed.

If a substance can dissolve, it is called **soluble**. If it is not able to dissolve it is **insoluble**. While salt dissolves in water, sand does not. Sand is insoluble in water.



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To separate out a solute we can use a setup like that in the diagram to the left. Here, we are trying to obtain copper sulphate crystals from the solution.

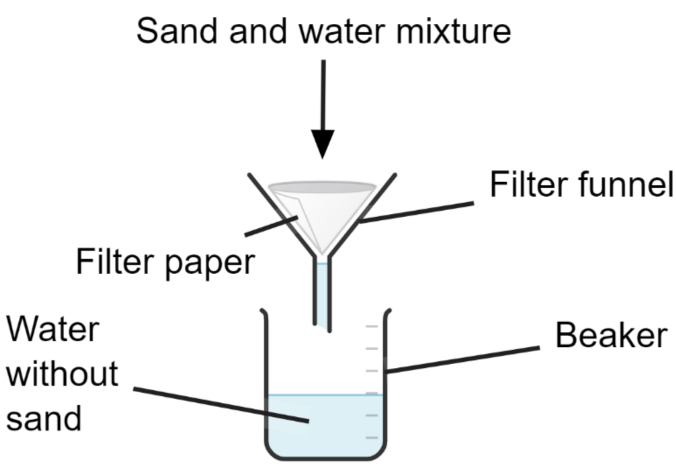
The solution is poured into an evaporating basin and gently heated. When some of the solvent has evaporated, the solution is removed from the heat.

Eventually, copper sulphate crystals are formed as the solvent evaporates.

Because sand is insoluble in water, this method cannot work for a sand and water mixture.

Instead, we use **filtration**. The sand and water mixture is poured onto some filter paper.

Because the water molecules are smaller than the sand particles, water passes through the filter funnel but the sand doesn't. Therefore, we can separate the water and sand.



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Q1. The following statements are either true or false. State which are true and which are false.

a) Sand is soluble in water.

....

b) Salt is soluble in water.

....

c) Sugar dissolves faster in hot water than it does in cold water.

....

d) You can filter out the salt from a saltwater solution by passing the solution through filter paper.

....

Q2. In fizzy drinks, the bubbles are caused by carbon dioxide. The carbon dioxide is initially dissolved in the water.

a) State the solute.

....

b) State the solvent.

....

Q3. Describe what the word soluble means.

....

Q4. Describe what the word insoluble means.

....

Q5. State two ways of making salt dissolve faster in water.

....

Q6. Describe how you would separate sand from a sand and water mixture.

....

....

....

Q7. Describe how you would separate sugar from a sugar and water solution.

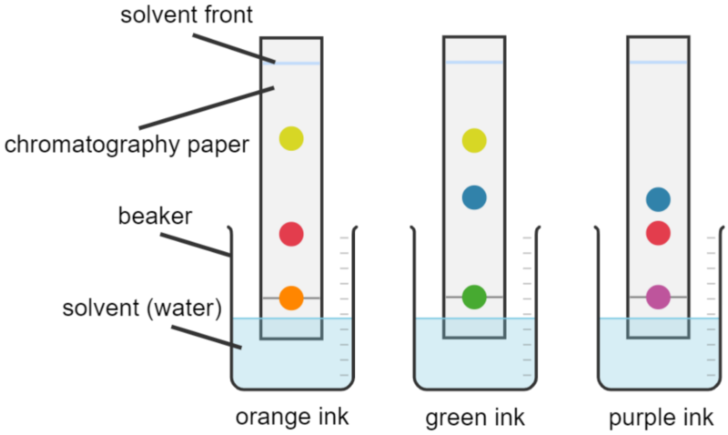
....

....

....

Chromatography and distillation

Chromatography allows us to separate different substances in a mixture. For example, the diagram to the right shows three inks undergoing chromatography.



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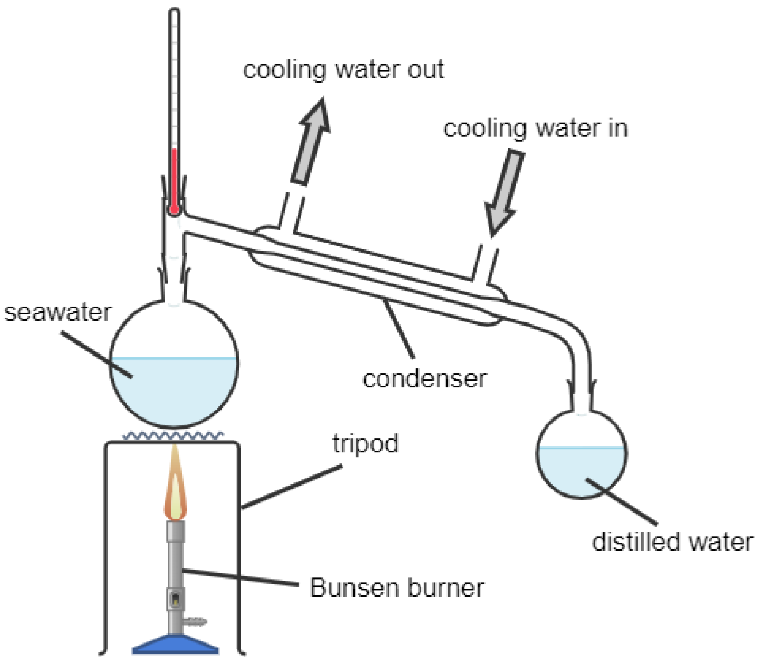
Here, a spot of ink is placed on **chromatography paper** and the paper is placed in water. The water rises up the paper and acts as a **solvent**. The ink is made of different dyes that are **soluble** in water.

As the water rises, it brings the dyes up the chromatography paper with it. However, different dyes move up the chromatography paper at a different rate. Therefore, the different dyes are separated.

If we look at the diagrams above, we can see that both orange ink and purple ink both have one dye in common. We know this because the dye has risen by the same amount up the chromatography paper.

The green and purple inks also have one dye in common, as do the orange and green inks.



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The apparatus to the left shows **simple distillation**.

Here, a Bunsen burner applies heat to some seawater. The water evaporates, leaving the salt in the seawater behind.

The water vapour then travels through a **condenser** where cooling water passes through.

Because the condenser is cool, it condenses the water vapour. The distilled water can then be collected.

This method can also be used to separate liquids with different boiling points.

Q1. The following statements are either true or false. State which are true and which are false.

a) In chromatography, ink is the solvent.

....

b) In chromatography, the dyes are soluble in water.

....

c) Chromatography allows us to separate different elements in a compound.

....

d) Simple distillation allows us to separate liquids with different boiling points.

....

e) Cooling water is used in a condenser to condense hotter gases.

....

Q2. Name the state change in going from gas to liquid.

....

Q3. Name the state change in going from liquid to gas.

....

Q4. Describe what the word soluble means.

....

Q5. Describe what the word solvent means.

....

Q6. A mixture of liquids undergoes simple distillation. Liquid A has a boiling point of 100°C. Liquid B has a boiling point of 300°C. As the mixture is heated, state and explain which liquid will evaporate and be collected first.

....

....

Q7. Describe how chromatography is used to separate dyes in an ink.

....

....

....

Q8. A student claims that salt can be filtered out of seawater by passing seawater through filter paper. Explain why the student is wrong and describe a correct method for obtaining pure water from seawater.

....

....

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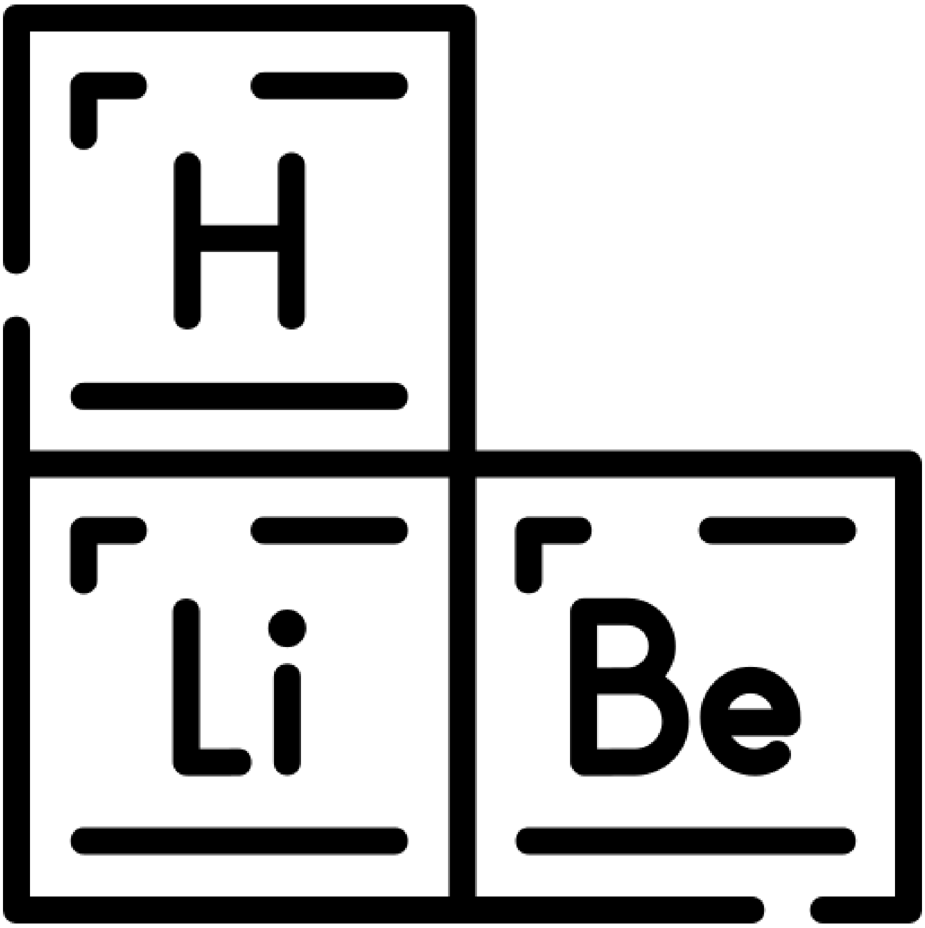
....

The periodic



table

Metals and non-metals

As there are over 100 known elements, it is important to have a written way of organising them that makes finding each element easy.

We now organise elements in the **periodic table** according to their properties and the number of protons in the element (called the atomic number). This means that making predictions about the properties of different elements is easy.

Elements are also categorised as **metals** and **non-metals**. This is because metals and non-metals have different properties to one another.

Properties of metals and non-metals are summarised in the table below:

Properties of metals	Properties of non-metals	Example
Metals are good **electrical conductors**. Good electrical conductors have a low resistance. Resistance is a measure of how hard it is for current to flow through something.	Non-metals are normally poor electrical conductors. A poor electrical conductor is also called an **electrical insulator**. Electrical insulators have a high resistance.	Copper is often used as wires in an electrical circuit. This is because it is a good **electrical conductor**.
If a material is able to conduct heat well, it is a good **thermal conductor**. Metals are good thermal conductors.	Non-metals are often poor conductors. Non-metals are usually **thermal insulators**.	Cooking pans are often made of aluminium as it is a good **thermal conductor**.
Metals are generally **malleable** (easy to make into different shapes), **ductile** (can be drawn out into thin wires) and **strong**.	Non-metals are generally **brittle**.	Steel is often used in construction as it is **strong**. Copper is used in electrical wires as it is **ductile**.
Metals usually have **high melting and boiling points**.	Non-metals often have **low melting and boiling points**. Many non-metals are gases at room temperature.	The melting point of iron is 1500 °C, whereas the melting point of oxygen is -220 °C.

Q1. The following statements are either true or false. State which are true and which are false.

a) Metals are good thermal insulators.

....

b) Metals are good electrical conductors.

....

c) There are over 100 known elements.

....

d) Non-metals are ductile.

....

e) Metals usually have high melting and boiling points.

....

f) Metals are generally brittle.

....

g) The atomic number is the number of neutrons in an element.

....

Q2. Describe what a material being a good electrical conductor means.

....

....

Q3. Describe how the melting point of a metal generally compares to the melting point of a non-metal.

....

....

Q4. State an element that would make a good material for an electrical wire. Give two reasons describing why that element is suitable for that purpose.

....

....

Q5. Describe what the word malleable means.

....

Q6. Describe why cooking pans are made of metals.

....

....

Q7. Describe why we organise elements in the periodic table in groups where elements have similar properties.

....

The periodic table

In early versions of the periodic table, elements were arranged according to their atomic weight. This had some problems, though, as the order of the atomic weights did not align with the order of the properties of the elements.

In 1869, Dmitri Mendeleev made several changes to this arrangement. He put elements together in groups where elements had the same properties. As these properties are in a repeating pattern, it is called the **periodic table**.

The order of elements was no longer in the exact order of the atomic weight (although most elements were in this order) to allow for elements with similar properties to be in the same group. Gaps were also left for elements that had not yet been discovered. When new elements were discovered, they followed the pattern that Mendeleev predicted and were placed into the gaps. Below is a copy of the periodic table.

