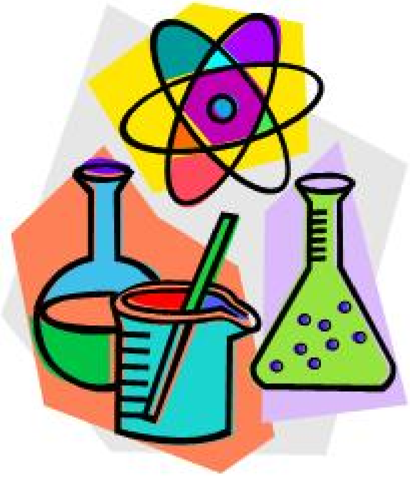
Year 10 Chemistry

Revision Materials for February Exams 2017

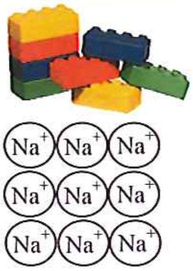
(made using pages taken from old Bangor Revision Guides)



This material contains <u>both</u> Higher and Foundation Tier content – check with your teacher if you are unsure if you should revise certain sections.

Elements

Element

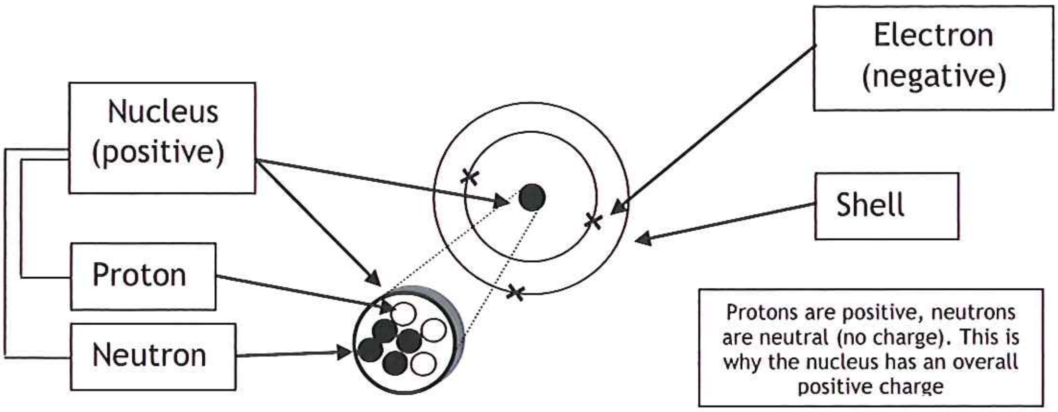


Elements are the building blocks of all substances. They cannot be broken down into simpler substances by chemical means

An Element contains only one type of atom

Atom

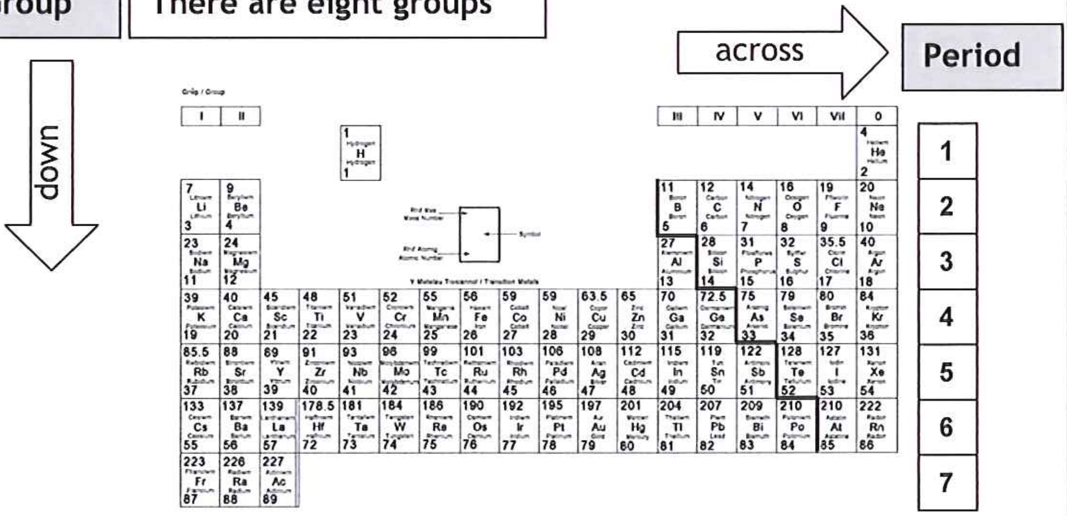
Each atom has negatively charged electrons orbiting a positively charged nucleus



