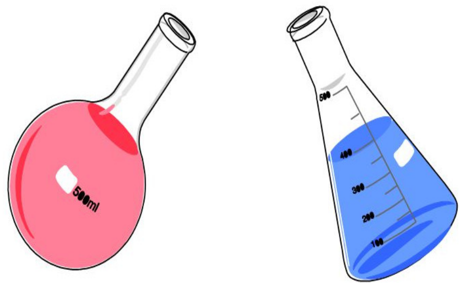
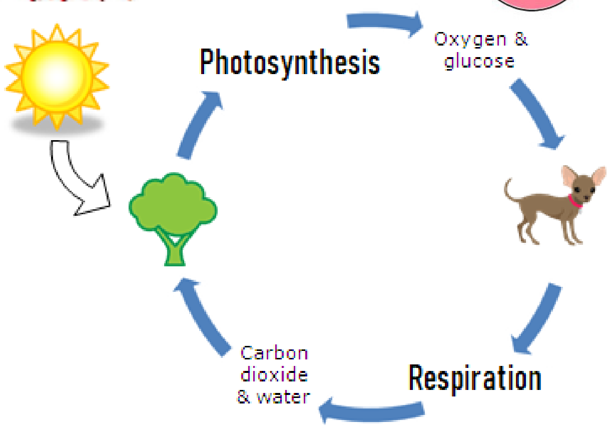
St. Ninian's High School





S2 Chemistry

Pupil notes

Name ____________________ **Teacher** ________

Unit 1
Substances and Reactions

Unit 1: Substances & Reactions Learning Outcomes

Elements

1. Everything in the world is made from about 100 elements.
2. Each element has a name, an atomic number and a unique symbol.
3. Chemists have arranged elements in the Periodic Table.
4. Most elements are solid at room temperature.
5. Mercury and bromine are liquid at room temperature.
6. Hydrogen, Helium, Nitrogen, Oxygen, Fluorine, Neon, Chlorine, Argon, Krypton, Xenon & Radon are gases at room temperature.
7. Elements can be classified as metals or non-metals.
8. There are more metals than non-metals in the Periodic Table.
9. Metals are all conductors of electricity
10. The most recently discovered elements have been made by scientists.
11. Elements with similar chemical properties are placed together in vertical groups.
12. Identify, name and describe the reactivity of the following groups in the Periodic Table
    - Alkali metals group 1
    - Halogens group 7
    - Noble gases group 8

Compounds and mixtures

13. Compounds are formed when elements react together.
14. Most compounds with a name ending in '-ide' contain the two elements indicated; the ending '-ite' or '-ate' indicates the additional element oxygen.
15. Mixtures occur when two or more substances come together without reacting.
16. Mixtures can be separated using the following techniques:
    a) Filtration
    b) Evaporation
    c) Magnetism
    d) Distillation
    e) Chromatography

Unit 1: Substances & Reactions Learning Outcomes continued

Chemical reactions

17. Know the following prefixes

Prefix	Meaning
Mono	1
Di	2
Tri	3
Tetra	4

18. All chemical reactions involve the formation of one or more new substances.
19. Chemical reactions can be identified by changes including colour change, gas evolved, change in temperature
20. Chemical reactions can be identified by energy changes.
21. Chemical reactions can be speeded up by using more concentrated solutions, increasing temperatures and using finely powdered solids.

You should be able to

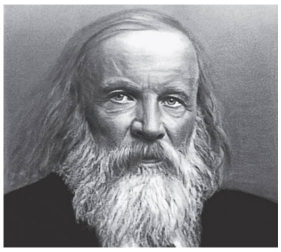
22. Write a chemical formula for a molecule
23. Write a word equation for a reaction
24. Identify variables in reactions
25. Write a chemical formula from a name e.g. Sulfur dioxide must be SO_2
26. Work out a name from a chemical formula, Carbon tetrachloride is CCl_4.

Unit 1: Substances and Reactions

Chemical Elements

Elements and the Periodic Table

Everything in the world is made up of substances called elements. There are about 100 different elements in the world. The elements are listed in the periodic table of the elements.



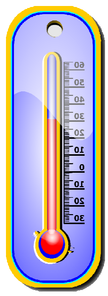
Mendeleev, a Russian chemist who made the first periodic table in 1867.

hydrogen 1 **H** 1.0079																		helium 2 **He** 4.0026
lithium 3 **Li** 6.941	beryllium 4 **Be** 9.0122												boron 5 **B** 10.811	carbon 6 **C** 12.011	nitrogen 7 **N** 14.007	oxygen 8 **O** 15.999	fluorine 9 **F** 18.998	neon 10 **Ne** 20.180
sodium 11 **Na** 22.990	magnesium 12 **Mg** 24.305												aluminium 13 **Al** 26.982	silicon 14 **Si** 28.086	phosphorus 15 **P** 30.974	sulfur 16 **S** 32.065	chlorine 17 **Cl** 35.453	argon 18 **Ar** 39.948
potassium 19 **K** 39.098	calcium 20 **Ca** 40.078		scandium 21 **Sc** 44.956	titanium 22 **Ti** 47.867	vanadium 23 **V** 50.942	chromium 24 **Cr** 51.996	manganese 25 **Mn** 54.938	iron 26 **Fe** 55.845	cobalt 27 **Co** 58.933	nickel 28 **Ni** 58.693	copper 29 **Cu** 63.546	zinc 30 **Zn** 65.39	gallium 31 **Ga** 69.723	germanium 32 **Ge** 72.61	arsenic 33 **As** 74.922	selenium 34 **Se** 78.96	bromine 35 **Br** 79.904	krypton 36 **Kr** 83.80
rubidium 37 **Rb** 85.468	strontium 38 **Sr** 87.62		yttrium 39 **Y** 88.906	zirconium 40 **Zr** 91.224	niobium 41 **Nb** 92.906	molybdenum 42 **Mo** 95.94	technetium 43 **Tc** [98]	ruthenium 44 **Ru** 101.07	rhodium 45 **Rh** 102.91	palladium 46 **Pd** 106.42	silver 47 **Ag** 107.87	cadmium 48 **Cd** 112.41	indium 49 **In** 114.82	tin 50 **Sn** 118.71	antimony 51 **Sb** 121.76	tellurium 52 **Te** 127.60	iodine 53 **I** 126.90	xenon 54 **Xe** 131.29
caesium 55 **Cs** 132.91	barium 56 **Ba** 137.33	57-70 *	lutetium 71 **Lu** 174.97	hafnium 72 **Hf** 178.49	tantalum 73 **Ta** 180.95	tungsten 74 **W** 183.84	rhenium 75 **Re** 186.21	osmium 76 **Os** 190.23	iridium 77 **Ir** 192.22	platinum 78 **Pt** 195.08	gold 79 **Au** 196.97	mercury 80 **Hg** 200.59	thallium 81 **Tl** 204.38	lead 82 **Pb** 207.2	bismuth 83 **Bi** 208.98	polonium 84 **Po** [209]	astatine 85 **At** [210]	radon 86 **Rn** [222]
francium 87 **Fr** [223]	radium 88 **Ra** [226]	89-102 **	lawrencium 103 **Lr** [262]	rutherfordium 104 **Rf** [261]	dubnium 105 **Db** [262]	seaborgium 106 **Sg** [266]	bohrium 107 **Bh** [264]	hassium 108 **Hs** [269]	meitnerium 109 **Mt** [268]	ununnilium 110 **Uun** [271]	unununium 111 **Uuu** [272]	ununbium 112 **Uub** [277]		ununquadium 114 **Uuq** [289]				

*Lanthanide series	lanthanum 57 **La** 138.91	cerium 58 **Ce** 140.12	praseodymium 59 **Pr** 140.91	neodymium 60 **Nd** 144.24	promethium 61 **Pm** [145]	samarium 62 **Sm** 150.36	europium 63 **Eu** 151.96	gadolinium 64 **Gd** 157.25	terbium 65 **Tb** 158.93	dysprosium 66 **Dy** 162.50	holmium 67 **Ho** 164.93	erbium 68 **Er** 167.26	thulium 69 **Tm** 168.93	ytterbium 70 **Yb** 173.04
**Actinide series	actinium 89 **Ac** [227]	thorium 90 **Th** 232.04	protactinium 91 **Pa** 231.04	uranium 92 **U** 238.03	neptunium 93 **Np** [237]	plutonium 94 **Pu** [244]	americium 95 **Am** [243]	curium 96 **Cm** [247]	berkelium 97 **Bk** [247]	californium 98 **Cf** [251]	einsteinium 99 **Es** [252]	fermium 100 **Fm** [257]	mendelevium 101 **Md** [258]	nobelium 102 **No** [259]

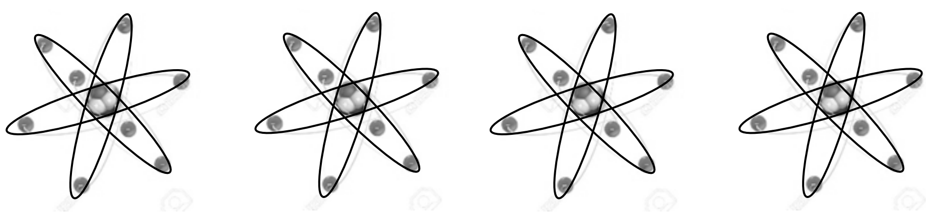
Modern computers use element no. 14 silicon and no. 32 germanium.

Each element has a name and a symbol. Hydrogen is the lightest of all the elements and has the symbol H. The next lightest element is Helium which has the symbol He. Hydrogen is the simplest and smallest atom of any element. It is given an atomic number of 1. Helium is the next simplest element, it is given the atomic number 2.



Some thermometers contain element no. 80, mercury which is a liquid. However, the thermometers we use in school contain alcohol, because mercury is toxic.

Most elements are made of much more complicated atoms. Carbon, an element found in all living things has an atomic number of 6, and has the symbol C. As you can see the atoms of different elements are different from each other. But atoms of the same element are the same as each other.



All atoms of carbon are identical!

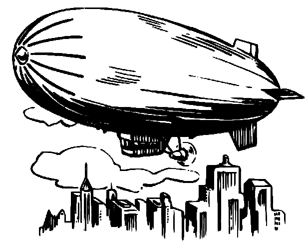
Types of Elements

Solids, liquids & gases

Most of the elements are solids at room temperature. Out of more than 100 elements only 13 are not solid.

Eleven elements are gases at room temperature. These are listed below along with their symbols:

Hydrogen, H	Helium, He	Nitrogen, N
Oxygen, O	Fluorine, F	Chlorine, Cl
Neon, Ne	Argon, Ar	Xenon, Xe
Radon, Ra	Krypton, Kr	



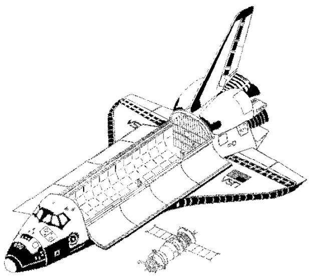
Airships originally were filled with Hydrogen, they are now filled with helium. Both hydrogen and helium are gas elements.

Metals & Non Metals

Metals have the following properties:

- Good conductors of Heat
- Good conductors of electricity
- Can be hammered into shape.
- Most of the elements are metals.

Page 6 of the data booklet shows the metal and non-metal elements.



Many different metals are used to make the space shuttle.

Mercury and bromine are the only liquid elements in the periodic table.

Bromine (Br)

Mercury (Hg)

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 0
1 Hydrogen H 1							2 Helium He 2
3 Lithium Li 2,1	4 Beryllium Be 2,2	5 Boron B 2,3	6 Carbon C 2,4	7 Nitrogen N 2,5	8 Oxygen O 2,6	9 Fluorine F 2,7	10 Neon Ne 2,8
11 Sodium Na 2,8,1	12 Magnesium Mg 2,8,2	13 Aluminium Al 2,8,3	14 Silicon Si 2,8,4	15 Phosphorus P 2,8,5	16 Sulfur S 2,8,6	17 Chlorine Cl 2,8,7	18 Argon Ar 2,8,8
19 Potassium K 2,8,8,1	20 Calcium Ca 2,8,8,2	31 Gallium Ga 2,8,18,3	32 Germanium Ge 2,8,18,4	33 Arsenic As 2,8,18,5	34 Selenium Se 2,8,18,6	35 Bromine Br 2,8,18,7	36 Krypton Kr 2,8,18,8
37 Rubidium Rb 2,8,18, 8,1	38 Strontium Sr 2,8,18, 8,2	49 Indium In 2,8,18, 18,3	50 Tin Sn 2,8,18, 18,4	51 Antimony Sb 2,8,18, 18,5	52 Tellurium Te 2,8,18, 18,6	53 Iodine I 2,8,18, 18,7	54 Xenon Xe 2,8,18, 18,8
55 Caesium Cs 2,8,18, 18,8,1	56 Barium Ba 2,8,18, 18,8,2	81 Thallium Tl 2,8,18, 32,18,3	82 Lead Pb 2,8,18, 32,18,4	83 Bismuth Bi 2,8,18, 32,18,5	84 Polonium Po 2,8,18, 32,18,6	85 Astatine At 2,8,18, 32,18,7	86 Radon Rn 2,8,18, 32,18,8
87 Francium Fr 2,8,18,32, 18,8,1	88 Radium Ra 2,8,18,32, 18,8,2						

← The elements on this side of the dark line are metals. The elements on this side of the dark line are non-metals. →

Elements and groups

New elements were found in he clouds from atomic bombs.

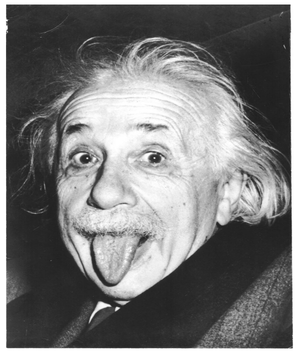
Elements in History

Some elements have been known for a very long time. Over 500 years ago the Egyptians used gold, iron, and copper. These metals were rare and expensive. The year of discovery of elements is shown on page 7 of the data booklet.

The mask of Tutankhamun is made of gold

New Elements

Of the more than 100 elements known, less than 90 are natural. All of the other elements have been made by scientists. Most of the new elements can only be made in very small amounts.



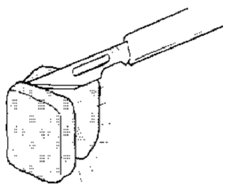
Albert Einstein, element number 99; Einsteinium was made by scientists in 1957.

Groups in the Periodic Table

Elements in the same group in the periodic table all show similar properties. We can see this if we examine group one.

Group one elements

The group one elements are called the **Alkali Metals**. The Alkali metals are all soft and can cut by a knife. They are also very reactive, and react quickly with water.