Metals

Non-metals

Group → / Period ↓	1	2											3	4	5	6	7	0
1																		2 He
2	3 Li	4 Be					1 H						5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra		104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Uub	113 Uut	114 Fl	115 Uup	116 Lv	117 Uus	118 Uuo

Elements are arranged by increasing atomic number (the number of protons that an element has). Elements are also represented by their chemical symbol. Here, the atomic number is written above the chemical symbol.

The columns are called **groups**. Each group contains elements that have similar properties. For example, the metals in group 1 are known as the alkali metals. They all react vigorously when placed in water. As elements that have similar properties are in the same group, it makes it easy to predict what properties certain elements have.

Rows are called **periods**. Metals are to the left of the bold line, non-metals to the right. For example, Aluminium (with chemical symbol Al and atomic number 13) is a metal as it is to the left of the bold line.

Q1. The following statements are either true or false. State which are true and which are false.

a) Elements in the same period have the same properties.

....

b) In the periodic table, elements are ordered according to their atomic mass.

....

Q2. For each of the elements, write the atomic number of the element and whether it is a metal or a non-metal.

a) Iron (chemical symbol Fe).

....

b) Carbon (chemical symbol C).

....

c) Helium (chemical symbol He).

....

d) Copper (chemical symbol Cu).

....

e) Sodium chemical (symbol Na).

....

f) Gold (chemical symbol Au).

....

g) Oxygen (chemical symbol O).

....

h) Silver (chemical symbol Ag).

....

Q3. Describe why it is advantageous that elements with similar properties are kept in the same group.

....

....

Q4. State and explain which of aluminium (chemical symbol Al) or silicon (chemical symbol Si) is likely to make a better electrical wire.

....

....

Chemical formulae

In the periodic table, different **elements** are represented by different **symbols**. The first letter of a symbol is always a capital letter. If an element is represented by a symbol that has more than one letter, then the second letter is lower case. For example, the letter "C" represents carbon, whereas the letter "Cu" represents copper (some symbols come from the Latin for the elements).

Sometimes elements are found in pairs of atoms. For example, oxygen (with symbol "O") is found in a gas that is written as "O_2". The subscript 2 shows that two oxygen atoms are joined together.

Compounds can also be represented by chemical formulae. A compound is a substance where two or more atoms (of different elements) are **chemically joined**. Compounds have different properties to the elements that they are made from.

For example, the chemical formula for water is H_2O. Note that this formula means that water has two hydrogen atoms (with symbol "H_2") and one oxygen atom (with symbol "O").

Be careful as the chemical formulae of some compounds look very similar to the symbols of some elements. For example, the element "Co" is cobalt while the compound "CO" is carbon monoxide. Carbon monoxide has one carbon atom (symbol "C") and one oxygen atom (symbol "O"). We can tell the difference between the two as carbon monoxide has a capital letter "O". The table below shows a small number of common compounds:

Name of compound	Chemical formula	Elements in compound
Aluminium oxide	Al_2O_3	Two aluminium atoms (Al_2) and three oxygen atoms (O_3).
Carbon dioxide	CO_2	One carbon atom (C) and two oxygen atoms (O_2).
Hydrochloric acid	HCl	One hydrogen atom (H) and one chlorine atom (Cl).
Magnesium oxide	MgO	One magnesium atom (Mg) and one oxygen atom (O).
Silicon dioxide	SiO_2	One silicon atom (Si) and two oxygen atoms (O_2).
Sodium chloride	NaCl	One sodium atom (Na) and one chlorine atom (Cl).
Sulfuric acid	H_2SO_4	Two hydrogen atoms (H_2), one sulfur atom (S) and four oxygen atoms (O_4).
Water	H_2O	Two hydrogen atoms (H_2) and one oxygen atom (O).

Q1. The following statements are either true or false. State which are true and which are false.

a) Compounds have different properties to the elements that they are made from.

....

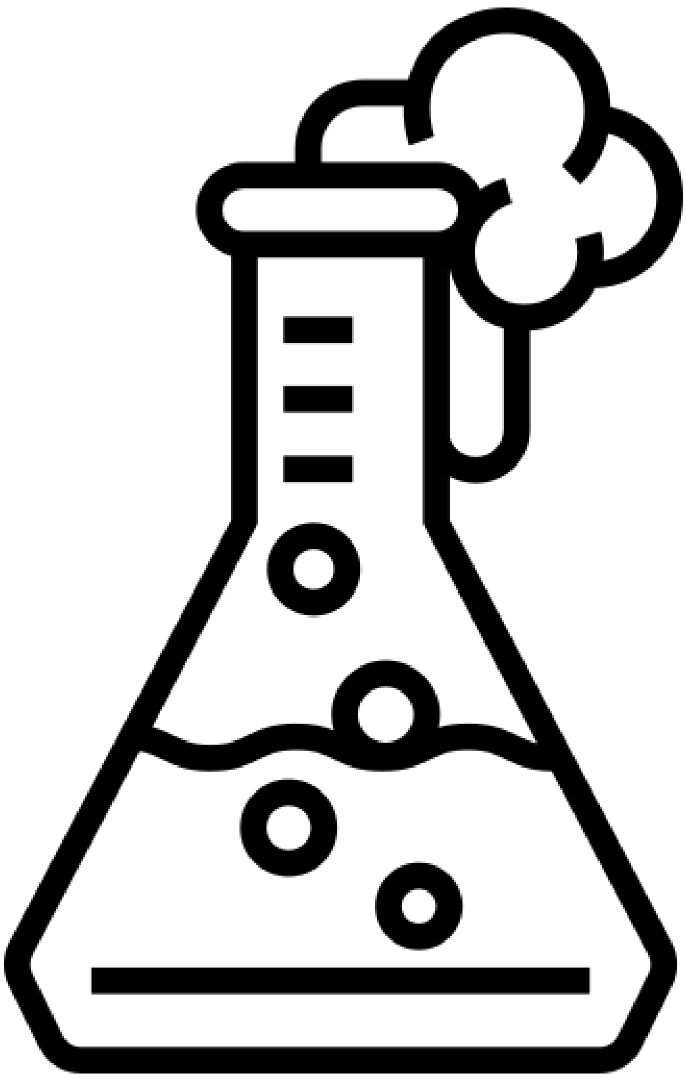
b) The chemical formula for carbon monoxide is Co.

....

Q2. Fill in the gaps in the table below. If you need to complete the "elements in compound" column, then include the names of each element and how many of each element there are. Use a copy of the periodic table to help.

	Name of compound	Chemical formula	Elements in compound
a)	Sodium hydroxide	NaOH	....
b)	Iron sulfide	FeS	....
c)	....	....	Two hydrogen atoms and one oxygen atom.
d)	Ammonia	NH_3	....
e)	Calcium oxide	....	One calcium atom and one oxygen atom.
f)	....	CO_2	....
g)	Lithium oxide	Li_2O	....
h)	Calcium chloride	$CaCl_2$	....
i)	Methane	....	One carbon atom and four hydrogen atoms.
j)	Sodium carbonate	Na_2CO_3	....
k)	Potassium sulphate	K_2SO_4	....

Chemical

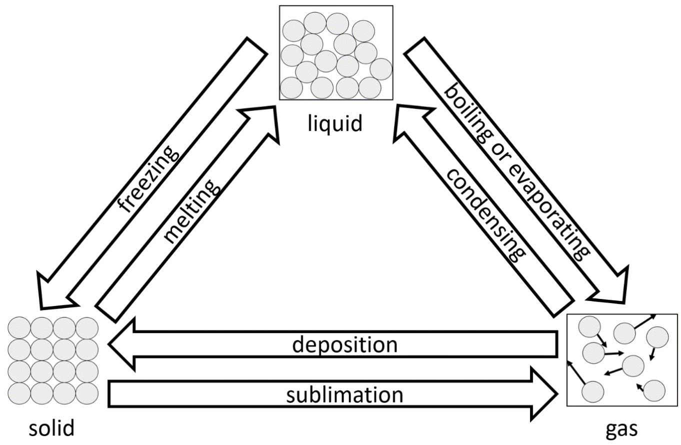


reactions

Physical changes and chemical reactions

When a substance undergoes a **physical change**, the chemical composition of the substance does not change. Because of this, a physical change is **reversible**.

One example of a physical change is that of ice melting to form water. Both ice and water have a chemical formula of H_2O, so there is no change to this. Water can also be frozen to form ice again. All the state changes are physical changes. The state changes are shown in the diagram to the right.



Another example of a physical change is the dissolving of sugar in water. This could also be reversed by heating the solution until all the water has evaporated. The sugar would be left behind.

In a physical change, **mass is conserved**. If 100 g of ice melts, it will form 100 g of water.

In a **chemical reaction**, the chemical composition of substances change. One example of this is the rusting of iron. Iron rusts when it reacts with oxygen to form iron oxide. The chemical composition has changed.

There are several signs that a chemical reaction has taken place. These include:

1. A colour change.
2. A temperature change.
3. Gas being given out – this might show as effervescence (bubbles in a liquid).
4. Light being emitted.
5. Precipitation (a precipitate is a solid formed in a chemical reaction).

Going back to the example of iron rusting – the iron is initially a grey/silver colour. After it rusts it becomes a reddish/brown colour. The colour change is a sign that a chemical reaction has occurred. The temperature will also rise.

As the chemical composition of substances change during a chemical reaction, it cannot be easily reversed.

Mass is also conserved in a chemical reaction. The mass of the reactants (the substances that undergo a reaction) will be equal to the mass of the products of the reaction. This is called **the conservation of mass**. If a mass of 70 g of iron reacts with 30 g of oxygen, it will form 100 g of iron oxide.

Q1. The following statements are either true or false. State which are true and which are false.

a) A chemical reaction is easily reversible.

....

b) When a mass of 200 g of water evaporates, the mass of the water vapour is less than 200 g.

....

c) A change in colour is a sign of a physical change.

....

d) Gas being given out is a sign of a chemical reaction.

....

Q2. Describe what is meant by the conservation of mass.

....

....

Q3. A mass of 50 g of copper reacts with 12 g of oxygen to form copper oxide. The colour changes from a reddish/brown colour to black.

a) State the mass of copper oxide formed.

....

b) State two reasons why we know that this is a chemical reaction.

....

....

c) Aside from your reasons above, state three other signs that could show a chemical reaction has taken place.

....

....

Q4. A substance is changing from being a gas to being a liquid.

a) State the name of the state change.

....

b) State whether this is a physical change or a chemical reaction.

....

c) Explain your answer to part b).

....

Q6. Some table salt is dissolved in some water. Describe how we could reverse this physical change to have table salt again.

....

....

Oxidation and combustion

One example of a chemical reaction is that of **oxidation**. Oxidation is when a substance gains oxygen. A general chemical equation for a metal undergoing oxidation is:

metal + oxygen → metal oxide

In a chemical equation, the **reactants** go on the left hand side of the equation. The reactants are the substances that undergo a reaction. An arrow then shows what the reactants turn into. The **products** of the reaction go on the right hand side of the equation.

In the general chemical equation above, metal and oxygen are the reactants. The product is the metal oxide. Two specific examples of oxidation are:

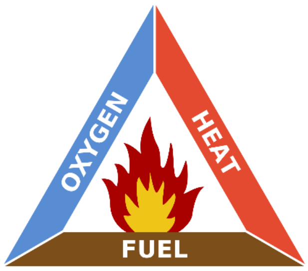
iron + oxygen → iron oxide

copper + oxygen → copper oxide

Another example of a chemical reaction involving oxygen is **combustion**. Combustion is the scientific word for the burning of a **fuel**. The fuel is generally made of hydrogen and carbon. A compound of hydrogen and carbon is called a **hydrocarbon**.

Three things are required for combustion to occur – oxygen, heat and fuel. This is shown in the **fire triangle** to the right.

There are two types of combustion – **complete combustion** and **incomplete combustion**.



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A general equation for complete combustion is:

fuel + oxygen → carbon dioxide + water

Carbon dioxide is formed as the carbon in the fuel reacts with the oxygen. Water is also formed as the hydrogen in the fuel reacts with oxygen. The fuel can be any fuel (petrol, propane, methane etc.). One specific example of complete combustion is:

propane + oxygen → carbon dioxide + water

Incomplete combustion occurs if there is not enough oxygen available. A general equation for incomplete combustion is:

fuel + oxygen → carbon monoxide + water

Incomplete combustion is dangerous as carbon monoxide is a poisonous gas. Carbon monoxide is also a colourless and odourless gas – so it is very difficult to tell if the gas is present. Carbon monoxide detectors can be used in homes to make sure that we are safe. An alarm sounds if the levels of carbon monoxide are too high.

Q1. Three substances undergo oxidation. Complete the word equations below:

a) magnesium + oxygen → ....

b) .... + oxygen → calcium oxide

c) aluminium + oxygen → ....

Q2. State the products of complete combustion.

....

Q3. State the products of incomplete combustion.

....

Q4. State what elements hydrocarbons consist of.

....

Q5. State the three things that are required for combustion to occur.

....

Q6. Describe why incomplete combustion is dangerous.

....

....

Q7. Three substances undergo complete combustion. Complete the word equations below:

a) methane + oxygen → ....

b) ethane + oxygen → ....

c) butane + oxygen → ....