Protons are positive, neutrons are neutral (no charge). This is why the nucleus has an overall positive charge

The Periodic Table - Basics

Group There are eight groups

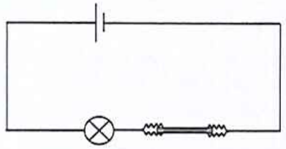


Describing Position

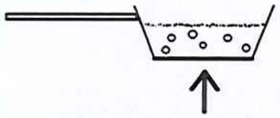
Sodium is in Group 1, Period 3
Helium is in Group 0, Period 1
Beryllium is in Group 2, Period 2

Physical Properties

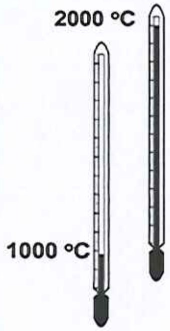
Metals



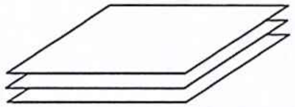
Conduct Electricity



Conduct Heat

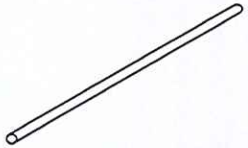


High
Melting point
Boiling point



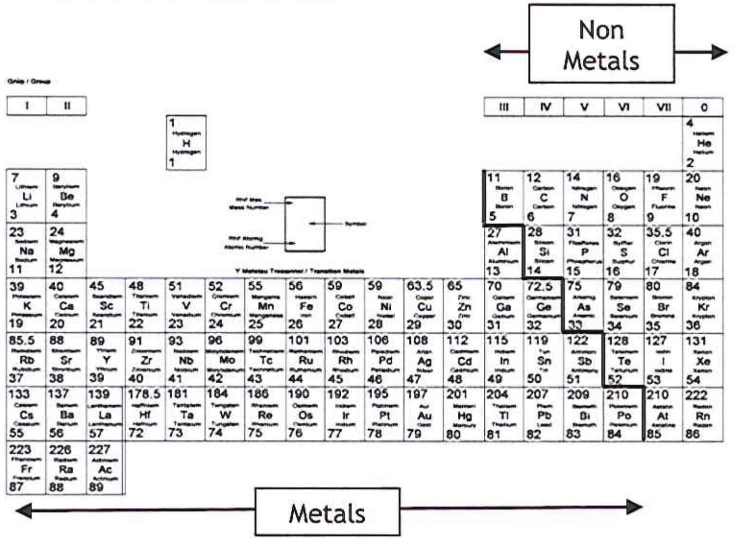
Malleable

Can be hammered into sheets



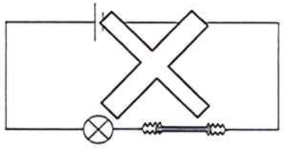
Ductile

Can be pulled into wires

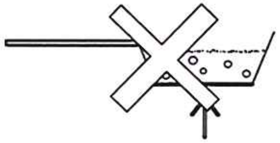


Non-Metals

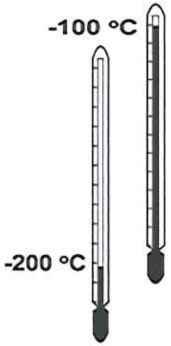
Does not conduct Electricity



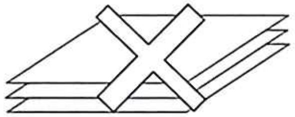
Does not conduct heat



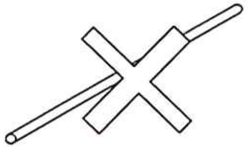
Low
Melting point
Boiling point



Not malleable



Not ductile



Elements change from being metals to non-metals on going from left to right across the Periodic Table