Li lithium
Na sodium
K potassium
Rb rubidium
Cs caesium
Fr francium

The group one elements

Group seven elements

The group seven elements are called the **Halogens.** The Halogens are also very re-active elements.

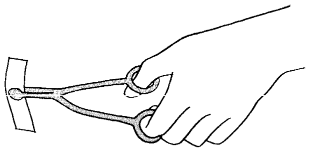
Group eight elements

The group eight elements are called the **No-ble Gases**. The Noble Gases are very unreactive.

Chlorine, a group 7 element, is used to make bleach.

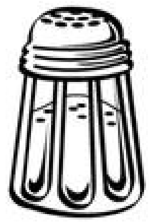
Compounds

Making compounds

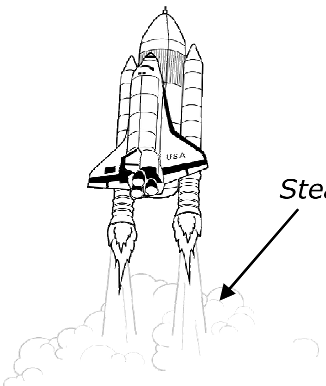


Heating magnesium changes it into magnesium oxide.

When a piece of magnesium is held in tongs and heated in a Bunsen flame it burns brightly to form a white powder. This powder is a compound of magnesium and oxygen. The two elements have joined to make a new substance called magnesium oxide.



The chemical name for salt is sodium chloride, a compound of the elements sodium and chlorine.



Launching the space shuttle

The space shuttle gets its power by burning hydrogen with oxygen. The hydrogen and oxygen react together to form a compound called hydrogen oxide- this is the chemical name for water. The clouds of 'smoke' seen when the shuttle launches are in fact clouds of steam.

The chemical name for water is hydrogen oxide. It is a compound containing the elements hydrogen and oxygen.

Naming Compounds

The name of a compound tells us the elements present in the compound.
Compounds ending in **'ide'** contain **only the two elements** given in the name. For example, rust has the chemical name iron ox<u>ide</u>. It contains the elements iron and oxygen.
The 'stinky' gas which comes from bad eggs is called hydrogen sulfide. The name tells us that it contains hydrogen and sulfur.
If a compound ends in **hydroxide**, then it is an **exception to the rule** e.g. calcium hydroxide contains calcium hydrogen and oxygen.

Prefixes

The bubbles in lemonade contain the gas carbon <u>di</u>oxide- a compound of carbon and oxygen. The ***di*** part of the name tells us that there are **two atoms** of oxygen for every atom of carbon. Sulfur <u>tri</u>oxide contains **three atoms** of oxygen for every atom of sulfur.

Lemonade contains carbon dioxide, CO_2.

Complex Compounds

Three element compounds

Until now we have only looked at compounds made from two elements. More complicated compounds exist. Any compound whose name ends in '-**ate**' contains oxygen. e.g.

- Potassium sulfate contains potassium, sulfur, and oxygen.
- Sodium carbonate contains sodium, carbon, and oxygen.
- Aluminium nitrate contains aluminium, nitrogen, and oxygen.
- Magnesium phosphate contains magnesium, phosphorus, and oxygen.

Aspirin is a very complicated chemical which contains the three elements; carbon, hydrogen and oxygen.

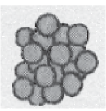
Similarly the ending **'-ite'** also tells us that a compound contains oxygen e.g.

- sodium nitrite contains the elements sodium, nitrogen and oxygen.
- Calcium sulfite contains the elements calcium, sulfur and oxygen.

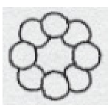
-'Ate' means oxygen. Plants make carbohydrates, compounds of carbon, hydrogen and oxygen.

Mixtures

Sulfur and copper are both elements. Sulfur is a yellow coloured solid and copper is a red-brown solid. When the two elements are mixed together nothing happens. The mixture contains atoms of sulfur and atoms of copper. The atoms have not joined together. This is a mixture of sulfur and copper.



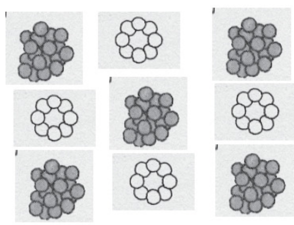
Atoms of copper joined to other atoms of copper.



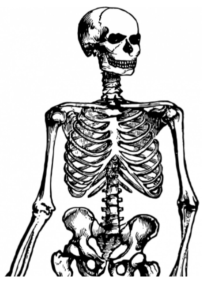
Atoms of sulfur, joined to other atoms of sulfur.

Copper is an element, its atoms are identical. Sulfur is an element, its atoms are also identical, but **not** the same as atoms of copper.

In a mixture, the atoms of copper and sulfur **do not join**. They can be separated from each other. On the right is a mixture. You can clearly see the separate atoms of copper and sulfur.



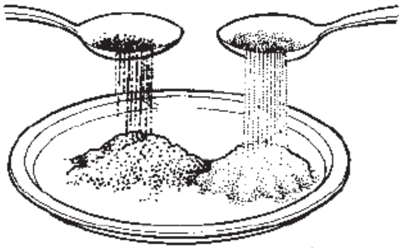
A mixture of copper and sulfur.



Our bones contain calcium phosphate. A compound of the elements contain calcium, phosphorus and oxygen.

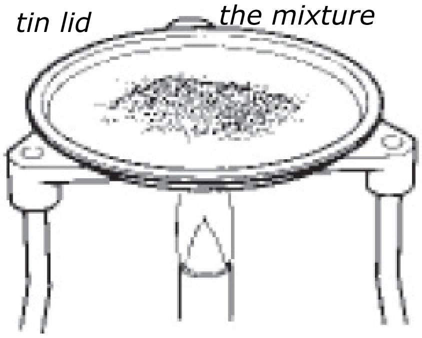
Making compounds

On page 10 we saw that when copper and sulfur were mixed together they did not react. We had only made a mixture of copper and sulfur. The atoms of copper and sulfur were not joined to each other.



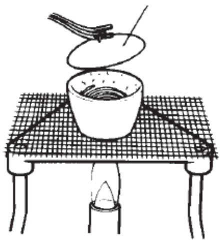
Nothing happens when the elements are mixed.

Cars use petrol as a fuel. Petrol is a hydrocarbon: a compound containing only two elements; hydrogen and



Heat is needed to start the ***chemical reaction***

If we start to heat the mixture of copper and sulfur things happen. The mixture begins to glow and give out energy. The atoms of copper and sulfur are joining together. They are reacting with each other to form the compound copper sulfide.



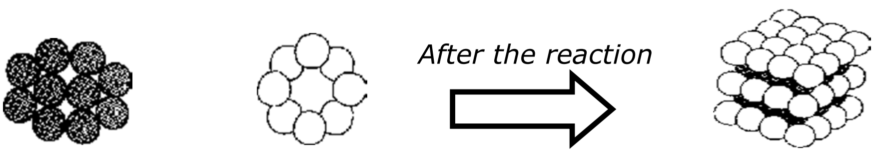
When magnesium is heated, it reacts with oxygen to make the compound magnesium oxide.

The magnesium oxide (white powder) looks completely different from the original elements. Magnesium is a shiny grey colour and oxygen is a colourless gas.

The new compound formed looks very different from the original elements.

When the reaction has stopped we can no longer see the colours of copper (red/ brown) or sulphur (yellow). The copper and sulfur atoms have joined to make a new substance called copper sulfide. Copper sulfide is a compound of the elements copper and sulfur. We can understand what has happened to the atoms of copper and sulfur if we look at the diagram below.

The copper sulfide compound



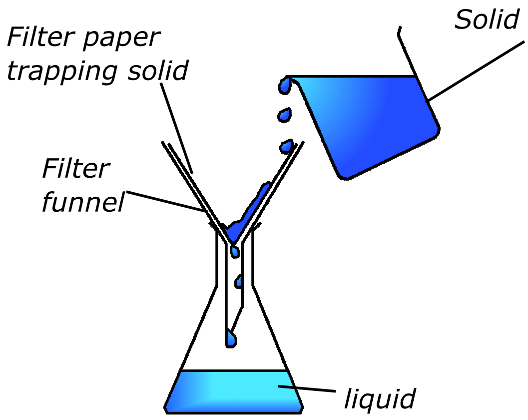
A mixture of copper and sulfur. The atoms are separate.

Copper sulfide. The atoms of copper and sulfur are joined together.

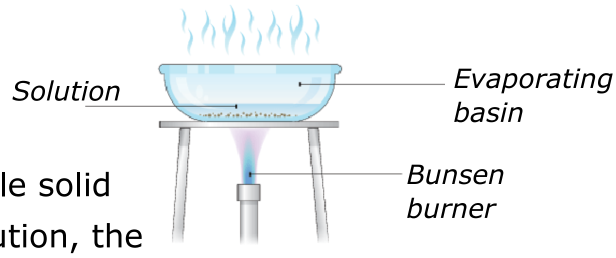
Separating mixtures

Different techniques can be used to separate mixtures.

Filtration



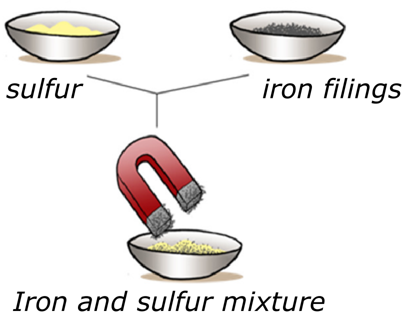
Filtration can be used to separate solids from liquids. The solid is trapped in the filter paper in the filter funnel and the liquid runs through.



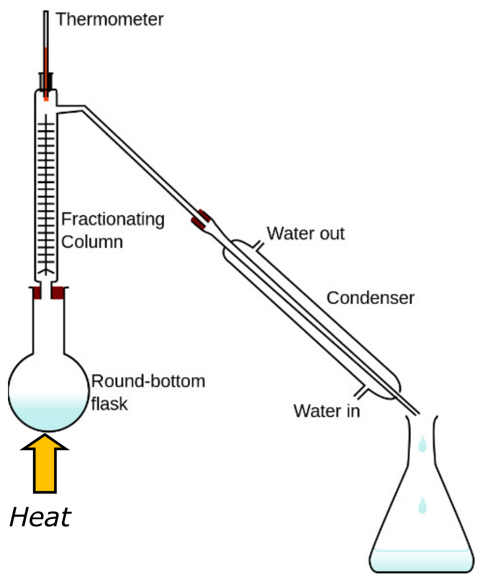
Evaporation

Evaporation can be used to separate a soluble solid from a liquid e.g. if you evaporate a salt solution, the water will evaporate and the salt will be left behind.

Magnetism



Magnetism can be used to separate magnetic metals (iron, cobalt and nickel) from non-magnetic materials.

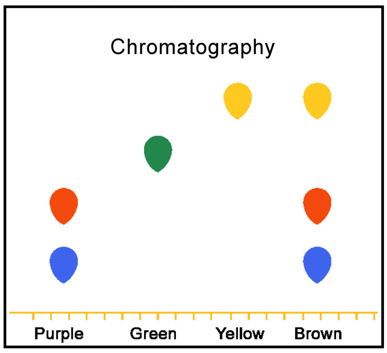


Distillation

This is used to separate a liquid from a mixture of two or more liquids.

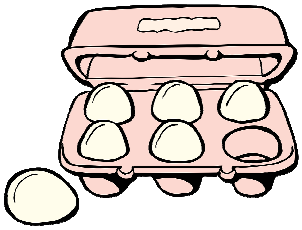
Chromatography

This is used to separate dissolved substances from one another. It is used when the dissolved substances are coloured e.g. inks, food colourings and plant dyes. It works because some of the coloured substances dissolve in the solvent used better than others, so they travel further up the paper.

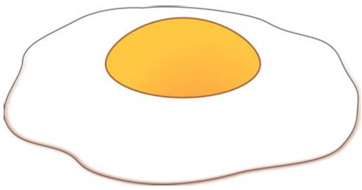


Chemical reactions

Changes


A mixture of chemicals

Eggs contain various chemicals, proteins, fats, minerals, and vitamins, as well as water. When the egg is heated these chemicals change, we say that a chemical reaction has occurred.


After the reaction

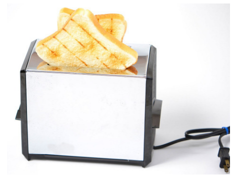
The cooked egg is solid, it is very different from the uncooked egg.

In chemical reactions new substances are formed. These new substances can look very different from the original substances.

A new products is always formed in a chemical reaction.

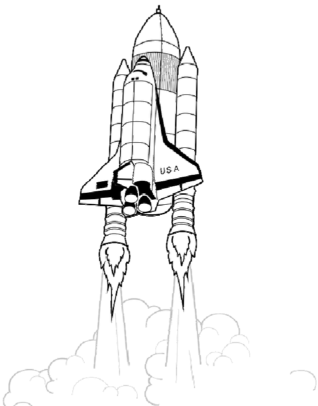
Signs of a chemical reaction are:

- *A colour change*
- *A gas released*
- *An energy change e.g. light, sound, heat (change in temperature)*

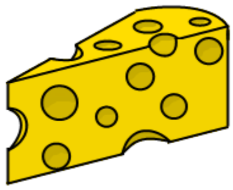

When you toast bread, a chemical reaction occurs.

Energy changes

Many chemical reactions involve energy changes. An example is the reaction which powers the space shuttle. The rocket motors of the shuttle react hydrogen and oxygen together. When the hydrogen and oxygen react together they produce steam and a large amount of heat. The 'smoke' at a shuttle launch is clouds of steam.



Space shuttle take off.


A chemical reaction is used to change milk into cheese.

Burning


Burning magnesium

One of the first chemical reactions you carried out in first year was to burn magnesium. When the magnesium burns it changes chemically. The magnesium is a silvery metal, after burning it changes into a white powder. This change of appearance often happens in chemical reactions. The white powder contains magnesium and oxygen. It is magnesium oxide. The reaction produces a great deal of energy.

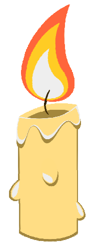

Burning gas in a fire is a chemical reaction. This reaction produces lots of heat.

Word equations

Carbon & oxygen

Charcoal is used as a fuel for barbecues. Charcoal contains the element Carbon which is a good fuel. When the charcoal is heated the carbon in it begins to react with the oxygen in the air. The carbon and oxygen are **reactants.**

Carbon reacting with oxygen to help cook chicken.



Burning wax, another chemical reaction.

When the carbon and oxygen react together they make carbon dioxide. Carbon dioxide is the **product** of the reaction. We show this reaction as a word equation:

carbon + oxygen —> carbon dioxide

Barbecuing is a chemical reaction.