Q8. The same substances undergo incomplete combustion. Complete the word equations below:

a) methane + oxygen → ....

b) ethane + oxygen → ....

c) butane + oxygen → ....

Q9. Oxidation is one example of a chemical reaction. State three ways that we can tell a chemical reaction has occurred.

....

....

Q10. Describe when incomplete combustion might occur.

....

....

Balancing chemical equations

When we write a chemical equation for the oxidation of copper, we can do so in words as in the equation below:

copper + oxygen → copper oxide

We can also represent this reaction using chemical symbols and formulae. The chemical symbol for copper is "Cu" and for oxygen is "O". However, oxygen exists as a diatomic molecule meaning that we write it as "O_2" (instead of just "O" by itself). The symbol for copper oxide is "CuO" meaning that each copper oxide particle has one copper atom and one oxygen atom. If we just used these symbols instead of words, then we'd end up with:

	Cu + O_2	**→ CuO**
Number of Cu atoms	1	→ 1
Number of O atoms	2	→ 1

As we can see, there are two oxygen atoms on the left side of the equation but only one oxygen atom is on the right side of the equation. This is not correct – there must be the same number of each of the atoms on each side of the chemical equation. We must **balance** the chemical equation to fix this.

The first step in balancing this equation will be to look at increasing the number of oxygen atoms on the right hand side of the equation. The only way that we can do this is to increase the number of "CuO" particles. We could change this to "2CuO" – this means that we have two lots of copper oxide particles. Changing the number in front of a compound is the only way that we can try to balance the equation. We cannot, for example, change "CuO" to "CuO_2" as that is changing what compound we have.

However, we now would have two copper atoms on the right side of the equation. We can fix this by changing the number of copper atoms on the left side of the equation to two. We now have:

	2Cu + O_2	**→ 2CuO**
Number of Cu atoms	2	→ 2
Number of O atoms	2	→ 2

The number of copper and oxygen atoms on each side of the equation is now the same. We have balanced the equation.

Note that if, for example, we have two lots of water particles (written as "$2H_2O$") then we will have a total of four hydrogen atoms and two oxygen atoms. Changing the number in front of a compound multiplies the number of all the atoms by that amount.

Q1. Hydrogen has the chemical symbol "H". State how many hydrogen atoms there are in each of the below:

a) H_2O ....
b) $2H_2O$ ....
c) $10H_2O$ ....
d) CH_4 ....
e) C_2H_4 ....
f) $4C_2H_4$ ....
g) $2C_7H_{16}$ ....
h) $Ca(OH)_2$ ....

Q2. a) Write a word equation for the oxidation of zinc.

....

b) Balance the chemical equation for the oxidation of zinc by filling in the gaps

.... $Zn + O_2 \rightarrow 2ZnO$

Q3. Balance the chemical equations below by filling in the gaps:

a) Oxidation of magnesium.

$2Mg + O_2 \rightarrow$ .... MgO

b) Complete combustion of methane.

$CH_4 +$ .... $O_2 \rightarrow CO_2 + 2H_2O$

c) Incomplete combustion of ethene.

$C_2H_4 + 2O_2 \rightarrow$ .... $CO + 2H_2O$

d) Oxidation of silver.

.... $Ag + O_2 \rightarrow 2Ag_2O$

e) Photosynthesis

$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 +$ .... O_2

f) Reaction of sodium and chlorine.

.... $Na +$ .... $Cl_2 \rightarrow$ .... $NaCl$

Thermal decomposition

One example of a chemical reaction is that of **thermal decomposition**. Thermal decomposition is when a compound is heated and breaks down into smaller and simpler products.

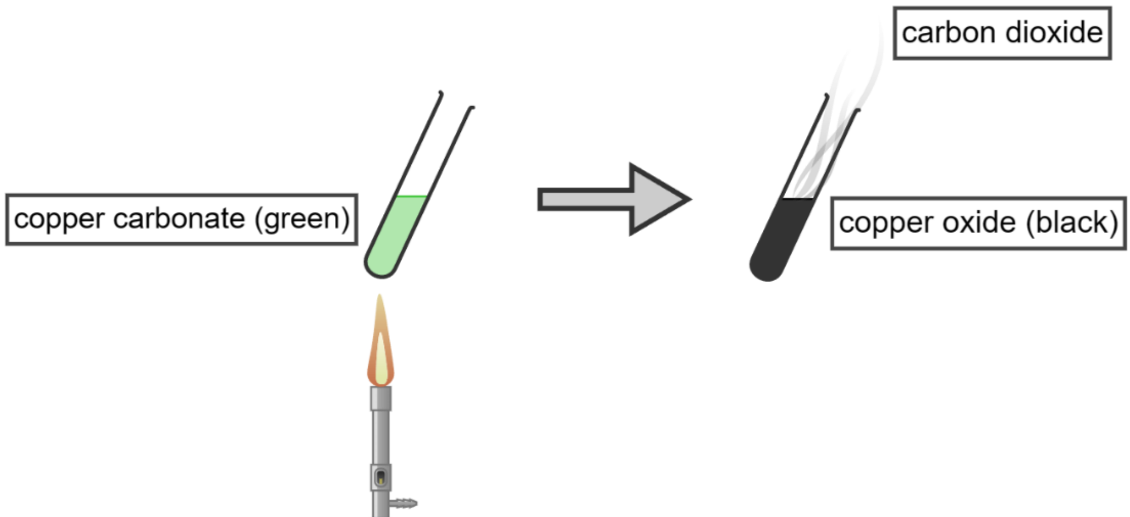
If we heat copper carbonate with a Bunsen burner, it will undergo thermal decomposition. The word equation for this process is:

copper carbonate → copper oxide + carbon dioxide

And in symbols, the balanced chemical equation for this is:

$$CuCO_3 \rightarrow CuO + CO_2$$

The carbon and some of the oxygen in copper carbonate have now formed carbon dioxide (CO_2). When heated, a metal carbonate will generally decompose into a metal oxide and carbon dioxde.



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Copper carbonate is green coloured, while copper oxide is black. This change in colour is a sign that a chemical reaction has occurred. Another sign that a chemical reaction has occurred is that a gas (carbon dioxide) is released.

We could verify that the gas is carbon dioxide by passing it through a calcium hydroxide solution (commonly known as **limewater**). If the gas is carbon dioxide, the limewater will turn milky or cloudy white.

Another example of thermal decomposition is that of hydrogen peroxide:

hydrogen peroxide → water + oxygen

This reaction creates oxygen gas. The test for oxygen is whether it will relight a glowing splint.

Q1. Describe what thermal decomposition is.

....

....

Q2. State two ways that we might know that a chemical reaction has taken place.

....

....

Q3. Magnesium carbonate undergoes thermal decomposition to form magnesium oxide and carbon dioxide.

a) State the reactant in this reaction.

....

b) State the products of this reaction.

....

c) Complete the chemical equation.

$MgCO_3 \rightarrow$ .... + ...

d) Describe how we could confirm that the gas produced was carbon dioxide.

....

....

Q4. Complete the chemical equation for the thermal decomposition of calcium carbonate.

$CaCO_3 \rightarrow$ .... + ...

Q5. Balance the chemical equation for the thermal decomposition of silver oxide by filling in the gaps.

.... $Ag_2O \rightarrow$ .... $Ag + O_2$

Q6. Hydrogen peroxide undergoes thermal decomposition to form water and oxygen.

a) Balance the chemical equation of this process by filling in the gap:

$2H_2O_2 \rightarrow$ .... $H_2O + O_2$

b) Describe how we could confirm that the gas produced was oxygen.

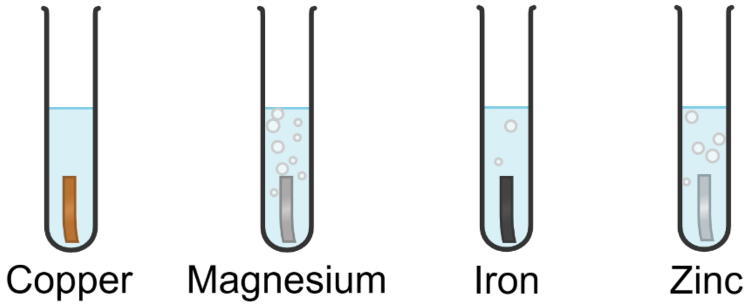
....

....

Reactivity series and displacement reactions

If we place different metals into water or an acid, then some metals react much more strongly. This is because some metals are more **reactive** than others.

The diagram to the right shows four metals that have been placed into hydrochloric acid. We can see that magnesium is the most reactive metal as the most bubbles (of hydrogen) are released. Remember that a gas being released is a sign of a chemical reaction. Copper is the least reactive metal shown as there are no bubbles.



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Reactivity

Potassium	K	Most reactive
Sodium	Na	
Lithium	Li	
Calcium	Ca	
Magnesium	Mg	
Aluminium	Al	
Carbon	C	
Zinc	Zn	
Iron	Fe	
Hydrogen	H	
Copper	Cu	
Gold	Au	Least reactive

We can also test the reactivity of metals by looking at their reactions with water. If we study this over a larger range of metals, then we end up with an order of reactivity that we call the **reactivity series**.

Even though they are not metals, carbon and hydrogen are often included in the reactivity series as it makes it easy to predict what will happen in certain chemical reactions.

During a **displacement reaction**, an element that is more reactive replaces another less reactive element in a compound. One example of this is if some iron is placed into a copper sulfate solution. As iron is more reactive than copper, it displaces the copper in the solution.

iron + copper sulfate → iron sulfate + copper

In this case, we can tell that a chemical reaction has taken place as copper sulfate is a blue solution and iron sulfate is a green solution. A change in colour is another sign of a chemical reaction. However, no displacement occurs in the example below. This is because gold is less reactive than copper.

gold + copper sulfate → gold + copper sulfate (no reaction)

Another example of a displacement reaction is below. Aluminium displaces the iron in iron oxide as aluminium is more reactive than iron.

aluminium + iron oxide → aluminium oxide + iron

Q1. The following statements are either true or false. State which are true and which are false.

a) Magnesium is more reactive than sodium.

....

b) Calcium would not displace iron from iron oxide.

....

c) One way of telling how reactive a metal is by how vigorously it reacts with water.

....

Q2. The reaction below is a displacement reaction.

magnesium + copper sulfate → magnesium sulfate + copper

As the reaction progresses, the blue copper sulfate colour fades and the solution becomes colourless.

a) Describe why a displacement reaction occurs.

....

....

b) State how we know that a chemical reaction has taken place.

....

Q3. A chemical reaction occurs between magnesium and lead nitrate as follows:

magnesium + lead nitrate → lead + magnesium nitrate

State which of magnesium and lead is more reactive. Explain the reason for your answer.

....

....

Q4. Describe why the below reaction is not possible.

calcium + sodium carbonate → sodium + calcium carbonate

....

....

Q5. Complete the word equation for the displacement reaction between aluminium and iron oxide.

aluminium + iron oxide → .... + ...

Q6. Complete the word equation for the displacement reaction between magnesium and copper chloride.

magnesium + copper chloride → .... + ...

Q7. Complete the word equation for the displacement reaction between zinc and iron sulfate.

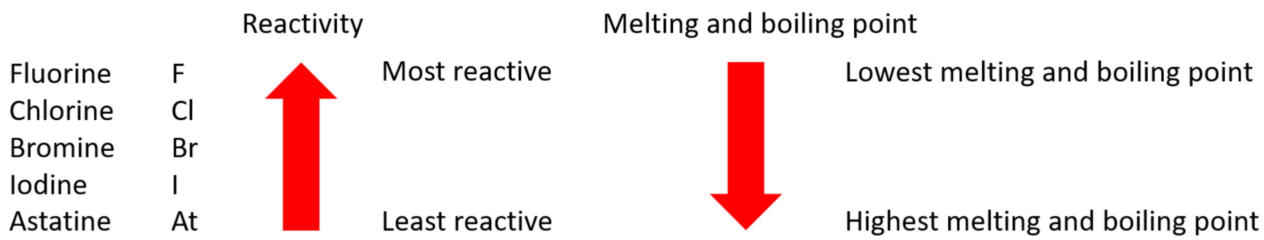
zinc + iron sulfate → .... + ...

Group 7 elements

Elements in group 7 of the periodic table are known as the **halogens**. As the halogens are all in the same group, they all have similar properties. The halogens are all **non-metals** and therefore do not conduct electricity or heat well. They also have low melting and boiling points. As you go down group 7, the melting and boiling points increase. This is because larger molecules have larger inter-molecular forces.

The halogens are also **very reactive** and, because of this, they are **toxic**. For example, chlorine gas was used as a weapon in World War One. In low concentrations, it is also used to limit bacteria growth in swimming pools.

As you go down group 7, the reactivity decreases. A summary of these trends are shown in the diagram below.



During a **displacement reaction**, an element that is more reactive replaces another less reactive element in a compound. Both metals and halogens can undergo displacement reactions.

Before we see an example, it's useful to know that if fluorine is in a compound the compound will generally end with "fluoride". Chlorine will form a "chloride", bromide will form a "bromide", iodine will form an "iodide" and astatine will form an "astatide". Collectively, these compounds are known as **halides**.