Many elements in Group 3, 4, 5 show metallic and non-metallic properties

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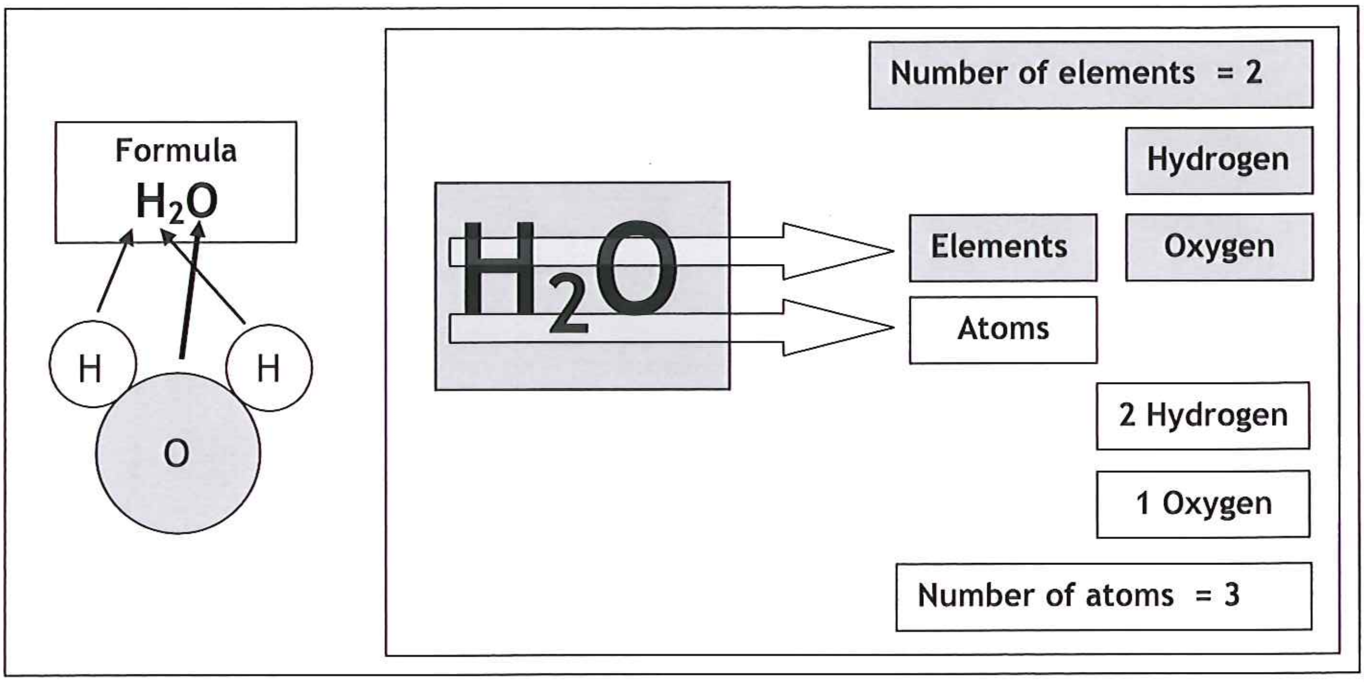
Compounds

Substance that contains two or more elements joined together chemically

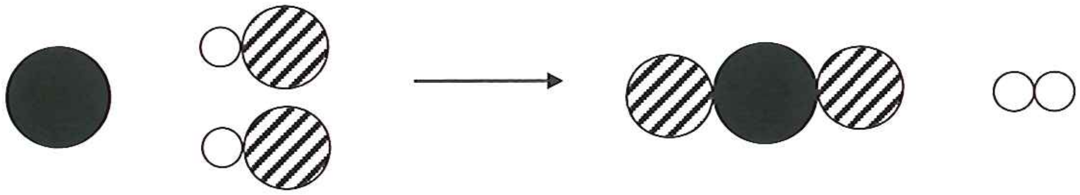


Compound	Formula	No. of elements	No. of atoms
Sodium Chloride	NaCl	2	2 (1 Na, 1 Cl)
Sodium Hydroxide	NaOH	3	3 (1 Na, 1 O, 1 H)
Sodium Oxide	Na_2O	2	3 (2 Na, 1 O)
Sodium Sulfate	Na_2SO_4	3	7 (2 Na, 1 S, 4 O)
Calcium Carbonate	$CaCO_3$	3	5 (1 Ca, 1 C, 3 O)

Chemical Reactions

Atoms are rearranged but none are created or destroyed

e.g.



$$Mg + 2HCl \longrightarrow MgCl_2 + H_2$$

Same number of atoms in reactants and products, atoms are differently arranged.