Hydrogen & oxygen

Many elements react with oxygen. Most space rockets use hydrogen as a fuel. In the photograph on the right you can see a space shuttle launch. The large, dark coloured tank attached to the shuttle contains hydrogen and oxygen. These two chemicals react together. They are the reactants. When they react together they make water. Water is the product.

Hydrogen reacting with oxygen.

The word equation for this reaction is:

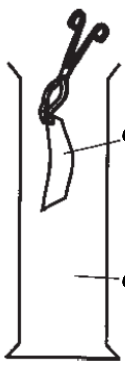
hydrogen + oxygen —> water

Lighters contain propane gas which reacts with oxygen and produces energy.

Copper & chlorine

Copper is a red-brown coloured metal. When a thin sheet of copper is put into a jar of green coloured chlorine gas a reaction occurs. Copper and chlorine are the reactants. A green coloured solid is made which contains both copper and chlorine. This solid is copper chloride. It is the product of the reaction. The word equation for the reaction is:

copper + chlorine —> copper chloride



Copper reacting with chlorine

Speed of reactions

Mixing cement- when cement sets solid– a chemical reaction occurs.

Slow

Iron reacts with water and oxygen in the air to form rust. Rusting is a very slow chemical reaction which can take years to finish.
The photograph on the right shows the Forth rail bridge in Edinburgh which is regularly painted to prevent the bridge rusting away.

Rusting is a very slow reaction

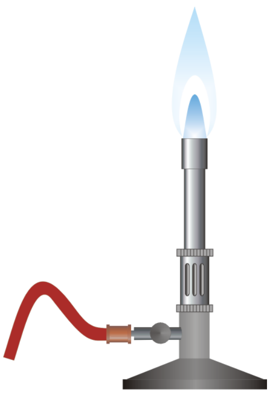
Fire is a chemical reaction which uses up oxygen.

Medium

Cooking food is an example of a medium speed chemical reaction. The vegetables in the stir-fry on the right might take about 10 minutes to cook fully.

Fast reactions

Some chemical reactions are very fast indeed. To push a bullet out of a rifle a small explosion happens. Explosions are chemical reactions which produces large volumes of gases in a very short time. In this case the reaction is over in less than one thousandth of a second.



Bunsen burner: A chemical reaction

Extremely fast reactions

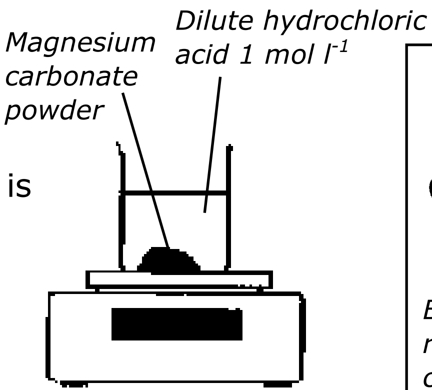
The man on the right, Ahmed Zewail is famous Egyptian Chemist who is interested in extremely fast chemical reactions. He has designed a method for studying reactions which occur in fractions of one millionth of a second. In 1995 he was awarded the Nobel prize for chemistry for his work.

Ahmed Zewail

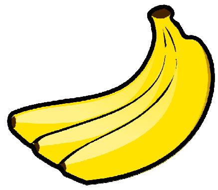
Speed of reactions

Reactions which make gases

If a reaction produces a gas and the gas is allowed to escape then the weight of the reaction mixture will get less.
It is possible to measure how fast the reaction is by measuring how fast the weight falls.



Measuring weight



Bananas become ripe because of chemical reactions.

It is important that these experiments are fair. The results of an experiment are shown below.

Experiment	Concentration of acid (mol per litre)	Form of magnesium carbonate
A	1	Lump
B	2	Lump
C	1	powder

Fire– a chemical reaction which produces heat energy.

If we compare experiments A and B the only difference is the concentration. So any difference in speed of the reactions will be due to the different concentrations.

If we compare experiments A and C the only difference is the difference in the form of the magnesium carbonate. So any difference in the speed of the reactions will be due to the different forms of magnesium carbonate.

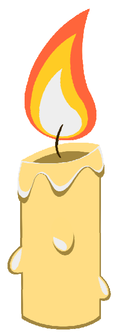
If we compare experiments B and C, both the form of magnesium carbonate and the concentration of the acid are different. We cannot make any conclusions in this case as, in a fair experiment only one thing is changed at a time.

Chemical reactions in batteries produce electricity.

Burning candles

When a candle burns the wax reacts with oxygen from the air to make carbon dioxide and steam. The carbon dioxide and steam are both gases and escape into the air. So when the candle burns the reaction produces gases and the weight of the candle gets less. The word equation for the reaction is:

wax + oxygen —> carbon dioxide + steam



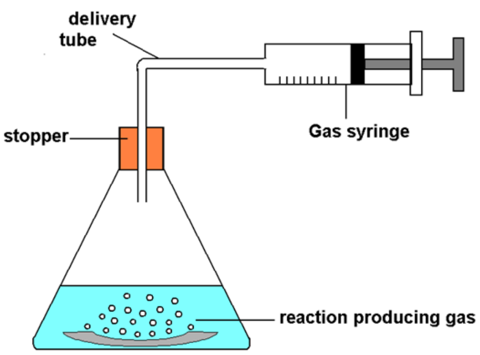
Burning candlewax– a chemical reaction

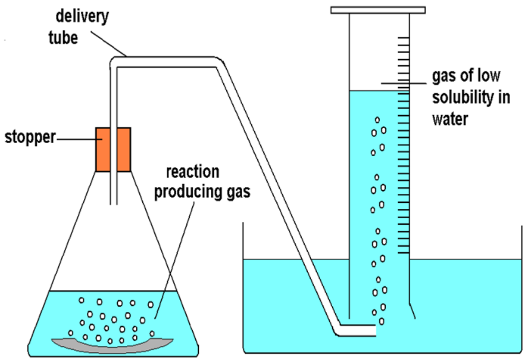
Measuring volumes of gas

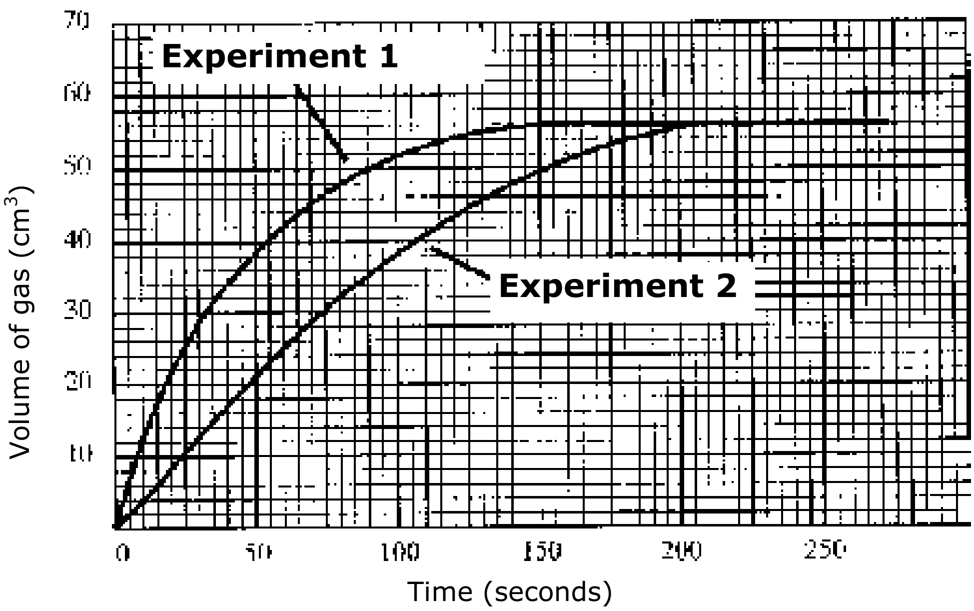
Using syringes

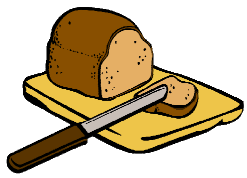
It is possible to measure the speed of reactions by measuring the volume of gas made in a reaction. We can do this using two methods; using a gas syringe or an upturned measuring cylinder. When sulfuric acid reacts with a metal, the reaction makes hydrogen gas. The hydrogen gas is trapped in the gas syringe or the upturned measuring cylinder.

Beer is frothy because the reaction which makes beer also makes a gas.









Bread rises because when bread is made a reactions occurs which makes a gas.

By measuring the volume of gas in the syringe every 20 seconds we can see how fast the reaction is. The results for two experiments are shown in the graph above. After 50 seconds the volumes of gas produced by each experiment is:

Experiment 1: 40 cm^3 **Experiment 2: 20 cm^3**

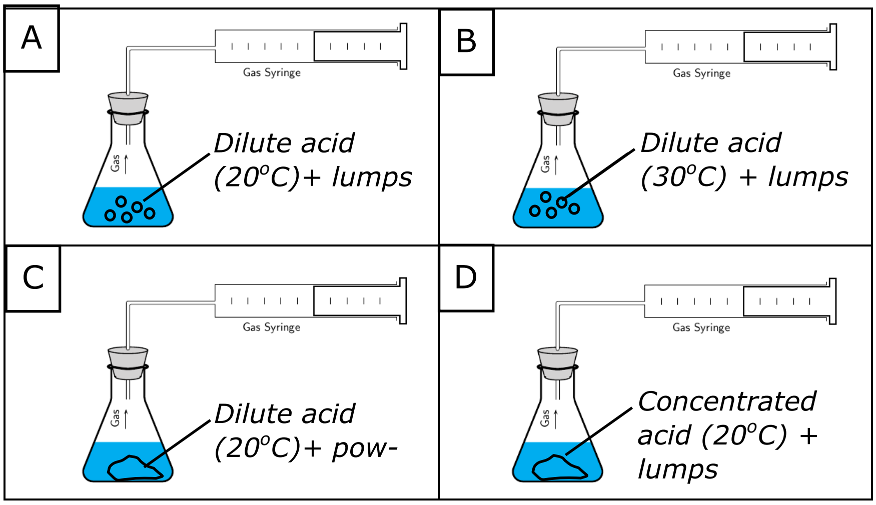
We can see that experiment 1 produces gas faster than experiment 2. The final volume of gas produced by each experiment is 56 cm^3.

The time each experiment takes to produce 56 cm^3 is :

Experiment 1: 150 s **Experiment 2: 200 s**

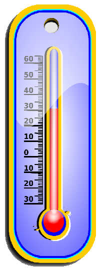
Again we can see that experiment 1 is faster than experiment 2.

Factors affecting reaction speed

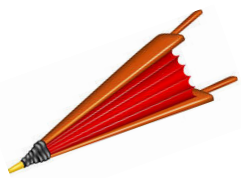


Food is stored in a fridge as the low temperature slows down the speed of decay; another chemical reaction.

Temperature



If we compare experiment A with experiment B the only variable which changes is the temperature. Experiment B is the faster experiment. **Increasing temperature increases the speed of a chemical reaction.**

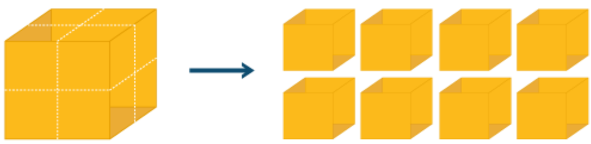


Bellows can be used to increase oxygen concentration in the air being blown into a fire. This helps the fire to burn more efficiently.

Particle size

If we compare experiment A with experiment C the only variable which changes is that A uses lump chalk and C uses powdered chalk. Experiment C is the faster experiment.

Powdered solids normally react faster than lumps.

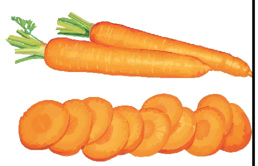


Lumps
(large particle size)

Powder
(small particle size)

Concentration

If we compare experiment C with experiment D the only variable which changes is the concentration of the acid. Experiment D is the faster experiment. **Increasing the concentration of a solution increases the speed of a chemical reaction.**



Chopped carrots cook faster than whole carrots because they have a smaller particle size.

Catalysts

Catalysts are chemicals which can speed up a chemical reaction without being used up. Catalysts remain unchanged in the course of a reaction. Enzymes are biological catalysts.

Keeping Experiments fair

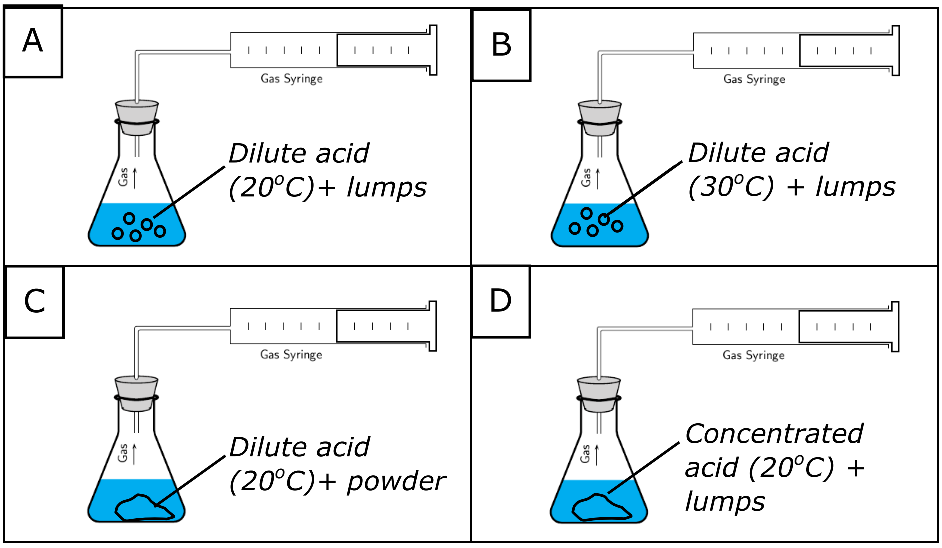
Variables

Anything which we can change in an experiment is called a **variable**.

You should be aware of independent, dependent and control variables for investigations you carry out.

In experiments investigating the speed of reactions the important variables are **temperature**, **concentration** of solutions, whether any solids in the reaction are lumps **or powders** and whether a **catalyst (or enzyme)** is present.

The diagram below shows some experiments carried out with chalk and sulfuric acid.



The **independent variable** is the one that you will change (temperature for reactions A and B above).

The **dependent variable** is the one that you will measure (volume of gas produced for the reactions above).

The **control variables** are those that are kept the same for each experiment so that you are performing a fair test (concentration of acid/ particle size of chalk for reactions A and B above).

Skills: Tables

When constructing a table the independent variable goes in the left hand column.

The dependent variable goes in the right hand column.

Skills: Graphs

When drawing a graph the independent variable is plotted on the x-axis.