One example of this is the reaction between sodium bromide and chlorine. Chlorine is more reactive than bromine and so it displaces the bromine.

sodium bromide + chlorine → sodium chloride + bromine

However, no displacement occurs in the example below. This is because iodine is less reactive than bromine.

sodium bromide + iodine → sodium bromide + iodine (no reaction)

Another example of a displacement reaction is below. Chlorine displaces the iodine in potassium iodide as chlorine is more reactive than iodine.

potassium iodide + chlorine → potassium chloride + iodine

During this reaction, the colour changes from colourless to brown. A change in colour is one sign of a chemical reaction.

Q1. The following statements are either true or false. State which are true and which are false.

a) Chlorine is an example of a halogen.

....

b) Bromine is less reactive than iodine.

....

c) Fluorine has a higher melting point than astatine.

....

d) Group 7 elements are all good electrical conductors.

....

e) Group 7 elements are toxic and highly reactive.

....

f) Group 7 elements have high melting and boiling points.

....

Q2. Describe what a displacement reaction is.

....

....

Q3. The reaction below is a displacement reaction.

potassium bromide + chlorine → potassium chloride + bromine

a) Describe why a displacement reaction occurs.

....

....

b) Balance the chemical equation of this process by filling in the gaps:

.... $KBr + Cl_2 \rightarrow$ .... $KCl + Br_2$

c) State one way that we might know that a chemical reaction has taken place.

....

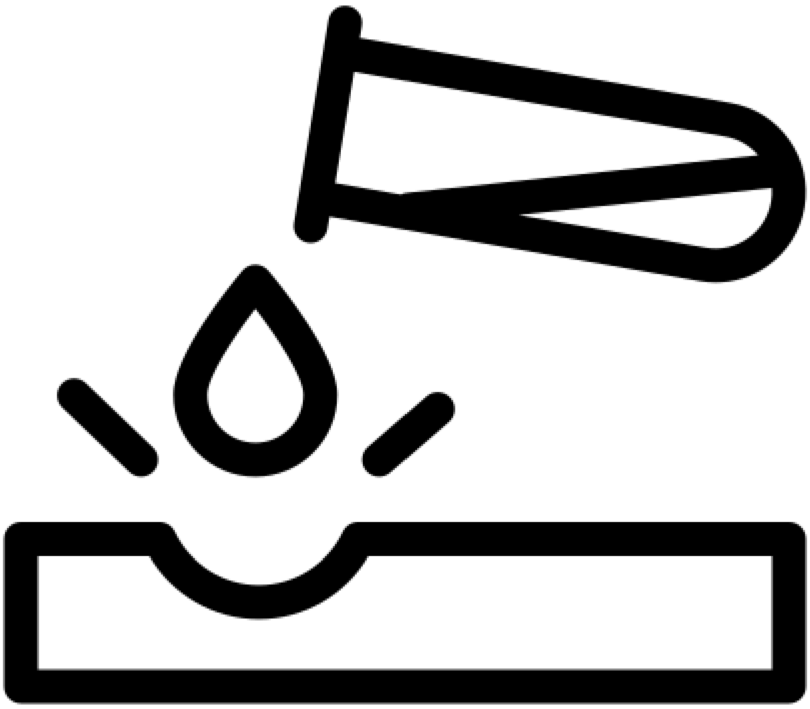
Q4. Complete the word equation for the displacement reaction between potassium iodide and bromine.

potassium iodide + bromine → .... + ...

Q5. Complete the word equation for the displacement reaction between sodium chloride and fluorine.

sodium chloride + fluorine → .... + ...

Acids and



alkalis

Acids, bases and alkalis

You might have already heard of a group of chemicals called **acids**. Certain foods like lemons and vinegar are **acidic** - these foods have a sharp taste to them. Our stomach contains an acid called hydrochloric acid to help us digest food. Some batteries also contain an acid.

Acids can be hazardous and some need to be stored in containers labelled with **hazard symbols**. If an acid is strong, then it is likely to be labelled as an **irritant** (can cause irritation to skin and eyes), as **toxic** (can cause harmful health effects) or as **corrosive** (can damage substances that it comes in contact with). The hazard symbols for these are below.

Harmful / Irritant   Toxic   Corrosive

We use a scale called the **pH scale** to show how acidic a substance is. The pH scale ranges from 0 to 14 and acids have a pH of less than 7. Strong acids have lower pH values compared to weak acids. If a substance has a pH of 7, then we call this substance **neutral**. Pure water is neutral.

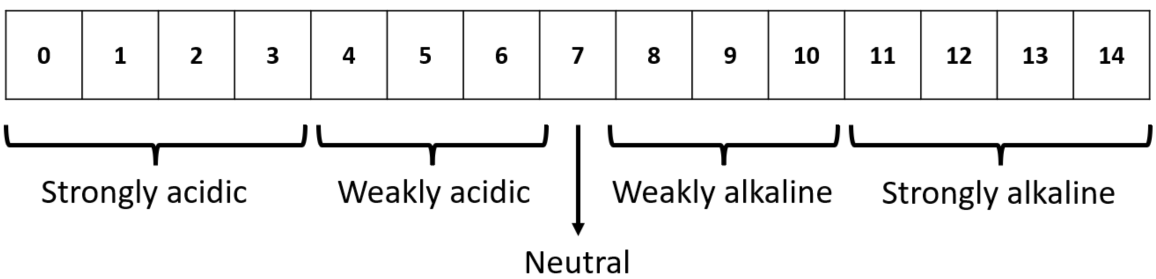
Examples of acids that you might use in a lab include hydrochloric acid (with chemical formula HCl), sulfuric acid (H_2SO_4) and nitric acid (HNO_3). These are all strong acids and so would have a pH of less than 3.

A **base** is a substance that **neutralises** an acid. Neutralisation is a chemical reaction – if an acid is neutralised then the pH will be raised to 7.

If a base is soluble (can be dissolved) in water then we call it an **alkali**. An alkali has a pH of more than 7. Strong alkalis have higher pH values compared to weak alkalis. Common examples of alkalis are soap and bleach. Just like acids, alkalis can also be irritants, toxic and corrosive.

Examples of alkalis used in a lab include sodium hydroxide (NaOH), potassium hydroxide (KOH) and calcium hydroxide ($Ca(OH)_2$).

A diagram showing the pH scale is shown below.



Q1. The following statements are either true or false. State which are true and which are false.

a) Some foods are acidic.

....

b) Acids have a pH of less than 8.

....

c) Pure water is alkaline.

....

d) Neutral substances have a pH of 7.

....

e) A base is a substance that neutralises an acid.

....

f) If a base is insoluble in water then we call it an alkali.

....

Q2. a) State three hazard symbols that a strong acid might be labelled with.

....

....

b) State what pH value a strong acid might have.

....

Q3. Describe what neutralisation is.

....

....

Q4. State the pH value of pure water.

....

Q5. State what pH value a weak alkali might have.

....

Q6. State two examples of common acids.

....

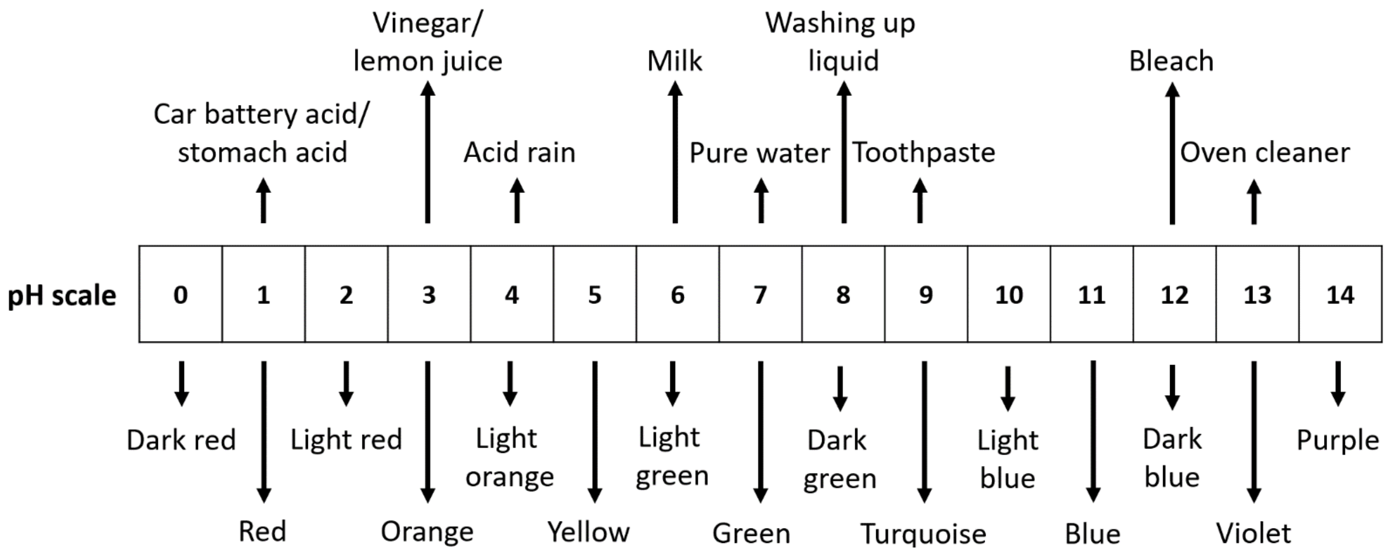
Q7. State two examples of common alkalis.

....

The pH scale and indicators

We can use **indicators** to tell us whether a substance is acidic or alkaline. Some different indicators are described in the table below.

Name of indicator	Description
Blue litmus paper	Blue litmus paper turns red when in contact with an acid.
Red litmus paper	Red litmus paper turns blue when in contact with an alkali.
Phenolphthalein	Phenolphthalein remains colourless unless in contact with an alkali (when it will turn pink).
Red cabbage	Turns to a range of colours, depending on the pH of the substance. In an acid, it turns a pink/red colour. It is purple if in a neutral substance and turns blue or green when added to an alkaline substance.
Methyl orange	Is red in acids and yellow in alkaline solutions.
Universal indicator	Made from a mixture of dyes and changes colour gradually based on the pH. Colours for each pH level (and examples of substances that have those pHs) are in the diagram below.



Remember than any substance with a pH of less than 7 is **acidic** and any substance with a pH of more than 7 is **alkaline**. If a substance (such as pure water) has a pH of 7 then it is **neutral**.

An electronic **pH meter** can also be used to measure the pH of a substance. This has the advantage of not having to interpret a colour as it gives a number to the pH value instead.

Q1. The following statements are either true or false. State which are true and which are false.

a) A substance with a pH of 4 is alkaline.

....

b) If blue litmus paper were placed in lemon juice, it would turn red.

....

c) If red litmus paper were placed in stomach acid, it would turn blue.

....

d) If phenolphthalein were placed in vinegar, it would turn pink.

....

e) Universal indicator would turn green when placed in pure water.

....

f) Methyl orange would turn red in milk.

....

Q2. State two examples of common acids.

....

Q3. State two examples of common alkalis.

....

Q4. State the pH of a substance that is neutral and give an example of a neutral substance.

....

Q5. Describe an advantage of using an electronic pH meter.

....

....

Q6. Universal indicator turns orange when placed into a substance.

a) State what the pH of the substance might be.

....

b) Suggest what the substance might be.

....

c) The substance is now neutralised. What colour will the universal indicator turn?

....

Q7. State an example of a substance that would turn universal indicator red.

....

Acids and metals

If we place a metal into an acid, a **chemical reaction** can occur. One sign of the chemical reaction occurring would be a temperature rise. If the reaction is more vigorous, then effervescence (fizzing) in the acid could be observed or even flames.

The more reactive the metal, the more vigorous the reaction will be. The **reactivity series** (in the diagram to the right) shows the order of reactivity of metals.

		Reactivity
Potassium	K	Most reactive
Sodium	Na	
Lithium	Li	
Calcium	Ca	
Magnesium	Mg	
Aluminium	Al	
Carbon	C	
Zinc	Zn	
Iron	Fe	
Hydrogen	H	
Copper	Cu	
Gold	Au	Least reactive

When a metal reacts with an acid it creates a chemical compound called a **salt** and hydrogen gas. This can be summarised in a general word question as:

metal + acid → salt + hydrogen

Hydrochloric acid will form metal chloride compounds. Two examples of this are below:

iron + hydrochloric acid → iron chloride + hydrogen

magnesium + hydrochloric acid → magnesium chloride + hydrogen

Note that magnesium would have a much more vigorous reaction with hydrochloric acid as it is higher in the reactivity series.

Sulfuric acid will form metal sulfate compounds. For example:

zinc + sulfuric acid → zinc sulfate + hydrogen

aluminium + sulfuric acid → aluminium sulfate + hydrogen

Again, note that aluminium will have a more vigorous reaction as it is more reactive.

Nitric acid will form metal nitrate compounds. For example:

iron + nitric acid → iron nitrate + hydrogen

calcium + nitric acid → calcium nitrate + hydrogen

In all of the reactions above, hydrogen gas is formed. This is because all the acids contain hydrogen and the metals involved are more reactive than hydrogen. The metals therefore **displace** the hydrogen. If copper or gold were to be placed in an acid, there would therefore be no reaction. This is because copper and gold are less reactive than hydrogen. For example, there would be no reaction with gold and nitric acid:

gold + nitric acid → gold + nitric acid

Q1. Complete the general word equation for the reaction between a metal and an acid.

metal + acid → .... + ...

Q2. Magnesium reacts with some hydrochloric acid.

a) Complete the word equation for the reaction.

magnesium + hydrochloric acid → .... + ...

b) State how the temperature of the products would compare to the temperature of the reactants.

....

c) Other than a temperature change, state another way that we could tell a chemical reaction has taken place.

....

d) Describe why there would be no reaction between gold and hydrochloric acid.

....

....

e) Some calcium now reacts with the hydrochloric acid. State and explain how the reaction would compare to that of magnesium and hydrochloric acid.

....

....

f) Complete the word equation for the reaction between calcium and hydrochloric acid.

calcium + hydrochloric acid → .... + ...

Q3. Complete the word equations for all the reactions below

a) calcium + sulfuric acid → .... + ...

b) zinc + hydrochloric acid → .... + ...

c) aluminium + nitric acid → .... + ...

d) iron + sulfuric acid → .... + ...

e) magnesium + nitric acid → .... + ...

f) aluminium + hydrochloric acid → .... + ...

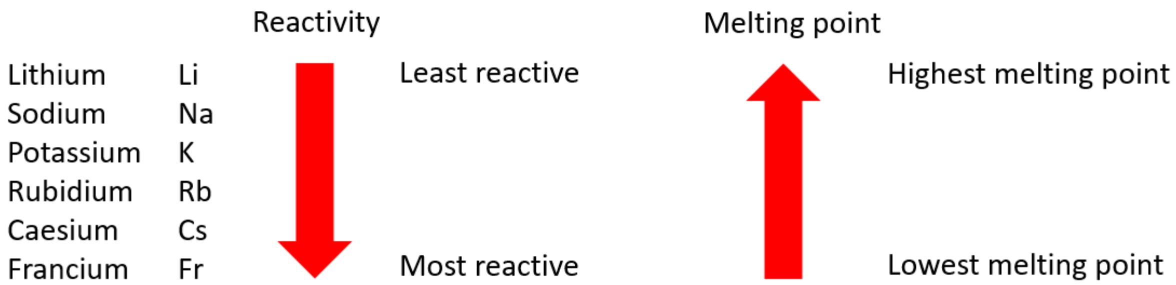
g) copper + sulfuric acid → .... + ...

h) zinc + nitric acid → .... + ...

Alkali metals

The first group (column) of elements in the periodic table is known as the **alkali metals**. As the alkali metals are all in the same group, they all have similar properties. For example, all the alkali metals have low melting points and are so soft that they can be cut with a knife. They also have low densities and are all very reactive. Alkali metals are stored in oil so that air and water are kept away from them.

As you go down group 1, the **reactivity** of the elements goes up and the melting points go down. This is shown in the diagram below.



The alkali metals react strongly with water. It can be quite dangerous to do this, though, and safety precautions need to be taken. If you observe a demonstration of this, it will be behind a safety screen and only small amounts of an alkali metal will be used.

When an alkali metal is added to water it forms a metal hydroxide and hydrogen. These metal hydroxides are **alkaline** (which is why they are called alkali metals). Alkaline solutions have a pH greater than 7. The reaction can be summarised in the general word equation below:

alkali metal + water → metal hydroxide + hydrogen

These reactions become more fierce as you go down group 1. If lithium is added to water, then it fizzes in the water. The fizzing is from the release of hydrogen gas. The word equation for this reaction is:

lithium + water → lithium hydroxide + hydrogen

If potassium is added to water, the reaction is stronger as potassium is more reactive than lithium. The reaction increases the temperature so much that the hydrogen gas released ignites. The word equation for this reaction is:

potassium + water → potassium hydroxide + hydrogen

Elements further down group 1 would have an even stronger reaction. For example, that of caesium:

caesium + water → caesium hydroxide + hydrogen

Q1. The following statements are either true or false. State which are true and which are false.

a) The reactivity of the alkali metals goes up as you go up group 1.

....

b) The melting points of the alkali metals goes up as you go up group 1.

....

c) The alkali metals react strongly with water.

....

d) The alkali metals all have high melting points.

....

e) Alkaline solutions have a pH greater than 7.

....

f) Alkali metals are usually stored in oil.

....

Q2. Complete the general word equation for the reaction between an acid and a metal oxide.

alkali metal + water → .... + ...

Q3. Sodium undergoes a reaction with water.

a) Complete the word equation for the reaction between sodium and water.

sodium + water → .... + ...

b) State an alkali metal which will have a stronger reaction with water.

....

Q4. Complete the word equations for all the reactions below

a) lithium + water → .... + ...

b) rubidium + water → .... + ...

c) potassium + water → .... + ...

Q5. A teacher decides to do a demonstration of the reaction between sodium and water. State any safety precautions that the teacher is likely to take.

....

....

Neutralisation

A **base** is a substance that **neutralises** an acid. An acid has a pH of less than 7 – if an acid is neutralised then the pH will be raised to 7. Neutralisation is a chemical reaction. Two ways of telling a chemical reaction has taken place is that there is a temperature rise during neutralisation and there may be some effervescence.

Metal oxides and metal hydroxides are bases. Some of these are soluble – a soluble base is called an **alkali**. If an acid is neutralised by a metal oxide or metal hydroxide, then a chemical compound called a **salt** and water is formed. This is summarised in the two general word equations below:

acid + metal oxide → salt + water

acid + metal hydroxide → salt + water

Hydrochloric acid will form metal chloride compounds. For example:

hydrochloric acid + iron oxide → iron chloride + water

hydrochloric acid + sodium hydroxide → sodium chloride + water

Sulfuric acid will form metal sulfate compounds. For example:

sulfuric acid + zinc oxide → zinc sulfate + water

sulfuric acid + potassium hydroxide → potassium sulfate + water

Nitric acid will form metal nitrate compounds. For example:

nitric acid + calcium oxide → calcium nitrate + water

nitric acid + magnesium hydroxide → magnesium nitrate + water

Metal carbonates are also bases and can neutralise acids, the products of this reaction are a salt, carbon dioxide and water. The general equation for this reaction is:

acid + metal carbonate → salt + carbon dioxide + water

Two specific examples of this are:

hydrochloric acid + calcium carbonate → calcium chloride + carbon dioxide + water

nitric acid + sodium carbonate → sodium nitrate + carbon dioxide + water

To tell when a neutralisation reaction is complete, it is best to not use universal indicator as there is a gradual colour change between the different pH levels. Instead, it is better to use an indicator that has a more sudden colour change. For example, litmus paper, phenolphthalein or methyl orange could be used.

Q1. Complete the general word equation for the reaction between an acid and a metal oxide.

acid + metal oxide → .... + ...

Q2. Complete the general word equation for the reaction between an acid and a metal hydroxide.

acid + metal hydroxide → .... + ...

Q3. Complete the general word equation for the reaction between an acid and a metal carbonate.

acid + metal carbonate → .... + ... + ...

Q4. Describe what a base is.

....

....

Q5. Describe what an alkali is.

....

....

Q6. State what pH an acid must have.

....

Q7. Complete the word equations for all the reactions below

a) hydrochloric acid + zinc oxide → .... + ...

b) nitric acid + calcium hydroxide → .... + ...

c) sulfuric acid + calcium carbonate → .... + ... + ...

d) nitric acid + zinc carbonate → .... + ... + ...

e) sulfuric acid + iron oxide → .... + ...

f) hydrochloric acid + magnesium oxide → .... + ...

g) sulfuric acid + sodium hydroxide → .... + ...

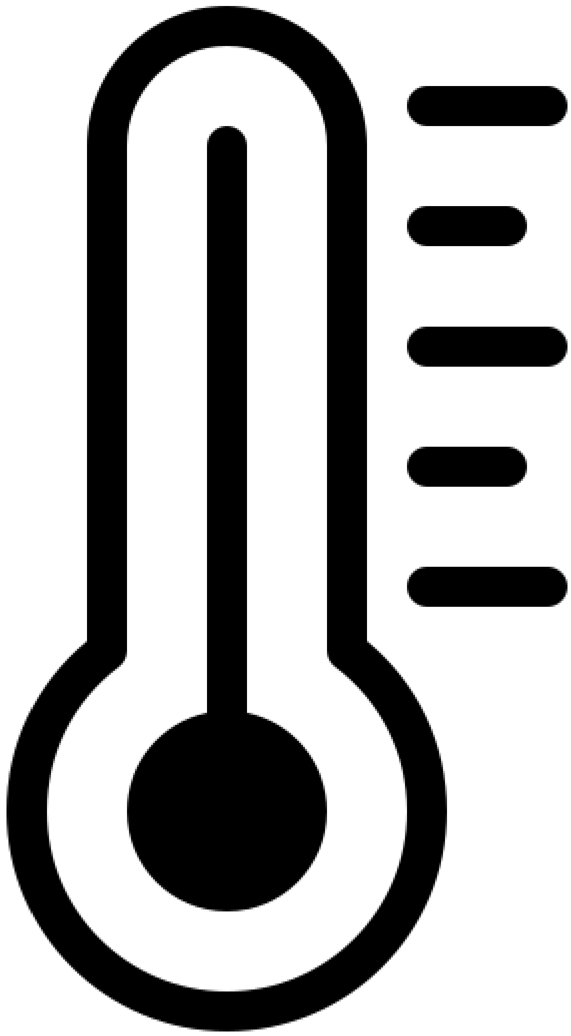
h) hydrochloric acid + potassium hydroxide → .... + ...

Q8. Describe why universal indicator shouldn't be used when being able to tell when a neutralisation reaction is complete.

....

....

Energy



changes

Exothermic and endothermic reactions

Chemical reactions that transfer energy to the surroundings are called **exothermic reactions**. Usually this energy transfer is by heating and so there will be a rise in temperature.

Hi-Res Images of Chemical Elements, CC BY 3.0, via Wikimedia Commons

The most obvious example of an exothermic reaction is that of **combustion**. Burning of a fuel like petrol is one example of combustion. This will increase the temperature of the surroundings. The general word equation for combustion is:

fuel + oxygen → carbon dioxide + water

Other examples of exothermic reactions are **neutralisation** and many **oxidation** reactions. Again, the temperature of the surroundings will increase.

We've seen before that the general word equations for neutralisation are:

acid + metal oxide → salt + water

acid + metal hydroxide → salt + water

acid + metal carbonate → salt + carbon dioxide + water

We've also seen that the general chemical equation for a metal undergoing oxidation is:

metal + oxygen → metal oxide

While exothermic reactions transfer energy to the surroundings, **endothermic reactions** take in energy from the surroundings. This results in a fall in temperature.

One example of an endothermic reaction is **thermal decomposition**. Thermal decomposition is when a compound is heated and breaks down into smaller and simpler products.

Both exothermic and endothermic reactions have everyday applications. Exothermic reactions are used in hand warmers and self-heating cans of hot drinks.

Endothermic reactions are used in "instant cold" packs used to treat sports injuries. These packs usually consist of two bags (with one inside the other). One contains water and one contains a different compound. When the inner bag is squeezed and bursts, water combines with this compound and an endothermic reaction occurs. The "instant cold" pack then decreases in temperature.

Q1. Describe what is meant by an exothermic reaction.

....

....

Q2. State two examples of exothermic reactions.

....

Q3. Describe what is meant by an endothermic reaction.

....

....

Q4. State an example of an endothermic reaction.

....

Q5. The following statements are either true or false. State which are true and which are false.

a) Oxidation is an example of an endothermic reaction.

....

b) Thermal decomposition is an example of an endothermic reaction.

....

c) Neutralisation is an example of an exothermic reaction.

....

Q6. Complete the general word equation for the reaction between an acid and a metal hydroxide.

acid + metal hydroxide → .... + ...

Q7. State whether the reaction in question 6 is exothermic or endothermic.

....

Q8. Copper carbonate undergoes thermal decomposition to form copper oxide and carbon dioxide.

a) State the reactant in this reaction.

....

b) State the products of this reaction.

....

c) Complete the chemical equation.

$CuCO_3 \rightarrow CuO +$ ....

d) State whether this reaction is exothermic or endothermic.

....

Rates of reaction

The phrase "rate of reaction" means how quickly a chemical reaction takes place. The rate of reaction depends on the frequency of **successful collisions** between reacting particles.

The rate of reaction depends on:

- **The temperature of the reactants**. Higher temperatures cause particles to move more quickly. This increases the frequency of collisions and the energy of those collisions, thus increasing the rate of reaction.
- **The concentration or pressure of reactants.** In a more concentrated solution, there are more particles within the same volume. Similarly, a gas at higher pressure has more particles in the same volume. In both cases, more particles lead to a higher rate of collisions, increasing the rate of reaction.
- **The surface area.** For solid reactants, breaking them into smaller pieces increases their surface area to volume ratio. This allows more collisions to occur on the surface of the solid, increasing the rate of reaction.
- **The use of a catalyst.** A catalyst is a substance that increases the rate of reaction without being used up in the process. It works by providing an alternative pathway with a lower activation energy for the reaction, therefore increasing the rate at which collisions result in a reaction.