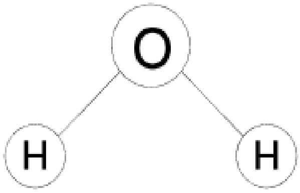
The dependent variable is plotted on the y-axis.

Compounds & Formulae

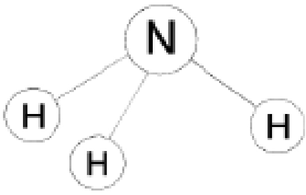
Water

Hydrogen reacts rapidly with oxygen to make water, formula H_2O.

Water has the chemical name hydrogen oxide. This tells us that it contains hydrogen and oxygen. The diagram on the right shows how the hydrogen and oxygen join. This is a molecule of water. Because the molecule contains 2 atoms of hydrogen joined to one atom of oxygen it has the chemical formula H_2O.



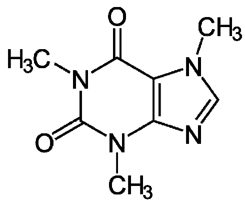
A molecule of water, chemical formula H_2O.



A molecule of ammonia, chemical formula NH_3.

Ammonia

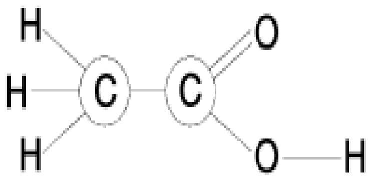
Ammonia is a gas which contains the elements nitrogen and hydrogen.
In a molecule of ammonia there are 3 atoms of hydrogen and one atom of nitrogen. Ammonia has the formula NH_3.



A molecule of caffeine, the drug in coffee and tea. Caffeine contains the elements carbon, hydrogen and oxygen.

Vinegar

Vinegar contains the chemical ethanoic acid. A molecule of ethanoic acid contains 2 atoms of carbon, 4 atoms of hydrogen, and 2 atoms of oxygen.
It has the chemical formula $C_2H_4O_2$.

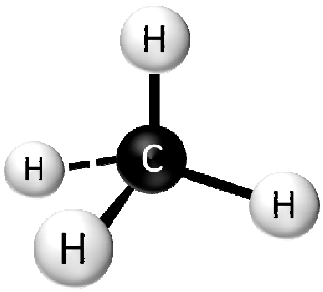


A molecule of ethanoic acid, chemical formula $C_2H_4O_2$.

Molecules

On the right is a drawing of molecule of methane, a compound with the formula CH_4. The atom in the centre is an atom of carbon. The four outside atoms are atoms of hydrogen. There are four bonds in the molecule.

A molecule is defined as, two or more atoms held together by strong bonds.



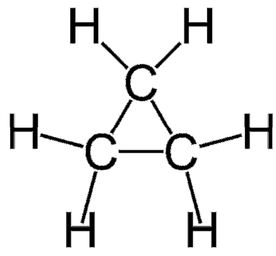
A molecule of methane, CH_4.

A crystal of salt– the compound sodium chloride.

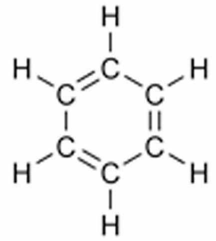
Formulae

Cyclopropane

On the right is a model of a molecule of a gas called cyclopropane, which is a hydrocarbon, a compound which contains the elements hydrogen and carbon only. The molecule contains 3 atoms of carbon and 6 atoms of hydrogen. Cyclopropane has the formula C_3H_6.



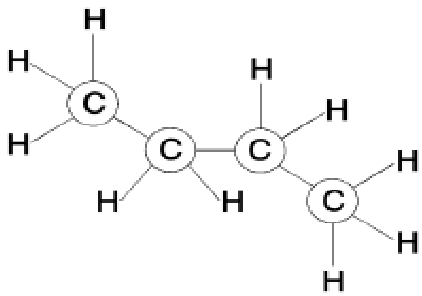
Cyclopropane– a hydrocarbon



A molecule of benzene– a hydrocarbon present in petrol.

Butane

On the left is a model of a molecule of a gas called butane, which is a hydrocarbon. Butane is used as a fuel in gas barbecues.
The molecule contains 4 atoms of carbon and 10 atoms of hydrogen. Butane has the formula C_4H_{10}.



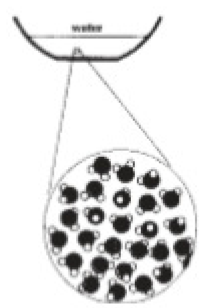
Butane is a hydrocarbon used as a fuel

An explosion is simply a very rapid reaction which produces heat and lots of gas.

Formulae and names

The name of a compound tells us which elements are present in the compound.
Sodium chloride contains the elements sodium and chlorine, and hydrogen oxide contains the elements hydrogen and oxygen. Carbon dioxide contains carbon and oxygen. The di- in from of the oxygen tells us that the molecule contains two atoms of oxygen. So the formula of carbon dioxide is CO_2.

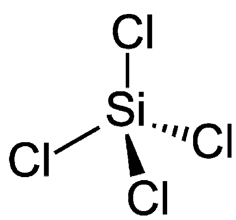
Name	Number
Mono	1
Di	2
Tri	3
Tetra	4



A cup of water contains millions of millions of millions of millions of molecules of water.

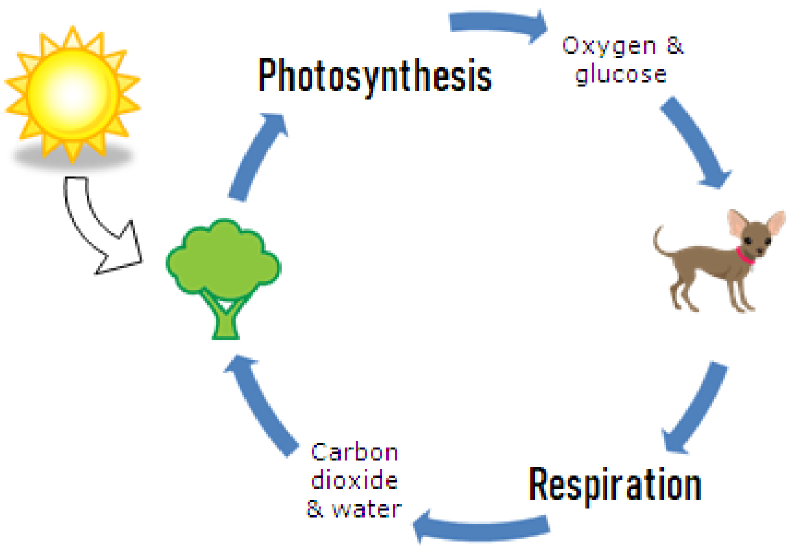
Names from formulae

The molecule on the right contains the elements silicon, symbol Si, and chlorine, symbol Cl. The formula is $SiCl_4$. The name is silicon tetrachloride. The tetra indicates that the molecule contains 4 atoms of chlorine.



Silicon tetrachloride

Unit 2
Gases and Life



Unit 2: Gases and Life

Learning Outcomes

1. Know that oxygen relights a glowing splint, makes a burning splint burn more brightly, and has no effect on lime water. The formula of oxygen is O_2.
2. Know that carbon dioxide turns lime water milky and puts out a burning splint. The formula of carbon dioxide is CO_2.
3. Know that nitrogen puts out a burning splint and has no effect on lime water. The formula of nitrogen is N_2.
4. Know that oxygen is used to help people breathe.
5. Know that nitrogen is used to help keep things cold and to make fertilisers.
6. Know that carbon dioxide is used in fizzy drinks and in fire extinguishers.
7. Know that argon is used to fill light bulbs. The formula of Argon is Ar.
8. Know that air contains 78% nitrogen, 20% oxygen, 1% argon, and 0·03% carbon dioxide.
9. Know how to show that the air contains 20% of oxygen.
10. Know that oxygen is used up when things burn.
11. Know that when animals breathe they take in oxygen which is then changed into carbon dioxide.
12. Know that all of the carbohydrates contain the three chemical elements: carbon, hydrogen and oxygen.
13. In carbohydrates, the ratio of hydrogen to oxygen is 2:1.
14. Know that many foods contain carbohydrates which are energy foods.
15. Know that animals obtain energy from carbohydrates and oxygen in a reaction called respiration.
16. The word equation for respiration is:

    Glucose + Oxygen —> Carbon dioxide + Water
17. Know that starch is a carbohydrate. To test for starch we add some iodine solution. If starch is present then the iodine solution will turn a blue-black colour.
18. Know that sugars are carbohydrates whose names end in -ose.
19. Know that sugars are soluble in water and that starch is insoluble in water.
20. Know that plants make glucose and oxygen from carbon dioxide gas and water. This is called <u>Photosynthesis.</u>

Unit 2: Gases and Life

Learning Outcomes

21. Photosynthesis is very important because -
    a) It makes glucose - an important food
    b) It makes oxygen - which animals need to breathe.
    c) It removes carbon dioxide from the atmosphere.
21. During photosynthesis plants absorb carbon dioxide through their leaves and water through their roots.
22. The energy to do this comes from the sun. Plants contain a chemical called chlorophyll. The chlorophyll traps the sun’s energy and changes it into chemical energy.
23. We can write a word equation for photosynthesis

    Carbon dioxide + Water —> Glucose + Oxygen
24. Know that plants make starch in their leaves by joining glucose molecules together.

I should be able to

25. Know that carbohydrates are a source of energy.
26. Know that Iodine solution is used to test for starch.
27. When starch is added to iodine solution, the iodine solution turns a blue-black colour.
28. Know that Benedict's solution changes from blue to brick red when heated with sugars. The only sugar which does not change the colour of Benedict's solution is sucrose.
29. Know that sugars are all carbohydrates. They all contain the elements carbon, hydrogen, and oxygen.
30. Know that
    a) All sugars have names which end in - ose.
    b) All sugars are sweet and dissolve in water.
    c) The hydrogen to oxygen ratio in carbohydrates is 2:1
31. Know that many different sugars exist; glucose, maltose, sucrose, lactose, fructose.

Unit 2: Gases and Life

Learning Outcomes

32. Carbon dioxide helps trap heat from the sun in the earth's atmosphere. This is called the greenhouse effect.
33. In the last 200 years the percentage of carbon dioxide in the atmosphere has increased, many scientists think that this will cause an increase in the average temperature of the earth. This process is called global warming.
34. The increase in the percentage of carbon dioxide in the atmosphere is due to:
    a) burning fossil fuels
    b) cutting down forests.
35. Know that digestion is the breaking down of
36. food molecules into smaller molecules by chemicals called enzymes.
37. Know that enzymes are catalysts found in living things.
38. Know that our saliva contains an enzyme called amylase which breaks down starch into simple sugars.
39. Know that the acid in our stomachs also helps break down starch into sugars.
40. Know that the acid in our stomachs is a catalyst but **not** an enzyme.
41. Know that only small food molecules like sugars can pass from the gut into the blood.

Unit 2: Gases and Life

Gases in the Air

Oxygen, Nitrogen, Carbon dioxide

Crisps are sometimes packed in an atmosphere of nitrogen to stop the crisps going 'off'.

Three of the gases in air are oxygen, carbon dioxide and nitrogen.

You have carried out the following three tests to identify these gases.

Test 1: **Burning splint test**
You put a burning splint into a test tube of gas. You saw if the gas supported burning.

Burning splint

Test 2: Glowing splint test
You put a glowing splint into a test tube of gas. You saw if the splint burst into flames.

Glowing splint

The gas used to make drinks fizzy is carbon dioxide, formula CO_2.

Test 3: Lime water test
You poured a little lime water into a test tube of gas. You then replaced the stopper and shook. You saw if the lime water turned milky.

Lime water

The results of the tests are shown in the table below.

Gas	Formula	Test result		
		Burning splint	**Glowing splint**	**Lime water**
Carbon dioxide	CO_2	Goes out	Goes out	Turns milky
Oxygen	O_2	Burns brighter	Relights	No effect
Nitrogen	N_2	Goes out	Goes out	No effect

Because carbon dioxide puts out fire it is often used in fire extinguishers.

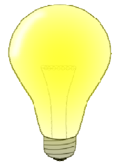
Composition of Air

Air contains:

78% Nitrogen 20% Oxygen

1% Argon 0·03% Carbon Dioxide + Other gases

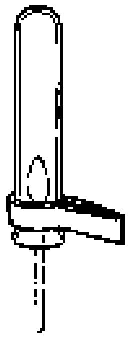
You did various experiments to show that about 1/5th of air is oxygen.

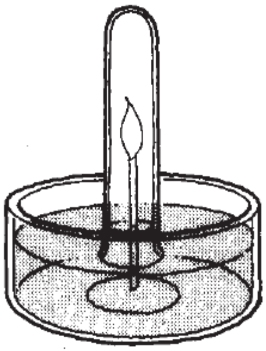


Light bulbs are filled with argon– a very unreactive gas.

Experiment One

You put a **dry** boiling tube in a test-tube holder.
You then put a burning splint in the tube. The splint stopped burning after a time as the burning had used up all the oxygen in the air in the tube.





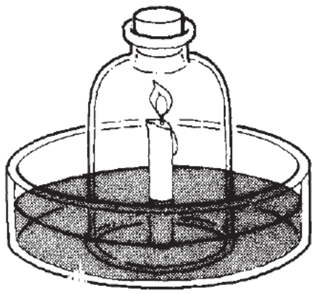
Experiment Two

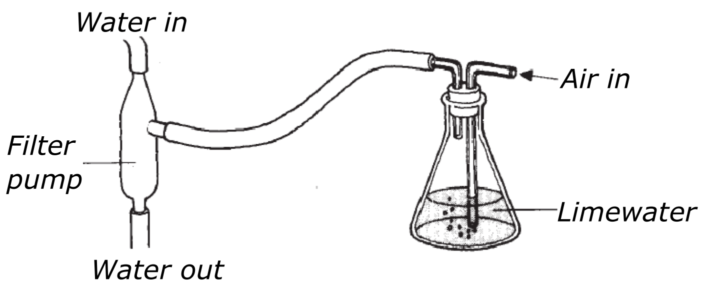
You put a burning splint into a beaker with some water in it and covered the splint with a boiling tube. After some time the splint stopped burning. This was because the oxygen in the tube had been used up. The water rose one fifth of the way up the tube. This showed that the oxygen took up approximately on fifth of the air.

Antoine Lavoisier is the French Chemist who discovered oxygen.

Experiment Three

You watched a candle burning in a jar of air. After the flame of the candle was extinguished the water rose one fifth of the way up the jar. Again we had proof that oxygen took up 20% (1/5th) of the air.





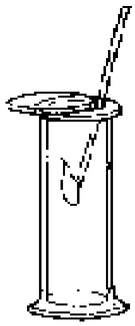
Carbon dioxide in Air

Your teacher used a water pump to suck air through lime water.
After about 10 minutes the lime water turned milky.

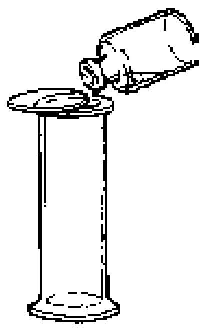
Burning and Breathing

Burning

You carried out this experiment.



A burning splint was put into a jar until it went out.



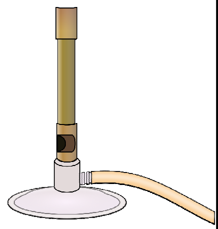
Lime water was added to the jar and shaken. The lime water turned milky.

Fuels are used to provide energy.

This showed that burning makes carbon dioxide. Wood contains the chemical elements carbon hydrogen and oxygen, we say that it is a carbohydrate. Carbohydrates burn, react with oxygen, to make carbon dioxide and water. Chemists call this burning reaction, combustion.

The word equation for the reaction is

carbohydrate + oxygen —> carbon dioxide + water



Methane burns easily. This is a chemical reaction between methane and oxygen.

Respiration

You also blew through lime water. The lime water turned milky. This showed that our breath contains more carbon dioxide than unbreathed air. A chemical reaction occurs in our bodies. The reaction uses the carbohydrates in our foods to provide us with energy.

The reaction is called respiration. The equation for respiration is:

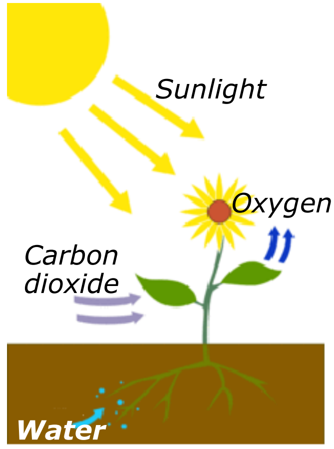
glucose + oxygen —> carbon dioxide + water

On a cold day you can see the water produced in this reaction, it shows up as steam in our breath.

Burning requires a minimum temperature. Water puts out fires as it lowers the temperature and so prevents further burning.

Photosynthesis

Photosynthesis & Chemicals



Plants needs sunlight to make food.

Plants are very important for us. Plants turn the light energy of the sun into the food which we need to help us live.

Plants need three things to make food.

1. Sunlight
2. Water
3. Carbon dioxide

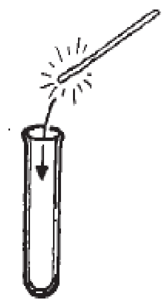
The plant contains a green chemical called **chlorophyll** which traps the sun's energy.

Water is taken into the plant through its roots.

Carbon dioxide is taken into the plant's leaves.

The water and carbon dioxide are changed into foods called carbohydrates and the gas called oxygen inside the plant. The carbohydrate foods are stored in the plant, the oxygen is released through the leaves of the plant. The carbohydrate made in photosynthesis is a sugar called glucose. This can then be changed into other carbohydrates such as starch. The word equation for photosynthesis is

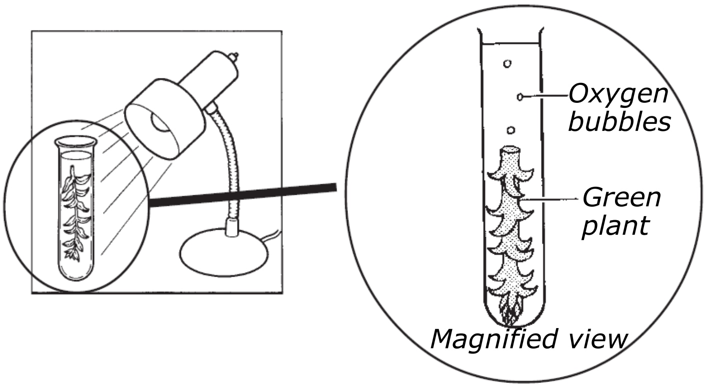
Carbon dioxide + water —> glucose + oxygen



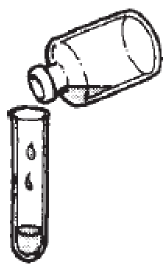
Oxygen relights a glowing splint

Light & Photosynthesis

The experiment shown below shows that light is needed for photosynthesis.

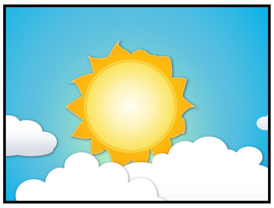


A lamp is used to shine light on a sample of pondweed inside a test tube. The pondweed gives off bubbles of oxygen. If a brighter light is shone on the pondweed the more bubbles of oxygen are seen. More light energy means more photosynthesis.



Carbon dioxide turns limewater milky.

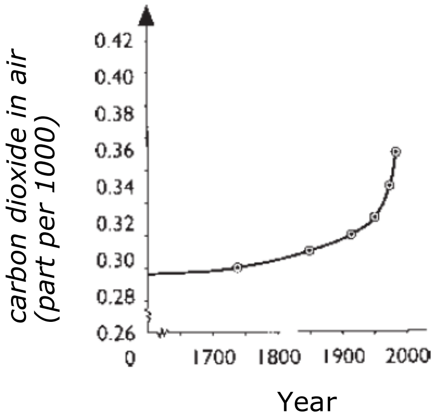
The Greenhouse effect



The sun gives us most of our energy.

Global warming

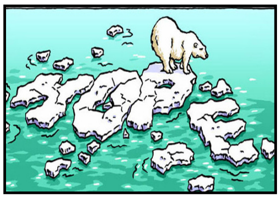
During photosynthesis plants remove carbon dioxide from the air and change it into oxygen. Animals take in oxygen and change it into carbon dioxide in respiration. Photosynthesis and respiration have helped keep the amount of carbon dioxide at a low level for millions of years. Since about 1800 A.D. the amount of carbon dioxide in the air has begun to increase and this worries some scientists.



Carbon dioxide in the air

Carbon dioxide traps heat energy from the sun

Chemists say that carbon dioxide is a greenhouse gas. It helps trap the heat energy from the sun and keeps the world war. They think that as the amount of carbon dioxide in the air increases the world will get warmer. Scientists call this Global warming.



Some scientists say that if the earth's temperature increases the artic ice will melt, or form icebergs and sea levels will rise.

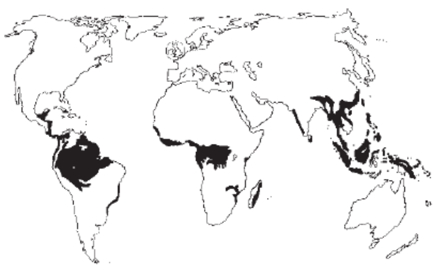
Burning fossil Fuels

Fossil fuels like coal, oil, and gas contain carbon. When the fuels are burned they make carbon dioxide. We are burning lots of fossil fuels and so are making lots of carbon dioxide.

Burning fossil fuels produces carbon dioxide.

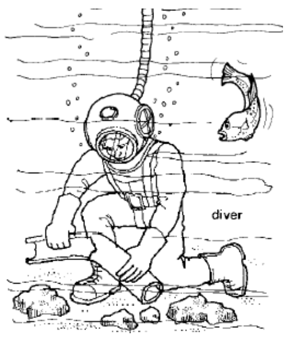
Cutting down Rain Forests

The map on the right shows the world's rain forests. Rain forests are filled with plants which remove carbon dioxide from the air and change it into oxygen. Cutting down the rain forests means that less carbon dioxide is removed from the air.



The rain forests are shown in black

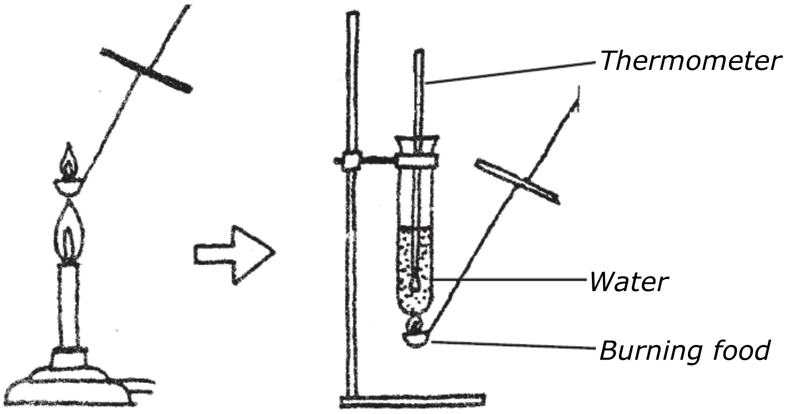
Respiration



We breathe in oxygen for respiration.

Burning Food

We need food to give us energy. Food contains chemical energy. When we burn food the chemical energy in the food turns into heat energy. In first year you carried out an experiment where you burned food to produce heat energy.



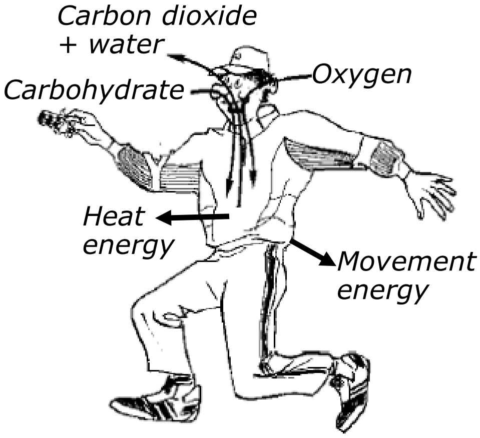
Measuring the energy in food

We breathe out carbon dioxide, which turns limewater milky.

You measured the amount of energy in different foods by measuring the change in the temperature of the water when the foods were burned. Food contains the energy which keeps us alive. We obtain our energy from glucose and oxygen. The glucose comes from our food, the oxygen comes from the air we breathe.

Respiration in our bodies

We take carbohydrates and oxygen into our bodies and change them into carbon dioxide and water. Inside our bodies the glucose and oxygen are changed into carbon dioxide and water. This reaction is called respiration and it provides all of the energy needed by our bodies.

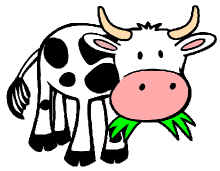


Respiration gives us energy

We need food to give us energy.

Energy in Food

All of the energy in our food comes from the sun. Plants use the sun's energy to make carbohydrates. Animals eat these plants to obtain energy. If we eat plants or animals the energy in them comes from the sun.



Animals obtain energy from the sun

Carbohydrates

Carbohydrates for energy

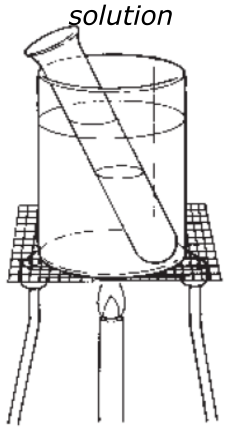
Plants use carbon dioxide, water, and the light energy from the sun to make the energy foods we call carbohydrates. There are **two types** of carbohydrates; **sugars** and **starches**. Sugars are sweet and dissolve easily in water. They give us energy quickly. Starches are not sweet and do not dissolve easily. Starch gives us energy slowly.

Carbohydrates are made by plants using the energy of the sun in photosynthesis.

Sugars

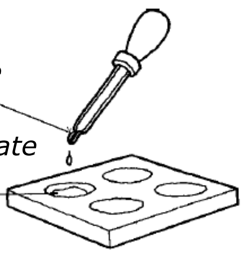
There are many different sugars. Table sugar is a chemical called sucrose. Lucozade contains glucose, fruits contain fructose. Barley, which is used to make beer contains a sugar called maltose. Most sugars, when heated with a blue liquid called Benedict's solution will turn it red-brown. The only sugar which does not do this is sucrose.

Sample of carbohydrate heated with Benedict's solution



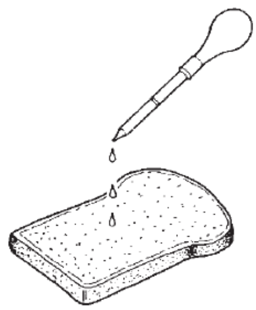
The Benedict's test

Starch



The iodine test

Many different foods contain starch. Potatoes, pasta, rice and flour all contain starch. To test for starch we use iodine solution. Starch turns iodine solution a blue-black colour.

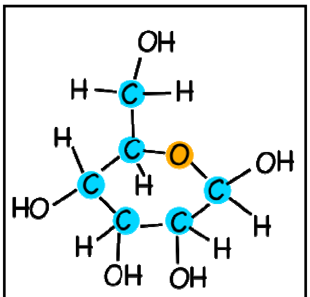


When iodine is added to bread, a blue-black colour is seen. This shows that bread contains starch.

Properties of carbohydrates

Name	Benedict's test	Iodine test	Taste	Solubility in water
Glucose	+ve	-ve	Sweet	soluble
Fructose	+ve	-ve	Sweet	soluble
Maltose	+ve	-ve	Sweet	soluble
Starch	-ve	+ve	Not sweet	insoluble
Sucrose	-ve	-ve	Sweet	soluble

Carbohydrates large and small

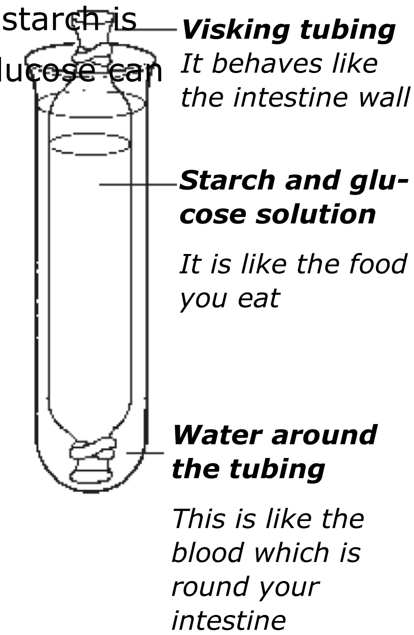


A molecule of glucose

Sugars are small, sweet-tasting, water-soluble carbohydrates. Glucose and fructose are common simple sugars with the molecular formula $C_6H_{12}0_6$. Sucrose (table sugar) and maltose are made of molecules which are almost twice as large since they both have molecular formula $C_{12}H_{22}O_{11}$. **Starch** is much larger and is made of many hundreds of glucose molecules joined together. All carbohydrates contain the elements carbon, hydrogen, and oxygen, with a **hydrogen to oxygen ratio of 2:1.**

Breaking down carbohydrates

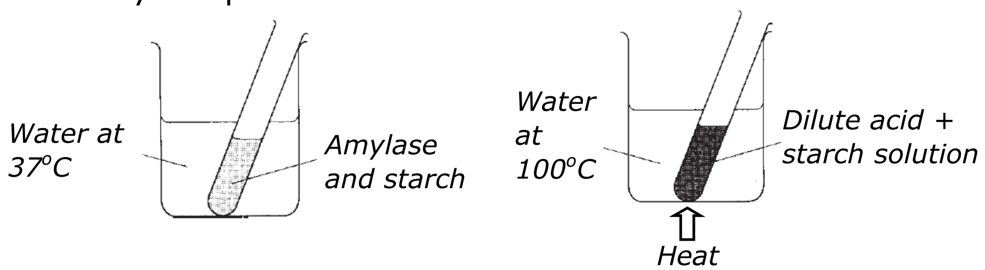
If you chew a piece of bread for about ten minutes, it will eventually taste of sugar. This is because bread contains starch and, and as you chew, this is broken down to produce maltose (sugar). On digestion, starch is changed to glucose. This is important because glucose can pass through the gut wall and into the bloodstream.