The rate of reaction can be measured with a few different methods. These include:

- **Measuring the change in mass**. For reactions that produce a gas, the rate can be measured by the loss of mass. One example of this is the reaction between magnesium and hydrochloric acid to form magnesium chloride and hydrogen gas. The hydrogen gas would escape and so the mass measured on the balance would decrease.
- **Measuring the volume of gas produced**. If a reaction produces a gas, the rate can also be measured by capturing the gas in a gas syringe and measuring the volume of gas produced over time.
- **Observing precipitation**. Precipitation is the formation of a solid in a solution during a chemical reaction. The rate of reaction can be measured by observing the time it takes for the precipitate to form. This can be done visually or using a light sensor to detect when a certain level of cloudiness is reached in the solution. One example of this is the reaction between sodium thiosulfate and hydrochloric acid. This reaction forms a yellow sulfur precipitate. The reaction can take place in a conical flask placed above a piece of paper with a black cross drawn on it. The time can then be measured for the black cross to no longer be visible.
- **Monitoring colour change**. Some reactions involve a change in colour. The rate of reaction can be measured by timing how long it takes for the colour change to occur.

Q1. The following statements are either true or false. State which are true and which are false.

a) Particles at a higher temperature move more quickly.

....

b) A catalyst is used up during a chemical reaction.

....

c) The rate of reaction depends on the frequency of successful collisions.

....

d) Breaking a solid up into smaller pieces decreases the surface area to volume ratio.

....

e) A gas at a higher pressure has more particles in the same volume.

....

Q2. Explain why increasing the temperature of reactants increases the rate of reaction.

....

....

Q3. Sodium thiosulfate is reacting with hydrochloric acid. A yellow sulfur precipitate is formed.

a) State what effect increasing the concentration of hydrochloric acid would have on the reaction. Explain the reasons why.

....

....

b) Describe an experiment that could investigate how the rate of reaction depends on the temperature of hydrochloric acid.

....

....

....

....

Q4. Magnesium is added to hydrochloric acid.

a) State whether magnesium powder or large pieces of magnesium would have a higher rate of reaction Explain the reasons why.

....

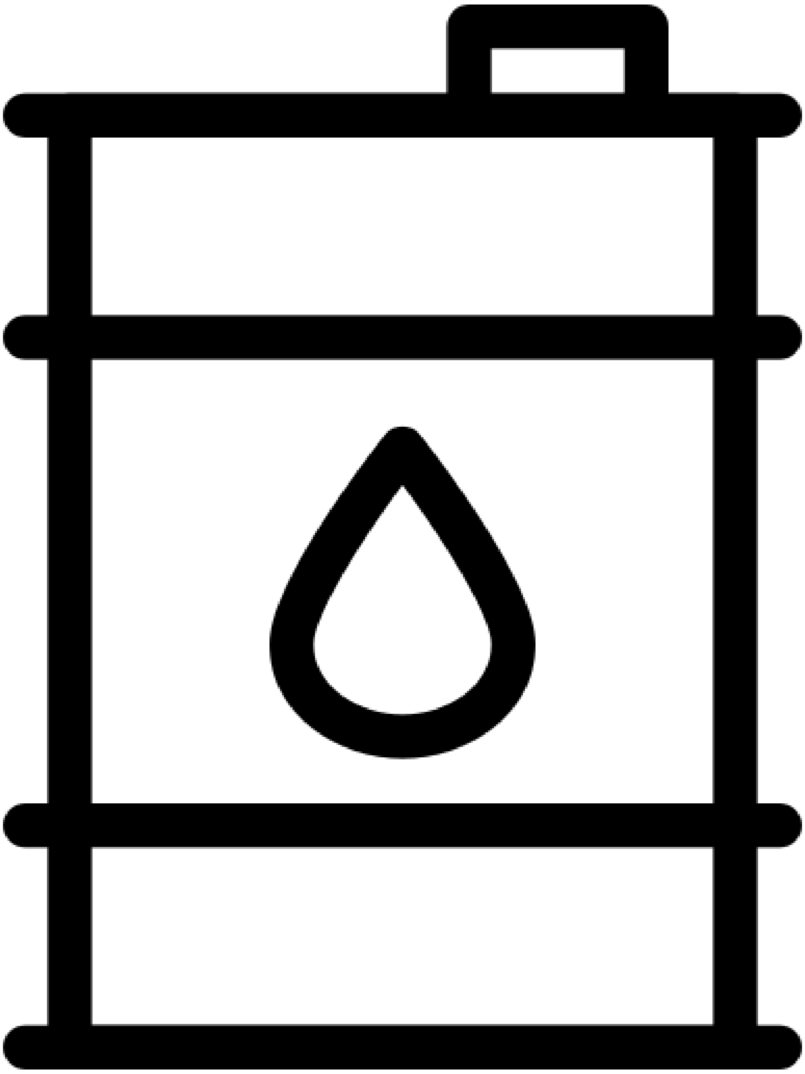
....

b) Describe how we could experimentally verify which of magnesium powder or large pieces of magnesium would have a higher rate of reaction.

....

....

Materials



Metal extraction

Many metals are found in the Earth in rocks called **ores**. To get the metals we need, we have to extract them from these ores. To understand which method we need to use for different metals, we need to recap the **reactivity series**.

Metals have different levels of reactivity. Some are very reactive, like potassium and sodium, while others are not very reactive, like gold and silver. The reactivity series (shown below) is a list that shows metals from most reactive to least reactive.

If a metal is less reactive than carbon, then a **displacement reaction** can be used to extract a metal from a metal ore. Metals like zinc, iron and copper tend to react with oxygen to form metal oxide compounds in ores. A reaction that separates a metal from a metal oxide is called a **reduction reaction**.

For example, to extract iron, the iron ore is heated with carbon (in the form of coke) in a blast furnace. The carbon reacts with the oxygen in the iron oxide to form carbon dioxide and leave behind pure iron:

iron oxide + carbon → iron + carbon dioxide

Another example would be separating copper from copper oxide:

copper oxide + carbon → copper + carbon dioxide

If a metal is more reactive than carbon, then carbon would not displace the metal. **Electrolysis** would need to be used to extract the metal from the ore.

As gold and silver are very unreactive, they can be found as a pure metal. Gold and silver therefore don't need to be extracted from ores by chemical reactions.

			Reactivity
Extracted by electrolysis	Potassium	K	Most reactive
	Sodium	Na	
	Lithium	Li	
	Calcium	Ca	
	Magnesium	Mg	
	Aluminium	Al	
	Carbon	C	
Extracted by reduction with carbon	Zinc	Zn	
	Iron	Fe	
	Copper	Cu	
Found in pure form	Silver	Ag	
	Gold	Au	Least reactive

Q1. The following statements are either true or false. State which are true and which are false.

a) Gold can be found as a pure metal.

....

b) Zinc is more reactive than carbon.

....

c) Iron can be extracted from its ore by heating with carbon.

....

d) Aluminium can be extracted from its ore by heating with carbon.

....

e) Magnesium can be extracted from its ore by electrolysis.

....

f) Carbon would not displace calcium from calcium oxide.

....

Q2. Complete the word equation for the displacement reaction between carbon and iron oxide

carbon + iron oxide → .... + ...

Q3. Complete the word equation for the displacement reaction between carbon and zinc oxide.

carbon + zinc oxide → .... + ...

Q4. Copper is extracted from copper oxide using carbon. Write down a word equation for this reaction.

....

Q5. Describe why the below reaction is not possible.

magnesium oxide + carbon → magnesium + carbon dioxide

....

....

Q6. Explain why carbon is used to extract metals like iron and copper but not aluminium.

....

....

....

....

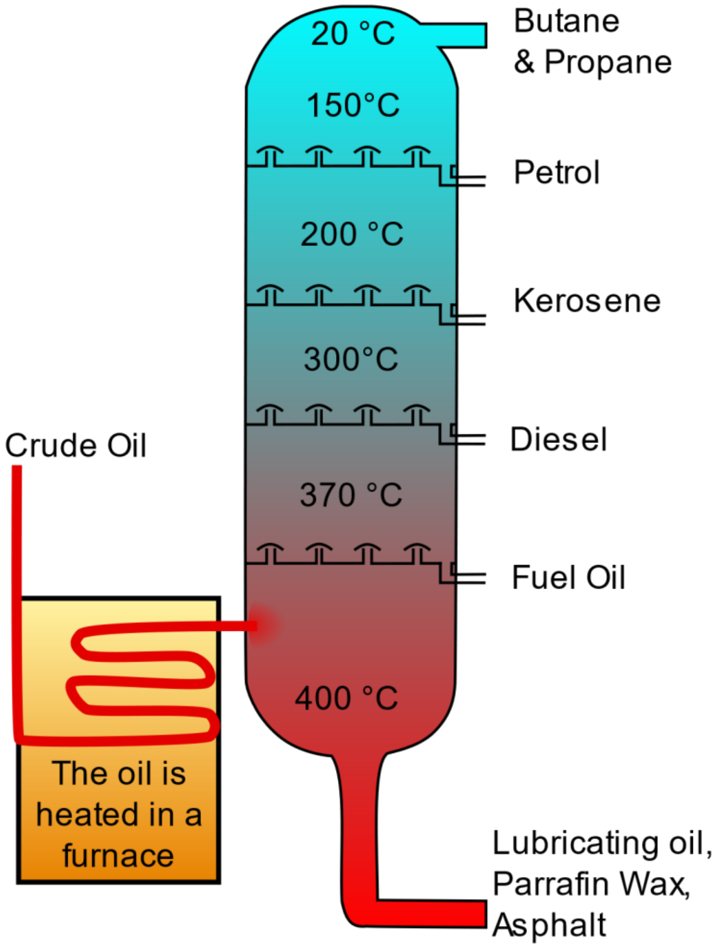
Crude oil

Crude oil is a liquid found deep under the Earth's surface. It is made from the remains of organisms like algae and plankton. These remains were deposited on the sea floor and were covered by sediments. Over millions of years, heat and pressure turned these remains into crude oil.

Crude oil is a mixture of many different substances. These are mostly **hydrocarbons**, which are compounds made of hydrogen and carbon. To use crude oil, we need to separate it into different parts. This is done using a process called **fractional distillation**. In a refinery, crude oil is heated until it turns into a gas. The gas then enters a tall tower called a fractionating column, which is hotter at the bottom and cooler at the top.

As the gas rises up the column, different substances cool down and turn back into liquids at different temperatures. This is because they have different boiling points.

The liquids are collected at various levels of the column. Each level collects a different fraction of the crude oil, such as petrol, kerosene, and diesel. This is why the process is called fractional distillation.



Crude_Oil_Distillation-fr.svg, CC BY-SA 3.0 via Wikimedia Commons

Some of the main uses of these products are:

- **Petrol**: Used as fuel for cars.
- **Diesel**: Is a fuel for trucks, buses, and some cars.
- **Kerosene**: Used as fuel for jet engines and heaters.
- **Fuel Oil**: Used in ships and large industrial plants for heating and power generation.
- **Butane and Propane**: Fuel for cooking, heating, and in lighters. Propane is also used as fuel for some engines and portable stoves.
- **Lubricating oils**: Used to reduce friction in engines and machines.

Burning the fuels made from crude oil releases carbon dioxide (CO_2), which is a greenhouse gas that contributes to **global warming**.

Q1. The following statements are either true or false. State which are true and which are false.

a) A fractionating column is hotter at the top than the bottom.

....

b) Butane, petrol and diesel are examples of products that are made from the fractional distillation of crude oil.

....

c) Petrol has a higher boiling point than diesel.

....

d) Burning fuels made from crude oil releases carbon dioxide.

....

e) Carbon dioxide is a greenhouse gas.

....

Q2. State what is meant by a hydrocarbon.

....

Q3. Describe how crude oil is formed.

....

....

Q4. Describe the process of fractional distillation.

....

....

....

....

Q5. State three products that can be made from crude oil and describe their uses.

....

....

....

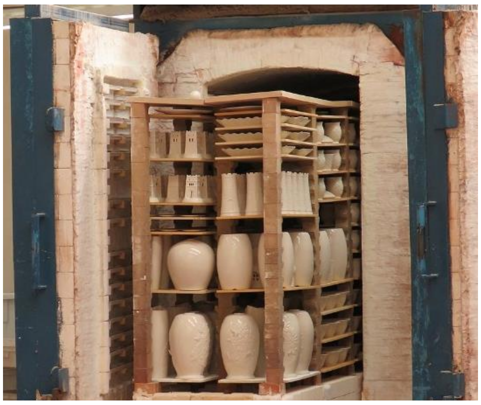
....

Q6. Describe why fuels produced from crude oil would be described as non-renewable resources.

....

....

Ceramics, polymers and composites



Ceramics are made by heating certain materials to high temperatures in a **kiln**. This process changes the properties of the starting material and makes them hard, but brittle. For example, clay can be heated in a kiln (shown in the image) to form pottery, bricks or tiles.