The much larger starch molecules cannot do this. In the diagram on the right a mixture of glucose solution and 'starch solution' is placed inside some visking tubing. This is made from a plastic that contains tiny pores, just like the gut wall. At regular intervals the water in the test tube is tested for starch and for glucose. It is found that glucose can pass through the visking tubing, but starch cannot. The same thing happens at the gut wall.

Amylase is an enzyme (natural catalyst) found in saliva. It catalyses the breakdown of starch to sugar. Body enzymes, like amylase, work best at body temperature, which is about 37°C. As a result, if a mixture of amylase and 'starch solution' is kept at about 37°C then the starch is broken down very quickly. The hydrochloric acid in our stomachs also helps break down starch. The acid will work at any temperature.

Amyl-



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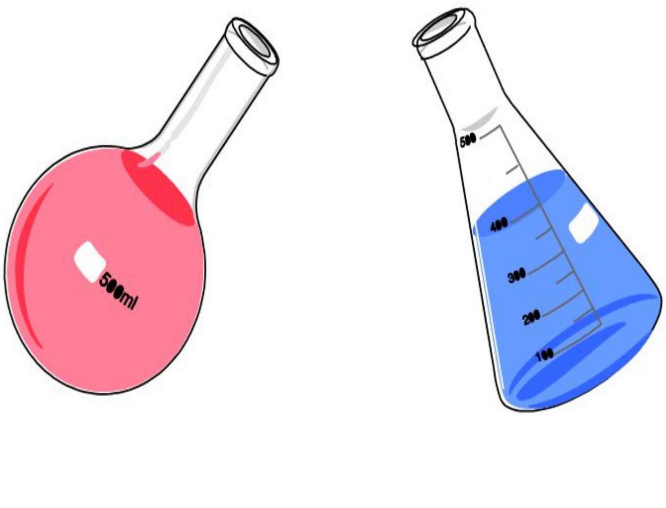
Enzyme and acid catalysed breakdown of starch

Unit 3
Acids and Metals



Unit 3: Acids and Metals

Learning Outcomes

I should be able to

1. Know the following facts about hydrogen
    a) Hydrogen burns with a pop
    b) Hydrogen is the least dense gas
    c) Hydrogen burns to make water
2. Know that the word equation for burning hydrogen is

    hydrogen + oxygen —> water

3. Know that water's correct chemical name is hydrogen oxide.
4. Know that water's chemical formula is H_2O, which shows that a molecule of water contains two atoms of hydrogen and one atom of oxygen.
5. Know that the low density of hydrogen led to its use in airships.
6. Know that the flammability of hydrogen led to
7. Helium now being used in airships.
8. Know that the test for water is that it boils at 100°C
9. and freezes at 0°C.
10. Know that the pH scale is used to measure if a substance is acidic, alkaline, or neutral.
11. Know that the pH of a substance can be measured by using universal indicator solution or pH paper.
12. Know that acids have a pH of less than 7.
13. Know that alkalis have a pH of more than 7
14. Know that neutral substances have a pH of 7.
15. Know that pure water is neutral.
16. Know that acidic substances turn pH paper or universal indicator red.
17. Know that neutral substances turn pH paper or universal indicator green
18. Know that alkaline substances turn pH paper or universal indicator blue.
19. Know that many common household substances are acids. Examples of acids are: vinegar, lemonade, coke & soda water
20. Most household cleaning products are alkaline. e.g. bleach, oven cleaner and dishwashing powder. Baking soda is also alkaline.

Unit 3: Acids and Metals

Learning Outcomes

I should be able to

21. Know that three acids used in the laboratory are hydrochloric acid, nitric acid, and sulfuric acid.
22. Know that three alkalis used in the laboratory are sodium hydroxide solution, potassium hydroxide solution, and calcium hydroxide solution (limewater).
23. Know that as you dilute an acid the pH rose.
24. Diluting an acid makes it less acidic.
25. Diluting an acid continuously can take the pH up to a value of 7.
26. Know that when you dilute an alkali the pH falls.
27. Diluting an alkali makes it less alkaline.
28. Know that when an alkali is added to an acid, the acid is neutralised.
29. Know that when an acid is added to an alkali, the alkali is neutralised.
30. Know that neutralisation reactions always make water and a salt.
31. Know that the name of a salt tells us about the acid it comes from.
32. Hydrochloric acid makes chlorides, e.g. sodium chloride
33. The salts of nitric acid are called nitrates.
34. Know that sulfuric acid forms salts called sulfates.
35. So when sodium hydroxide reacts with nitric acid:

    sodium hydroxide + nitric acid -> sodium nitrate + water
36. Know that the first part of a salt's name is that of a metal. Potassium, sodium, iron, magnesium and calcium are all metal elements.
37. The metal part of a salt comes from the substance used to neutralise the acid.
38. If sodium hydroxide is used to neutralise nitric acid then the salt made is sodium nitrate.

Unit 3: Acids and Metals

Learning Outcomes

I should be able to

39. Know that carbonates can neutralise acids- carbon dioxide gas is made in this reaction as well as a salt and water. e.g. when calcium carbonate reacts with nitric acid:

    calcium carbonate+nitric acid—>calcium nitrate + water+ carbon dioxide

40. Know that fossil fuels contain sulfur. When the fuel burns the sulfur reacts with oxygen to make sulfur dioxide (SO_2)

    sulfur + oxygen —> sulfur dioxide

41. Know that sulfur dioxide is a major cause of acid rain.
42. Know that the sparking of air in car engines causes the nitrogen to react with oxygen to form nitrogen dioxide (NO_2).

    nitrogen + oxygen —> nitrogen dioxide

43. Know that nitrogen dioxide is a cause of acid rain.
44. Know that Acid Rain can
    a) Damage the stone which buildings are made from
    b) Damage steel
    c) Slow plant growth
    d) Kill fish
45. Know that metals which react with water produce hydrogen.
46. Know that some metals, e.g. copper and gold, do not react with water.
47. Know that three metals react violently with water. These three metals were lithium, sodium, and potassium.
48. Know that calcium reacts with water.
49. Know the word equations for metals reacting with water.

    sodium + water —> sodium hydroxide + hydrogen

    calcium + water —> calcium hydroxide + hydrogen

50. Know that some metals e.g. magnesium, zinc, and iron react with acids to produce hydrogen gas
51. Know that both water and acids contain hydrogen.
52. Know that some metals e.g. copper and gold, do not react with acids.
53. Know that some metals react with oxygen to form metal oxides
54. The equation for a metal like calcium reacting with oxygen is :

    calcium + oxygen —> calcium oxide

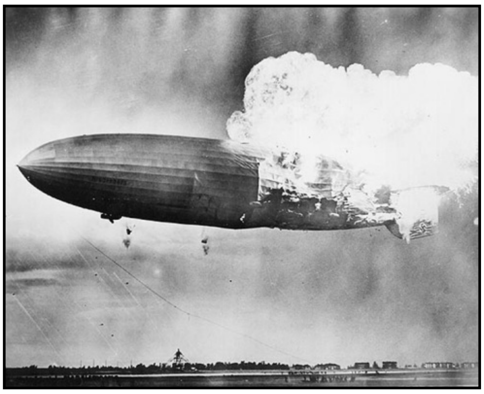
Unit 3: Acids and Metals

Acids

Hydrogen

Hydrogen is the least dense of all elements. It is a gas with the symbol H. Because it has such a low density- much less than air, it was used for a long time to fill airships. There is one drawback to the use of hydrogen in Airships. Hydrogen burns very easily.

R101 an early British airship



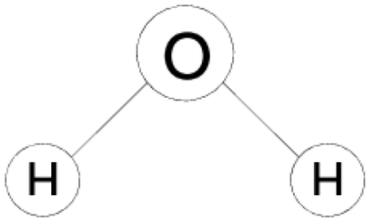
The Hindenburg burning

In 1936 an Airship called the Hindenburg was docking in New York when it caught fire. The airship burned out in less than 30 seconds. Due to the extreme flammability of hydrogen, airships now use the second lightest gas- Helium- whose chemical symbol is He.

Hydrogen burns with a pop. This is used to test if a gas is hydrogen. When hydrogen burns it reacts with oxygen to make hydrogen oxide. The common name for hydrogen oxide is water. The word equation for this reaction is:

hydrogen + oxygen --> water

Hydrogen burns with a pop



A molecule of water, chemical formula is H_2O.

Water's correct chemical name is hydrogen oxide.

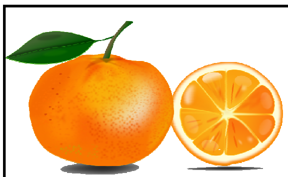
Water's chemical formula is H_2O, which shows that a molecule of water contains two atoms of hydrogen and one atom of oxygen.

If you want to test if a liquid is water measure its freezing and boiling points. Water boils at 100°C and freezes at 0°C.

The pH scale

Measuring pH

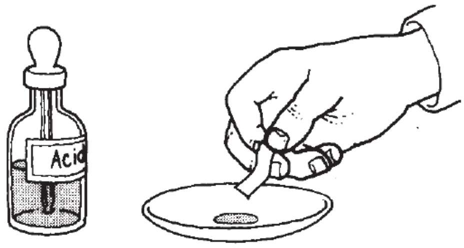
The pH scale is a scale of number which runs from below 0 to above 14. The pH of a substance tells us if the substance is acidic, alkaline, or neutral. There are two ways to measure the pH of a substance.



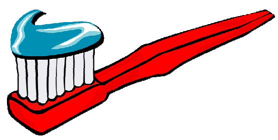
Oranges and all citrus fruits contain citric acid, which gives them their bitter taste.

pH paper

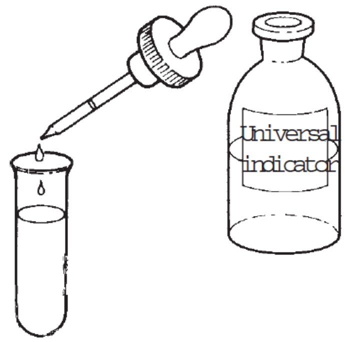
pH paper is paper soaked in special dyes which can change colour depending on the pH of the liquid the paper is placed in. By noting the colour the paper turns we can measure the pH of the liquid which the paper is placed in. Acids turn pH paper red, alkalis turn it blue.



Using pH paper



Toothpaste is usually alkaline.



Using Universal Indicator to measure pH

Universal Indicator

Universal indicator is like liquid pH paper. It is normally a green liquid. If it is added to acids it turns red. If added to alkalis it turns blue. The shade of red or blue tells us the pH of the liquid.

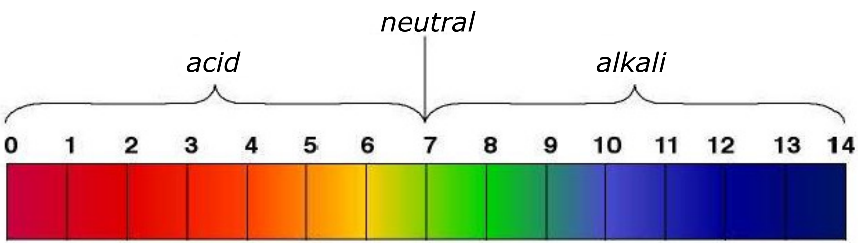
Pure water is neutral.

Acidity and pH

The pH scale

The pH scale is not just a whole number scale. A substance could have a pH of 3.24 . It is even possible for an acid to have a pH below zero, acids exist with pH values of -0.4!

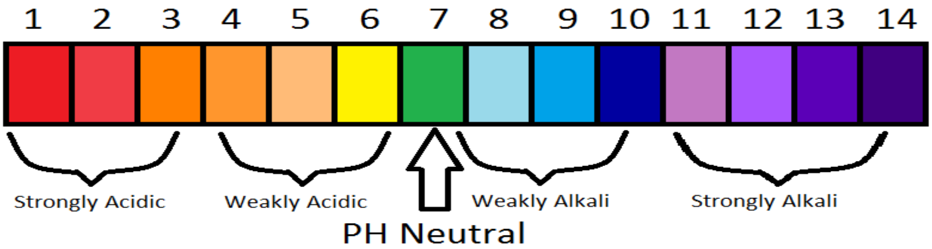
Acids all have pH values below 7 and alkalis have pH values above7. Only neutral substances have pH values of 7.



Cow's milk is slightly acidic

pH and acidity

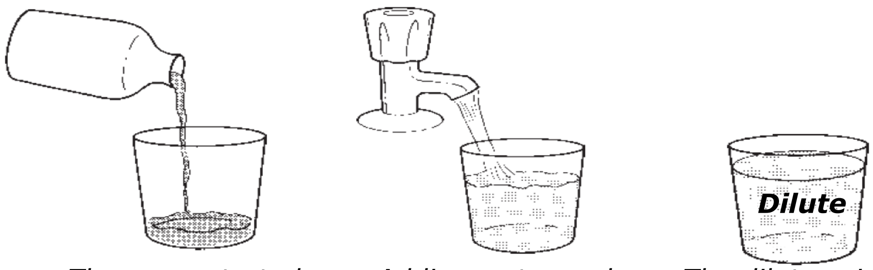
We know that acids have pH values of less than 7. The lower the pH of an acid, the more acidic it is. The closer the pH of an acid to 7 the less acidic the acid is.



In the same way, an alkali whose pH is close to 7 is not very alkaline. The larger the pH value of an alkali, the more alkaline it is.

Acidity and dilution.

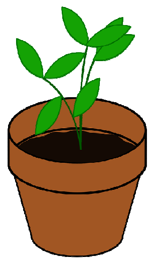
If we dilute an acid we change its pH .



The concentrated acid has a pH of 1

Adding water makes the acid more dilute

The dilute acid is less acidic. It has a pH of 3.

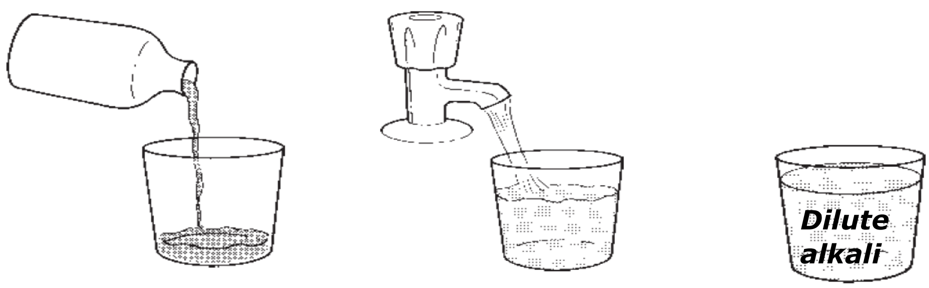


Some plants grow best in alkaline soil. Others prefer acidic soils. It is important for gardeners to know soil pH.

This pH of acids depends on how concentrated the acidic. A concentrated acid can have a pH of 1. If water is added the acid becomes more dilute and so less acidic. The pH falls and moves towards 7.

Alkalis and dilution.

If we dilute an alkali we change its pH .



The concentrated alkali has a pH of 14

Adding water makes the alkali more dilute

The dilute alkali is less alkaline. It has a pH of 12.

Although pure water is neutral, rain water has a pH of less than 7. It is acidic.

This pH of alkalis also depends on how concentrated the alkali is. A concentrated alkali might have a pH of 14. If water is added the alkali becomes more dilute and so less alkaline. The pH falls and moves towards 7.

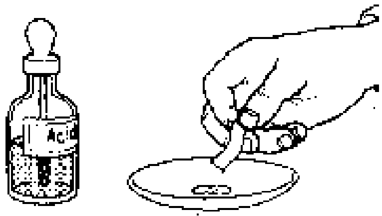
Common Acids & Alkalis

Most household cleaners have pH values greater than 7. They are alkalis.

Laboratory Acids

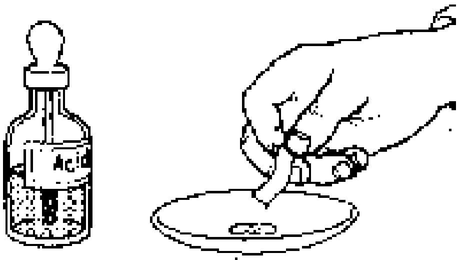
There are three common acid which we use in chemical laboratories.

- **Hydrochloric acid**
- **Sulfuric acid**
- **Nitric acid**



All acids have a pH lower than 7

Like all acids they have pH values which are lower than 7.



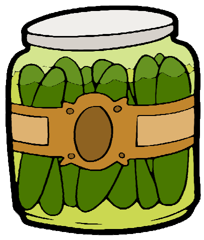
All alkalis have a pH greater than 7.

Laboratory alkalis

There are three common alkalis used in chemistry laboratories.

- **Sodium hydroxide**
- **Lime water &**
- **Ammonia solution.**

Like all alkalis they have pH values which are higher than 7.



Pickled foods contain vinegar, a household acid.

Household Acids

Most common household substances are acids. Examples of acids are

- Vinegar
- Lemonade
- Coke and soda water

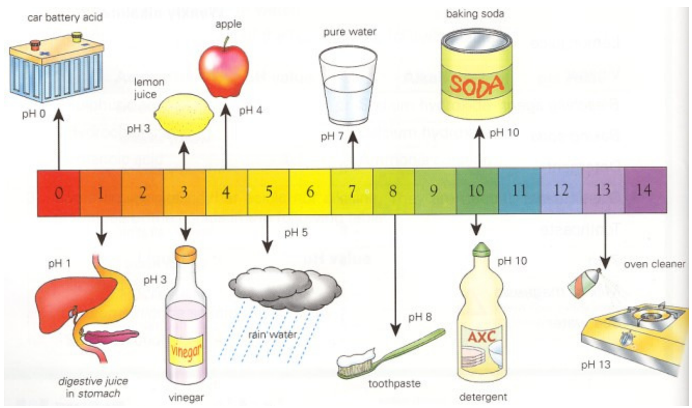
Some common household

Some common household alkalis

Household Alkalis

Most household cleaning products are alkaline e.g.

- Dishwashing powder
- Oven cleaner
- Baking soda
- Bleach
- Soap

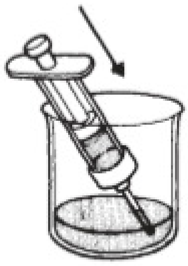


Neutralisation

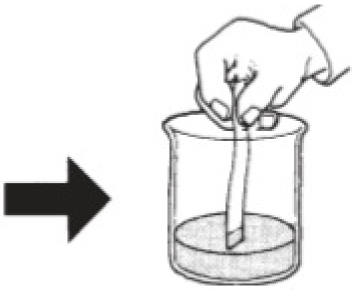
Neutralising an acid

If some acid is added to a beaker and the pH tested, the pH will be less than 7. This proves that the liquid in the beaker is an acid.

Toothpastes are alkaline to neutralise acids in our mouths.

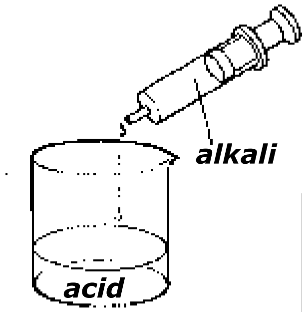


Acid being put in a beaker



Testing with pH paper shows a pH lower than 7

When alkali is added carefully to the acid in the beaker, the pH of the acid begins to rise. The acid is being neutralised. This is a chemical reaction called neutralisation. It is possible to make a solution of pH 7 by adding the correct amount of alkali to the acid. If more alkali is added than is needed then the pH will rise above 7.

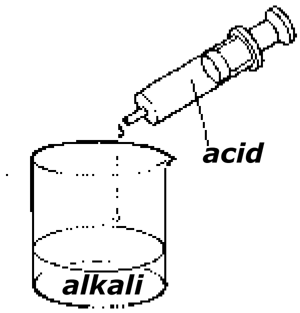


Neutralising an acid with an alkali.

Indigestion tablets are alkaline, they neutralise stomach acids.

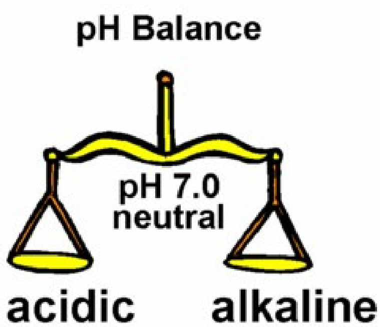
Neutralising an alkali

If some alkali is put into a beaker an universal indicator added to the alkali then a blue colour is seen, this shows that the pH of the liquid is greater than 7. The liquid is an alkali.
The alkali can be neutralised by careful addition of an acid. When the liquid is neutral the pH will have fallen to 7 and the indicator will be a green colour.



Neutralising an alkali with an acid.

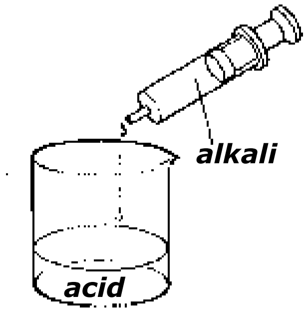
Wasp stings are alkaline. They can be neutralised by vinegar, which is an acid.



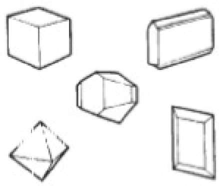
Substances made by Neutralisation

Neutralisation

We know that acids can neutralise alkalis. This is an example of a chemical reaction. During a chemical reaction we know that new substances are formed. This is true for the neutralisation reaction between an acid and an alkali.
During neutralisation a new substance called a salt is made. Water is also made in the neutralisation reaction. To remove the water we heat the liquid made in neutralisation.

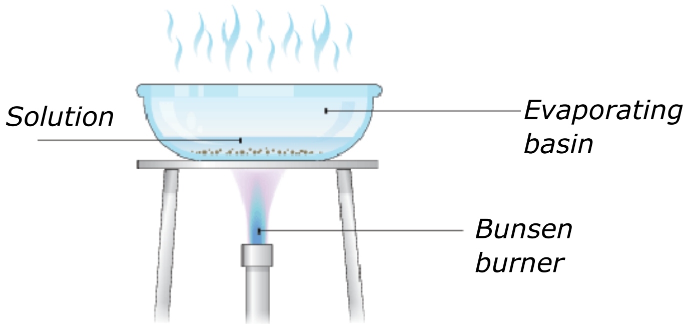


Neutralising an acid with an alkali.


Different salts have different crystal shapes.

Evaporation

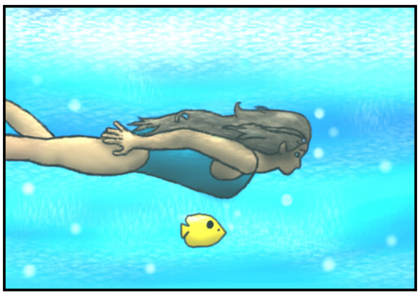
To evaporate the liquid it is placed in an evaporating basin and heated with a Bunsen burner. The liquid evaporates and turns into steam.
A solid is left in the basin. This is the salt made in the reaction.



Salts

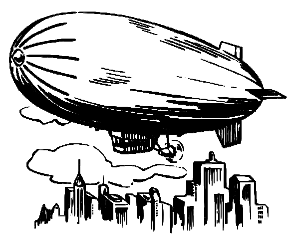
The name of the salt made in a neutralisation depends on the acid and alkali used to make the salt.
When sodium hydroxide reacts with hydrochloric acid the salt made is sodium chloride.


Crystals of sodium chloride


Swimming in a solution

Salt water

Sea water contains lots of dissolved salts. The most common salt in sea water is sodium chloride. Other salts in sea water are magnesium sulfate and calcium sulfate.


All acids contain hydrogen, the lightest element. Hydrogen used to be used in air-ships.

Naming salts

Chlorides

The name of a salt tells us about the acid it comes from.
Hydrochloric acid makes chlorides, e.g.
sodium chloride
calcium chloride.

Cooking salt- sodium chloride.

Rock salt, sodium chloride, helps melt ice on roads.

Calcium sulfate - plaster cast

Sulfates

Sulfuric acid forms salts called sulfates. A common sulfate is the plaster used to set broken arms and legs. It has the chemical name **calcium sulfate** other salts of sul-furic acid are **magnesium sulfate and iron sulfate.**

Nitrates

The salts of nitric acid are called nitrates. **Sodium nitrate** is an essential part of the gunpowder used in fireworks. Other nitrates are **potassium nitrate** which is used in fertilisers

Fireworks using sodium nitrate

Full names

If we look at the names of the salts mentioned above we see that the first part of a salt's name is that of a metal.
Potassium, sodium, iron, magnesium and calcium are all metal elements.
The metal part of a salt comes from the substance used to neutralise the acid.
If sodium hydroxide is used to neutralise nitric acid then the salt made is sodium nitrate.

Ancient ink contained the salt from iron sulfate.

Carbonates

Carbonates & Acids

When chalk is added to an acid there is a great deal of fizzing. A gas is made which turns lime water chalky. This gas is carbon dioxide. Chalk is calcium carbonate.
All carbonates react with acids to make carbon dioxide.

Chalk (calcium carbonate) reacting with acid

The Taj Mahal is made of marble, a carbonate which is eaten away by acid rain.

When a carbonate reacts with an acid, three substances are made. These are

1. A salt **2. water** **3. carbon dioxide**

The name of the salt is the name of the metal in the carbonate added to the salt name from the acid.
So when sodium carbonate reacts with hydrochloric acid the salt made is sodium chloride. The word equation for the reaction is

sodium carbonate	**+**	**hydrochloric acid**	**—>**	**sodium chloride**	**+**	**water**	**+**	**carbon dioxide**

Or when copper carbonate reacts with nitric acid the salt made is copper nitrate. The word equation for the reaction is

copper carbonate	**+**	**nitric acid**	**—>**	**copper nitrate**	**+**	**water**	**+**	**carbon dioxide**

Carbonate rocks and acid rain

The building on the right is made of marble and is over 2,500 years old. Marble is a type of calcium carbonate. It is worn away by acid rain.

Many 'white' cliffs are made of chalk– calcium carbonate.

Carbonate medicine

The medicine on the right contains a mixture of magnesium carbonate and calcium carbonate. It is used to neutralise acid in our stomachs.

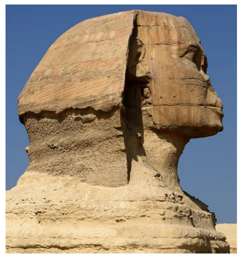
Carbonate medicine

Acid rain

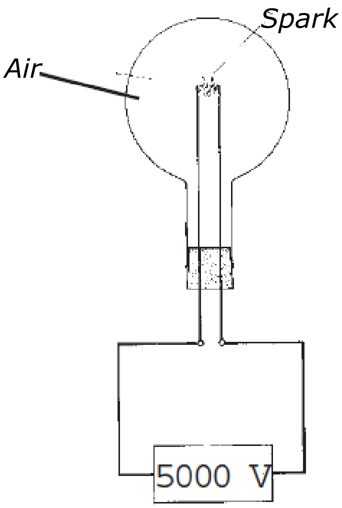
Fossil fuels

Fossil fuels all contain the element carbon. When the fuel burns the carbon reacts with oxygen to make carbon dioxide. The fuels also contain the element sulfur. When the fuel burns the sulfur reacts with oxygen to make sulfur dioxide. Both sulfur dioxide and carbon dioxide are gases which dissolve in rain water to make acid rain.

A coal burning power station which produces the acidic gases carbon dioxide and sulfur dioxide.



The sphinx, an ancient monument made of carbonate rock, wearing away from acid rain.



Nitrogen reacting with oxygen

Sparking air

When air is sparked the nitrogen and oxygen react together to make the acidic gas nitrogen dioxide. This sparking happens in car engines. The exhaust from a car contains nitrogen dioxide which dissolves in rain to make acid rain.

Acid rain can poison forests.

Effects of acid rain

Acid rain has various damaging effects:

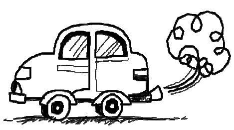
1. It damages buildings made from carbonate rocks like limestone
2. It damages steel
3. It slows plant growth
4. It can poison fish

The effect of acid rain on carbonate rocks

Neutralising acid soil

Treating acid rain

Acidity in lochs or farmland can be treated by adding carbonate rock to the loch or soil to neutralise any acidity.