Because ceramics like pottery are brittle, they will break if dropped. Ceramics are also resistant to high temperatures. This is why they are used in cookware.

Polymers are long chains of molecules made by joining many small molecules (monomers) together. There are two main types of polymers: natural and synthetic. Natural polymers include things like rubber and silk, while synthetic polymers are made by humans and include plastics like polythene and polyvinyl chloride (PVC).

Polymers can be flexible or rigid, are usually lightweight and can be moulded into different shapes. This makes them useful for applications such as in plastic bags or plastic bottles and containers for storing food and drinks.

Another property of polymers is that they are electrical and thermal insulators. An application of this is that PVC is used as an electrical insulator around wires. Polymers are also very unreactive. This is advantageous in applications like water bottles so that they don't react with their contents. It does mean that they do not break down quickly after being used, though. This can pose an environmental challenge.

Composites are made by combining two or more different materials to create a new material with improved properties. Each material in a composite keeps its own properties, but together they make the composite stronger, lighter, or more durable. Examples of composites include:

- **Fibreglass** is made from glass fibres and plastic. This combination results in a material that is lightweight like plastic but retains the strength of glass. Fibreglass is commonly used to make boat and car bodies.
- **Concrete** is made from cement, sand, and gravel and results in a material that can withstand high compressive forces. Concrete is therefore used as a building material in bridges, roads and buildings.
- **Carbon fibre** is made from a combination of carbon fibres and polymers and is a strong and lightweight material. It is used in high end sports cars, bicycles and other sports equipment.

Q1. The following statements are either true or false. State which are true and which are false.

a) Polymers are good conductors of electricity.

....

b) Ceramics are brittle.

....

c) Concrete is an example of a composite.

....

d) Polymers are usually very reactive.

....

e) Carbon fibre is a strong and lightweight material.

....

Q2. State an application of fibreglass.

....

Q3. State an application of carbon fibre.

....

Q4. State an application of PVC.

....

Q5. Describe how ceramics are made.

....

....

Q6. Describe why ceramics are suitable for use in cookware.

....

....

Q7. State one example of a polymer and a use for that polymer.

....

....

Q8. Describe the difference between a polymer and a monomer.

....

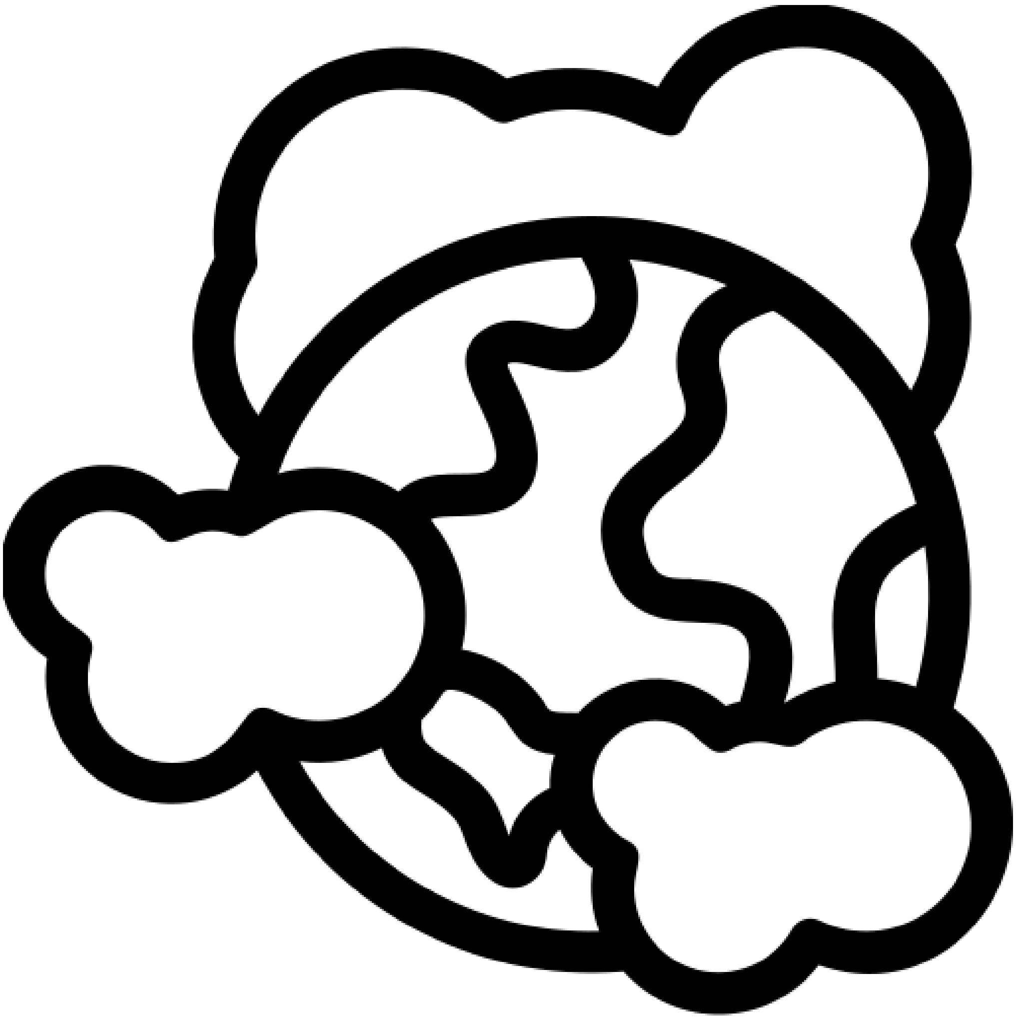
....

Q9. State one composite material and describe what it is made from.

....

....

Earth and the



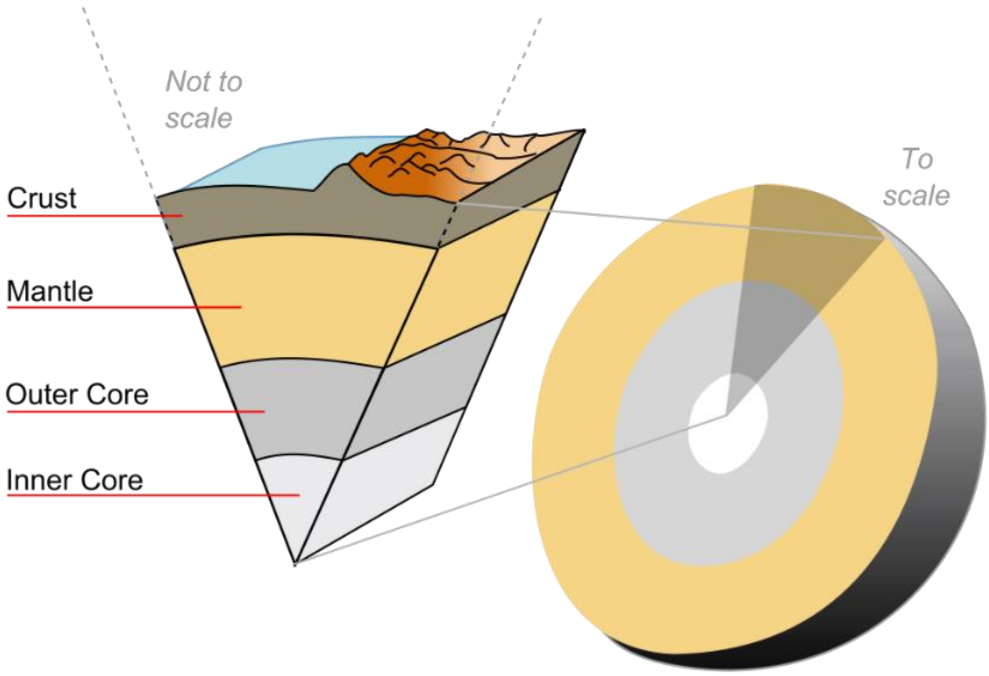
atmosphere

Composition of the Earth

The Earth is roughly spherical and consists of four layers:

1. The **crust** (at the surface of the Earth). The thinnest part of the Earth at 6 to 70 km thick. It is made of rock. The crust is divided into different parts called **tectonic plates**.
2. The **mantle** (below the crust). Around 3000 km thick. It is made of mostly solid rock that flows slowly over time. **Convection currents** in the mantle slowly move the tectonic plates.
3. The **outer core** (below the mantle). A liquid layer that is 2000 km thick. Primarily made of iron and nickel and responsible for the Earth's magnetic field.
4. The **inner core** (at the centre of the Earth). 1400 km radius and the hottest layer of the Earth at 6000 °C. Despite this, the inner core is solid as it experiences more pressure compared to the other layers.

Generally, the temperature of the Earth increases with depth.



Adapted from the public domain image File:Earth-crust-cutaway-english.png by Jeremy Kemp , CC BY-SA 3.0, via Wikimedia Commons

The most abundant elements in the Earth's crust are:

1. Oxygen (46%)
2. Silicon (28%)
3. Aluminium (8%)
4. Iron (6%)

Q1. Name the layer at the centre of the Earth.

....

Q2. State the thickest layer of the Earth, including its thickness.

....

Q3. State the thinnest layer of the Earth, including its thickness.

....

Q4. State the layer of the Earth that is the hottest.

....

Q5. Name all parts of the Earth in order from the outer layer to the inner layer.

....

....

Q6. Name the most abundant element in the Earth's crust.

....

Q7. State what is responsible for the Earth's magnetic field.

....

Q8. Name the different parts that the crust are divided into.

....

Q9. State what convection currents in the mantle lead to.

....

Q10. State what happens to the temperature of the Earth as depth increases.

....

Q11. State what the crust is made of.

....

Q12. State what the outer core is made of.

....

Q13. Describe why the inner core is solid, even though it is a higher temperature than the outer core.

....

....

Q14. State the thickness of the inner core.

....

Q15. State what the mantle is made of.

....

Types of rock and the rock cycle

There are three main types of rock; **sedimentary**, **metamorphic** and **igneous**. Over many years these constantly change from one type to another in the **rock cycle**.

Sedimentary rocks are formed from small rocks and sediment. **Weathering** produces these small rocks and sediment.

Once weathering has occurred, **sediment** is carried by rivers to the sea. Over many years, layers of this sediment build up and pressure compresses the sediment together to form the sedimentary rocks. Two examples of sedimentary rocks are **limestone** and **shale**.

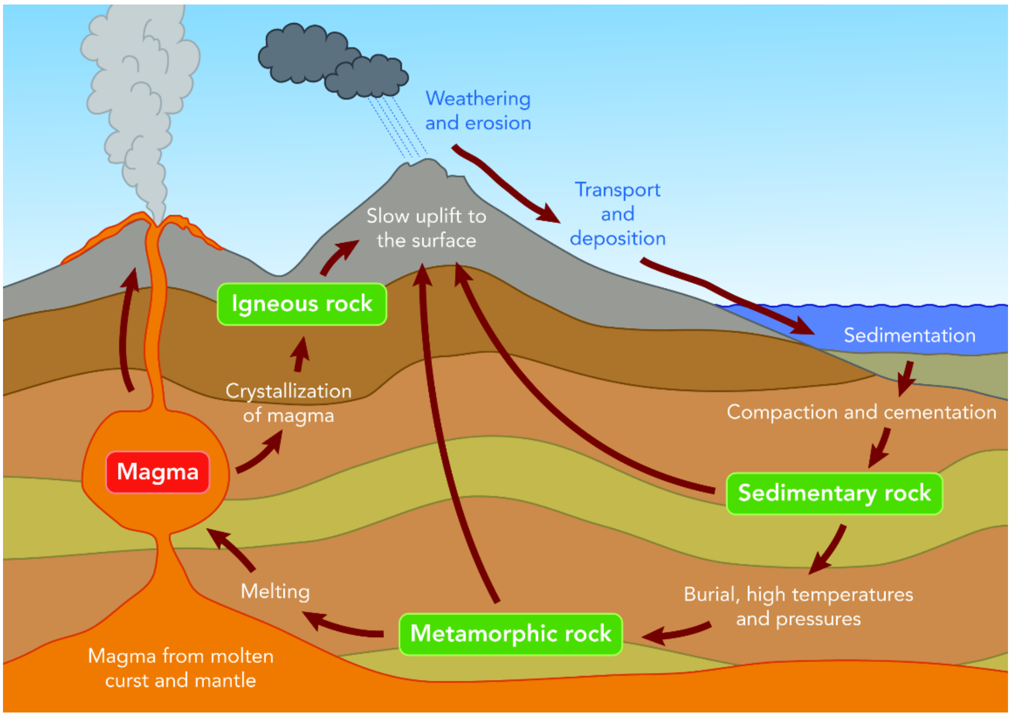
Metamorphic rocks are formed from other types of rocks that experience intense heat and pressure. **Slate** is a metamorphic rock originally made from shale and **marble** is a metamorphic rock made from limestone.

Igneous rocks form when molten rock (called **magma**) cools and solidifies. There are two types of igneous rocks; **intrusive** and **extrusive**.