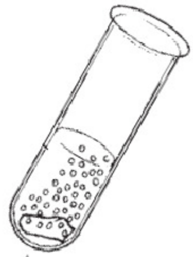


Nitrogen dioxide from car exhausts causes acid rain.

Reactions of Metals

Metals and water

When calcium is added to water there are many signs of a chemical reaction.
The water fizzes as a gas is made.
The gas burns with a pop-it is hydrogen.
The water gets very warm- chemical energy is being changed into heat energy during the reaction. Not all metals react with water.



Calcium reacting with water

H_2O

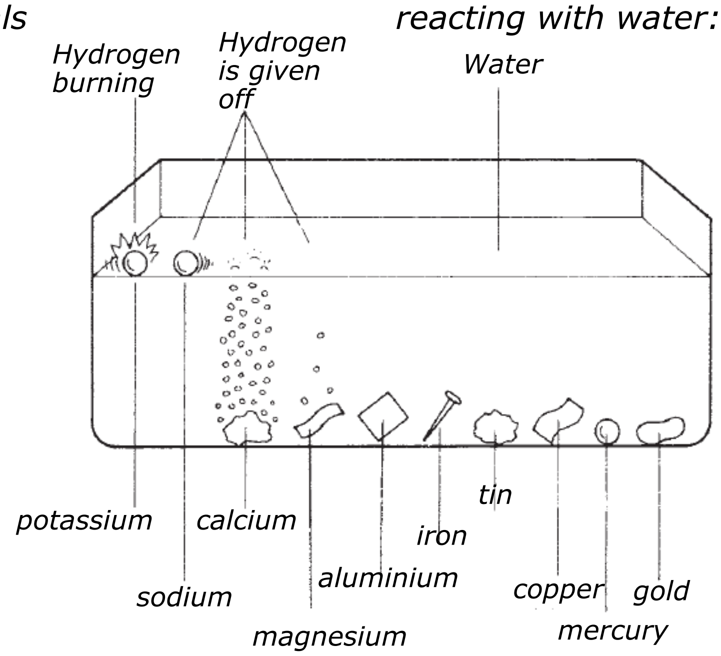
Water has the chemical formula H_2O. This shows that in water there are two atoms of hydrogen for every one atom of oxygen.

A reactivity series

We can use the metal- water reaction to make up a reactivity series for metals. Only 4 of the metals used in our labs react with water. Potassium reacts rapidly with water, so much energy is produced that the potassium burns. Sodium also reacts rapidly with water- though it produces less energy than potassium does.

Some Alkali Metals (group 1 metals) react explosively with water.

Metals reacting with water:



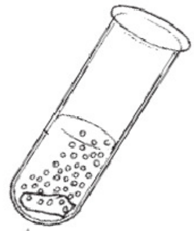
Calcium reacts with water and magnesium reacts slowly. In all cases hydrogen gas is made. So Potassium is more reactive than sodium. We can make a reactivity series:

potassium —>	sodium —>	calcium —>	magnesium
most reactive			***least reactive***

NaOH

When sodium reacts with water it makes sodium hydroxide and hydrogen. Sodium hydroxide has the formula NaOH.

Metal and water reaction



Calcium reacting with water

Aluminium is the main metal used to make aircraft because it is so light.

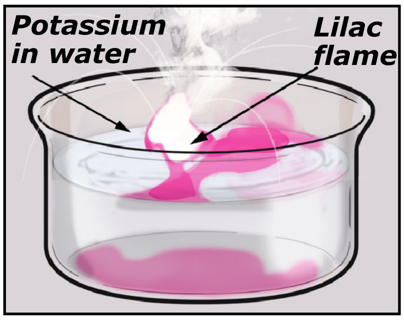
On page 42 we saw that calcium is one of the few metals which reacts with water.
Hydrogen gas is one of the products of the reaction.
The general word equation to represent the reaction when a metal reacts with water is:

metal + water —> metal hydroxide + hydrogen

When the solution left in the test tube above was tested with universal indicator it was found to be an alkali.
It was is a solution of calcium hydroxide.

A word equation for the reaction is

calcium + water —> calcium hydroxide + hydrogen.
Calcium hydroxide is an alkali. In fact all hydroxides are alkalis.



Potassium is very reactive with water. Again hydrogen is made when potassium reacts with water. The solution left behind is strongly alkaline-it is a solution of potassium hydroxide. The word equation for the reaction between potassium and water is:

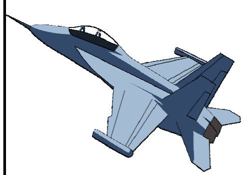
potassium+water —>potassium hydroxide+hydrogen

Group One- The alkali metals

Li lithium
Na sodium
K potassium
Rb rubidium
Cs caesium
Fr francium

On page three we saw that elements in the same group in the periodic table have similar chemical properties. Group one show this very well. All of the group one metals react with water to produce an alkali and hydrogen, because of this they are known as the alkali metals.
The further down the group the more reactive the metals are with water. Lithium, at the top of the group fizzes quietly in water, the reaction is:

lithium+ water —> lithium hydroxide + hydrogen



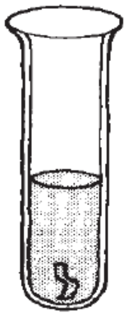
Titanium is the metal used to make military jets as it is stronger than aluminium.

Potassium in the middle burns brightly in water, whilst caesium at the bottom of the group explodes on contact with water.

Metals and acids

The general word equation to represent the reaction when a metal reacts with an acid is:

metal + acid —> salt + hydrogen



When magnesium is added to a test tube of acid the mixture fizzes- a gas is made in the reaction. The solution in the test tube gets warm-another sign that a chemical reaction is happening.
The chemical energy in the magnesium and acid is being changed into heat energy. The gas produced burns with a pop. This means that it is hydrogen.

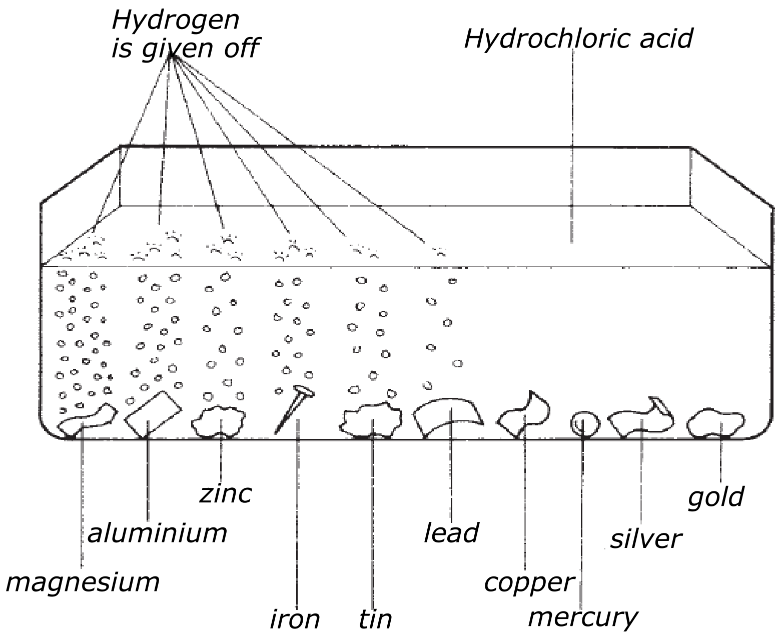
H_2SO_4

Sulfuric acid has the chemical formula H_2SO_4. This shows that it contains two atoms of hydrogen, 1 atom of sulphur and 4 atoms of oxygen.

Another reactivity series

We can use the reaction between metals and acid to get more information about the reactivity series.
Potassium, sodium, and calcium react violently with acid. When we put other metals into water we find the results below.

Metals reacting with acid:



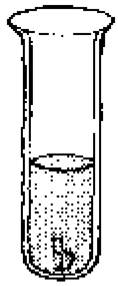
This shows that magnesium is more reactive than aluminium, which is more reactive than zinc.
We get the following reactivity series:

Magnesium	—>	aluminium	—>	zinc	—>	iron	—>	tin
most reactive								***least reactive***

Our stomachs contain acid to help digest food.

The metals copper, mercury, silver and gold **<u>do not</u>** react with ac-

Metals and acids- reaction



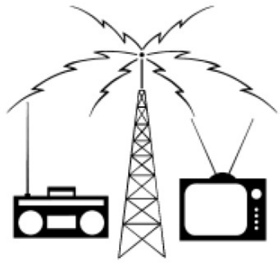
We know that when magnesium is added to a test tube of sulfuric acid the mixture fizzes- a gas is made in the reaction. The gas produced burns with a pop. This means that it is hydrogen. The solution left behind can be evaporated to produce a salt - magnesium sulfate. The word equation for the reaction is:

Metals can usually be hammered into new shapes.

magnesium + sulfuric acid —> magnesium sulfate + hydrogen

If magnesium is added to hydrochloric acid a similar reaction occurs- this time the salt produced is magnesium chloride. The word equation for the reaction is :

magnesium + hydrochloric acid —> magnesium chloride + hydrogen



Metals are used in many things. Metals are good conductors of electricity.

Similarly, if zinc is reacted with sulfuric acid then zinc sulfate and hydrogen are produced.

zinc + sulfuric acid —> zinc sulfate + hydrogen

Zinc also reacts with hydrochloric acid, again hydrogen gas is made. The salt made in this reaction is zinc chloride

zinc + hydrochloric acid —> zinc chloride + hydrogen

Modern water pipes are made from copper

Lead in Water

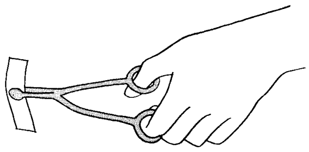
Ancient water pipes were made from the element lead. This was not a good idea as the some of the lead from the pipes dissolved in the water. This may seem odd as lead does not react with water. In fact water is naturally slightly acidic. The lead reacted with the acid in the water. Lead is a poisonous chemical. Modern water pipes are made from copper which is much safer.

Reactions of metals

Metals and oxygen

The general word equation to represent the reaction when a metal reacts with oxygen is:

metal + acid —> metal oxide



Heating magnesium changes it into magnesium oxide.

MgO

Magnesium oxide has the formula MgO. This tells us that it contains one atom of magnesium joined to one atom of oxygen.

When a piece of magnesium is held in tongs and heated in a Bunsen flame it burns brightly to form a white powder. This powder is a compound of magnesium and oxygen. The two elements have joined to make a new substance called magnesium oxide. The word equation for the reaction which occurs is:

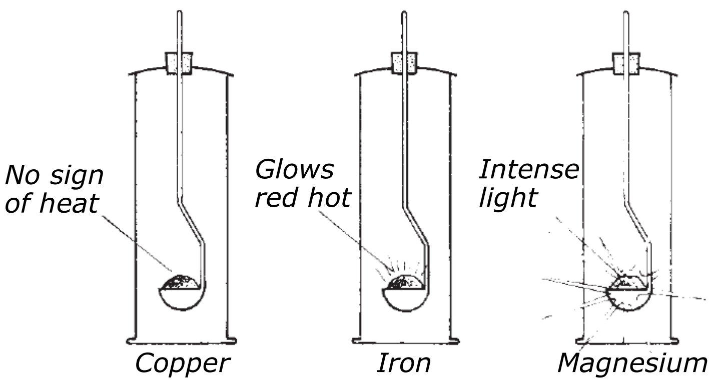
magnesium + oxygen —> magnesium oxide

All metals react with oxygen. For example a copper metal slowly turns black. The copper has reacted with oxygen to make copper oxide. The equation for the reaction is:

copper + oxygen —> copper oxide

A reactivity series

Some metals react faster with oxygen than others and give out more energy when they react. An example can be seen with the metals copper, iron, and magnesium. If copper is heated and put into a jar of oxygen the copper turns black- there is no sign that energy is released. The copper has reacted with the oxygen to make copper oxide.



Fe_2O_3

Iron oxide has the chemical formula Fe_2O_3. This tells us that for every two atoms of iron there are three atoms of oxygen.

When hot iron is put into oxygen, the iron glows brightly. Hot magnesium burns with a pure white bright flame releasing a great deal of energy. We can say that magnesium is the most reactive of the three metals and copper is the least reactive.

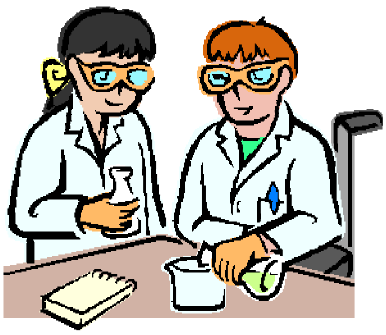
Skills Developed in S2 Chemistry

Through your work in S2 Chemistry you will develop a great number of scientific skills:

Inquiry and investigative skills

Individually or as part of a team, you will:

- *help to plan and design investigations. This will involve identifying aims, predictions and hypotheses. You will become familiar with independent, dependent and controlled variables. You will also be work with your peers to identify measurements, apparatus and methods to use to perform experiments.*



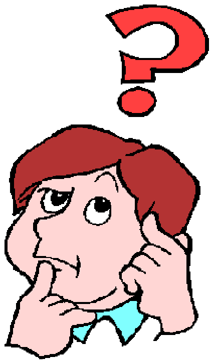
- *consider safety measures needed when carrying out practical work.*
- *perform control experiments to improve the validity of your results.*
- *analyse, interpret and evaluate your results.*
- *select suitable methods to record your results e.g. results table, a summary, a conclusion.*
- *become familiar with scientific language, units and scales, particularly when drawing tables and graphs.*

- *identify trends and relationships between the independent and dependent variables and links to the original hypothesis.*
- *relate your findings to knowledge and understanding from classwork.*
- *write conclusions based on your experimental results.*
- *evaluate your practical work and suggest at least two ways of improving the method.*

Skills Developed in S2 Chemistry

- *present experimental results in different formats, for example, tables, charts, diagrams and graphs and using suitable scales and units.*

- *communicate your findings effectively in a range of ways, for example, orally (presentations to your peers) and through scientific report writing.*



Scientific analytical thinking skills

Individually or as part of a team, you will:

- *discuss unfamiliar concepts and think analytically and creatively to solve problems and provide solutions.*

Skills and attributes of scientifically literate citizens

Individually or as part of a team, you will:

- *consider, discuss and debate the impact of chemistry and science on society and the moral and ethical implications of some scientific developments, demonstrating respect for the views of others.*

- *express informed views about topical scientific issues, including those featured in the media.*

- *demonstrate an increased awareness of technologies and inventions in chemistry science.*

- *demonstrate the relevance of science to your future in terms of a range of careers and occupations, including science, technology, engineering and mathematics (STEM) careers.*