Extrusive igneous rocks are formed above the Earth's surface. The magma therefore cools and crystallises quickly (leaving small crystals). **Basalt** is an example of an extrusive igneous rock.

Intrusive igneous rocks form when magma cools under the Earth's surface. The temperature under the Earth's surface is higher and so they cool and crystallise slower, forming larger crystals. **Granite** is an example of an intrusive igneous rock.

The diagram below shows these processes in the **rock cycle**.



Q1. State the names of the three different types of rock.

....

Q2. State how sediment is formed.

....

Q3. Describe how sediment forms sedimentary rocks.

....

....

Q4. State one example of a sedimentary rock.

....

Q5. State which rock is formed when limestone experiences intense heat and pressure.

....

Q6. Describe how metamorphic rocks are formed.

....

....

Q7. State one example of a metamorphic rock.

....

Q8. State the name for molten rock.

....

Q9. Describe how igneous rocks are formed.

....

....

Q10. Describe the difference in how intrusive and extrusive igneous rocks are formed.

....

....

Q11. State one example of an igneous rock.

....

Q12. Fossils are only found in sedimentary rocks. Using your knowledge about how metamorphic and igneous rocks are made, explain why this is the case.

....

....

....

Earth's resources

The earth has a **finite** number of resources. Finite means these resources are limited and could run out. As Earth's resources are limited, it's important that humans use them **sustainably**.

This means that we don't overuse the resources that are available to us and that they are available for future generations. This also might mean looking at what alternative resources are available.

Examples of resources we use on Earth are:

- Water
- Land
- Fossil fuels (for example, coal, oil and gas)
- Building materials
- Minerals and ores

To use resources more sustainably, it's important that we **reduce**, **reuse** and **recycle**.

Reducing means cutting back on the amount that we make and therefore limiting the amount of waste created.

Reusing means using the same items again, while recycle means using old resources again and turning them into new materials and objects.

One example of recycling is the recycling of **plastic**. Plastic is made from oil, which is a fossil fuel.

Fossil fuels were formed from the decay of dead plants and animals (like algae and plankton) over millions of years. Because it takes so long for fossil fuels to form, they are considered finite.

It is therefore more sustainable to recycle plastics. It is also cheaper and more energy efficient.

Another example of recycling is the recycling of **aluminium**.

Drinks cans are often made of aluminium. It would take more energy and cost more to extract new aluminium and so the drinks cans are recycled. Used cans can be melted and then turned into new cans. Other metals can be recycled in a similar way.

Q1. Explain what the term "finite" means.

....

....

Q2. State three ways that we can use resources more sustainably.

....

Q3. State three fossil fuels.

....

Q4. Describe how fossil fuels were formed.

....

....

Q5. Explain why fossil fuels are considered to be finite.

....

....

Q6. Describe what recycling means.

....

....

Q7. Describe how aluminium cans can be recycled.

....

....

Q8. State one other material that can be recycled.

....

Q9. State two benefits of recycling.

....

....

Q10. State what plastic is made from.

....

Q11. Describe what using resources sustainably means.

....

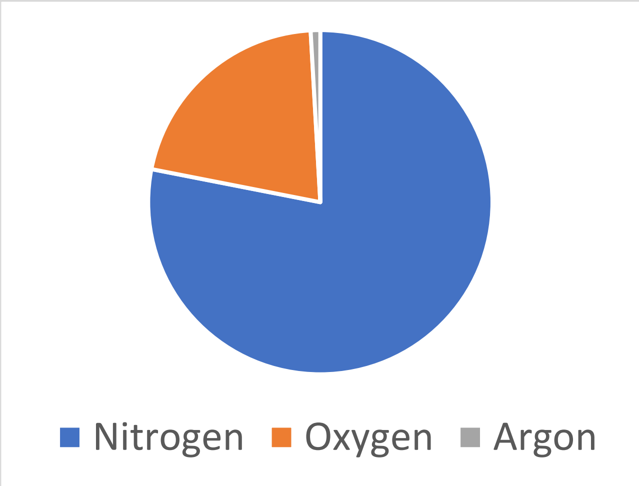
....

Earth's atmosphere

The most abundant gas in Earth's atmosphere is **nitrogen**, which accounts for 78% of the atmosphere.

The next most abundant gases are **oxygen** (at 21%) and **argon** (at 0.9%). These are shown in the pie chart opposite.

Carbon dioxide is also present in the atmosphere (at 0.04%), as well as small amounts of other gases.



The atmosphere of Earth has not always had this composition, though.

Earth was formed around 4.5 billion years ago and there was initially very intense volcanic activity. This volcanic activity led to an atmosphere which consisted of mostly carbon dioxide (and a smaller amount of water vapour). As the Earth cooled, this water vapour condensed to form oceans.

A single celled organism called **cyanobacteria** then arrived on Earth and carried out **photosynthesis**. In photosynthesis, carbon dioxide and water are (in the presence of light) used to produce glucose and oxygen.

Photosynthesis is responsible for producing oxygen on Earth.

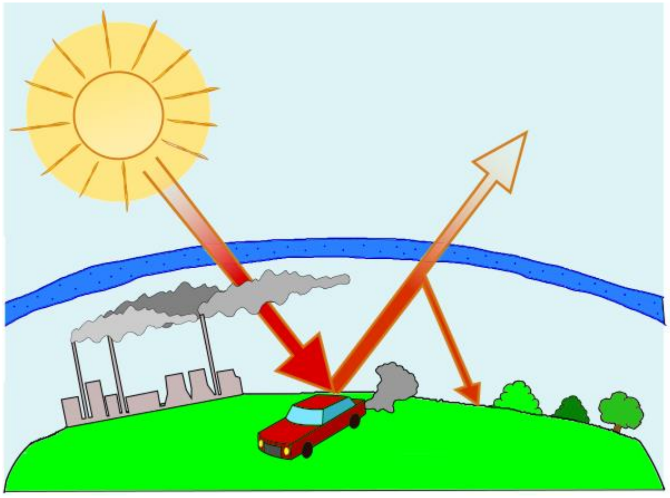
Carbon dioxide is also known as a **greenhouse gas**. Greenhouse gases are responsible for **global warming** (a raising of the average temperature of Earth).

Thermal (infra-red) radiation reaches the Earth from the Sun. The Earth absorbs and re-emits some infra-red radiation, but greenhouse gases reflect some of this back to Earth.

Due to this, the average temperature of the Earth is raised.

Burning **fossil fuels** (like oil, coal or gas) increases the amount of carbon dioxide in the atmosphere.

The global warming caused by this can cause more extreme weather events and lead to melting of the polar ice caps. This can cause flooding of low-lying countries.



Lars Ebbersmeyer, CC BY-SA 4.0, via Wikimedia Commons

Q1. State the three most abundant gases in the Earth's atmosphere.

....

Q2. State the percentage of Nitrogen in the Earth's atmosphere.

....

Q3. State the percentage of Oxygen in the Earth's atmosphere.

....

Q4. Describe the differences in the Earth's early atmosphere and the atmosphere now.

....

....

Q5. Describe the role of cyanobacteria in changing the composition of Earth's atmosphere.

....

....

Q6. State what global warming is.

....

Q7. Describe how greenhouse gases lead to global warming.

....

....

Q8. State what burning fossil fuels does to the levels of carbon dioxide in the atmosphere.

....

Q9. Name the three fossil fuels.

....

Q10. State two effects of global warming.

....

....

Q11. Venus has an atmosphere that mostly consists of carbon dioxide. Describe the effect that this has on Venus' average temperature.

....

....

Q12. Describe the effect that deforestation has on the carbon dioxide levels on Earth. Explain why planting more trees would be beneficial in reducing levels of global warming.

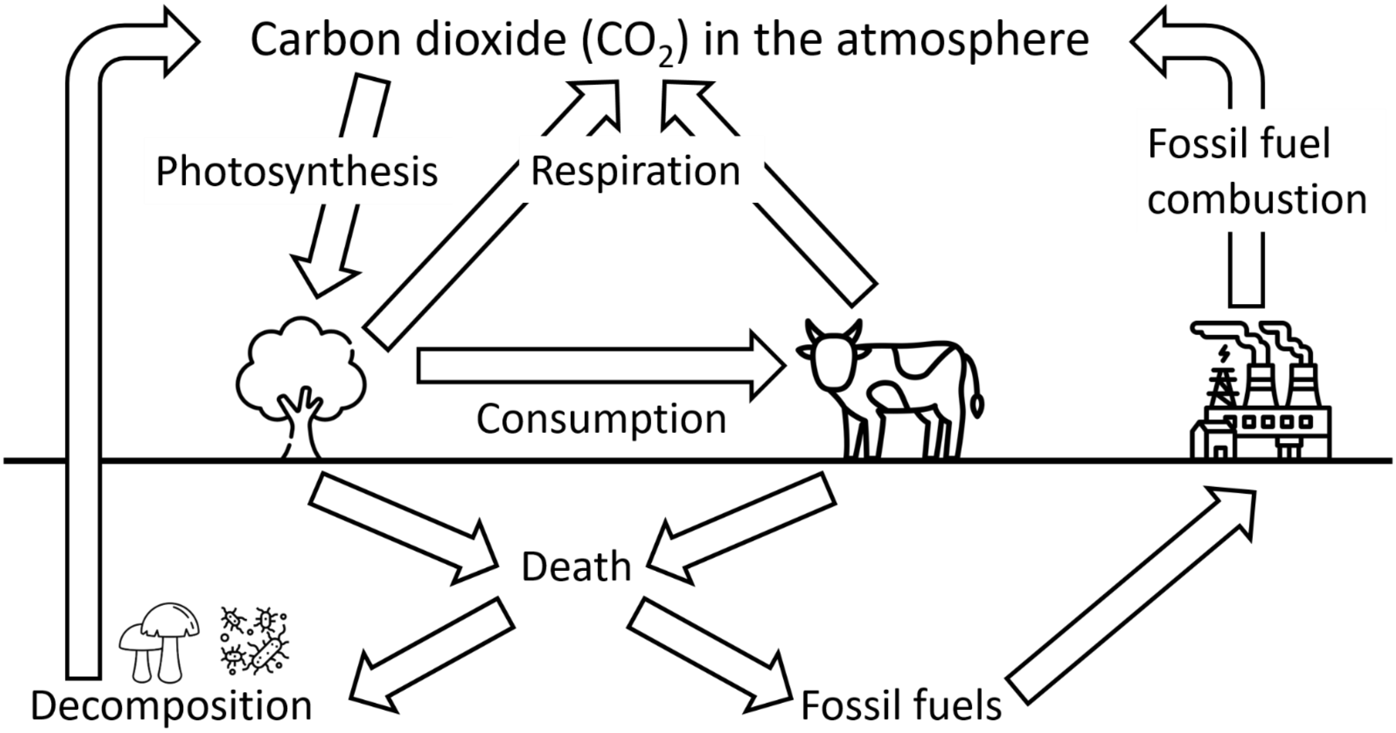
....

....

....

Carbon cycle

The **carbon cycle** describes the continuous movement of carbon into and out of the atmosphere, animals, plants and the ground. The diagram below shows this cycle.



Carbon in the atmosphere is in the form of **carbon dioxide**. Carbon dioxide is removed from the atmosphere by **photosynthesis**. Photosynthesis is a chemical process carried out by **plants**. Glucose and oxygen are made from carbon dioxide and water (under the presence of light).

While plants take carbon dioxide out of the atmosphere through photosynthesis, they also put some back into the atmosphere through **respiration**. Overall, though, plants remove more carbon dioxide from the atmosphere than they put back into it.

Animals also release carbon dioxide through respiration.

Carbon dioxide is also released into the atmosphere by **decomposition** of the remains of plants and animals. Decomposers (**bacteria** and **fungi**) break down dead organisms into simpler substances.

When conditions do not allow for decomposition, the remains of plants and animals also produce **fossil fuels**. This is a slow process that takes millions of years. Humans burn fossil fuels (like coal, oil and gas) in power plants and vehicles. This process releases carbon dioxide, which is a greenhouse gas. Greenhouse gases contribute to **global warming**.

Q1. Describe what the carbon cycle is.

Q2. State the name of the process that removes carbon dioxide from the atmosphere.

Q3. State three processes that release carbon dioxide into the atmosphere.

Q4. Name two decomposers.

Q5. Describe what decomposers do.

Q6. State what fossil fuels are formed from.

Q7. Name three fossil fuels.

Q8. State what burning fossil fuels does to the levels of carbon dioxide in the atmosphere.

Q9. State two uses of burning fossil fuels.

Q10. Carbon dioxide is a greenhouse gas. State what having a large amount of greenhouse gases in the atmosphere leads to.

Q11. Describe the effect that planting more trees would have on the levels of carbon dioxide in the atmosphere.

Q12. Describe what photosynthesis is.

Q13. Humans are increasingly looking at reducing the amount of fossil fuels burnt. Describe the effect that this would have on the carbon dioxide levels in the atmosphere and the effect this would have on global warming.

Answers

This is the free version of the Science Doctor KS3 Chemistry workbook. Hundreds of hours have gone into writing this workbook and sharing it freely. Answers are contained in the physical copy on Amazon. To support the work that has gone into this book, please consider buying one on Amazon.