Using ions to create formulae

Lithium = Li^+

chloride = Cl^-

Sodium = Na^+

Magnesium = Mg^{2+}

oxide = O^{2-}

bromide = Br^-

Potassium = K^+

Calcium = Ca^{2+}

sulfide = S^{2-}

iodide = I^-

Sodium Chloride

Na^+ Cl^-

Ions cancel

$NaCl$

Magnesium Oxide

Mg^{2+} O^{2-}

Ions cancel

MgO

Lithium Oxide

Li^+ O^{2-}
Li^+

Ions cancel

Li_2O

Magnesium Chloride

Mg^{2+} Cl^-
Cl^-

Ions cancel

$MgCl_2$

Hydroxide= OH^-

Sulfate= SO_4^{2--}

Carbonate = CO_3^{2--}

Nitrate = NO_3^-

Sodium Hydroxide

Na^+ OH^-

Ions cancel

$NaOH$

Magnesium Hydroxide

Mg^{2+} OH^-
OH^-

Ions cancel

$Mg(OH)_2$

Two sets of OH^- (brackets used)

Sodium Carbonate

Na^+ CO_3^{2} --
Na^+

Ions cancel

Na_2CO_3

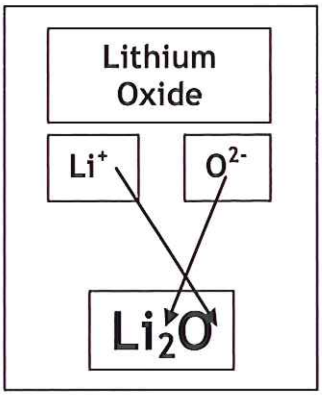
Calcium Carbonate

Ca^{2} + CO_3^{2} --

Ions cancel

$CaCO_3$

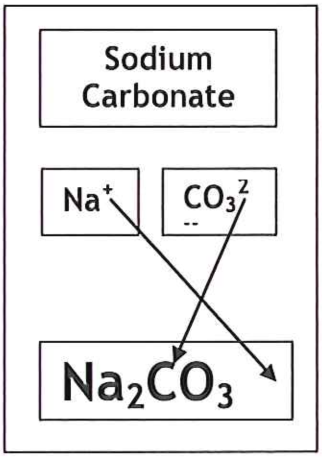
Quick method



Lithium Oxide

Li^+ O^{2-}

Li_2O



Sodium Carbonate

Na^+ CO_3^{2} --

Na_2CO_3

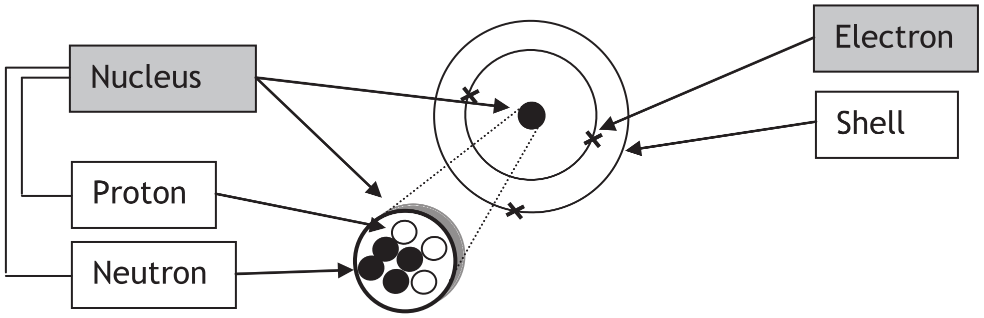
Atomic Structure

Atoms contain a **nucleus** and **electrons**

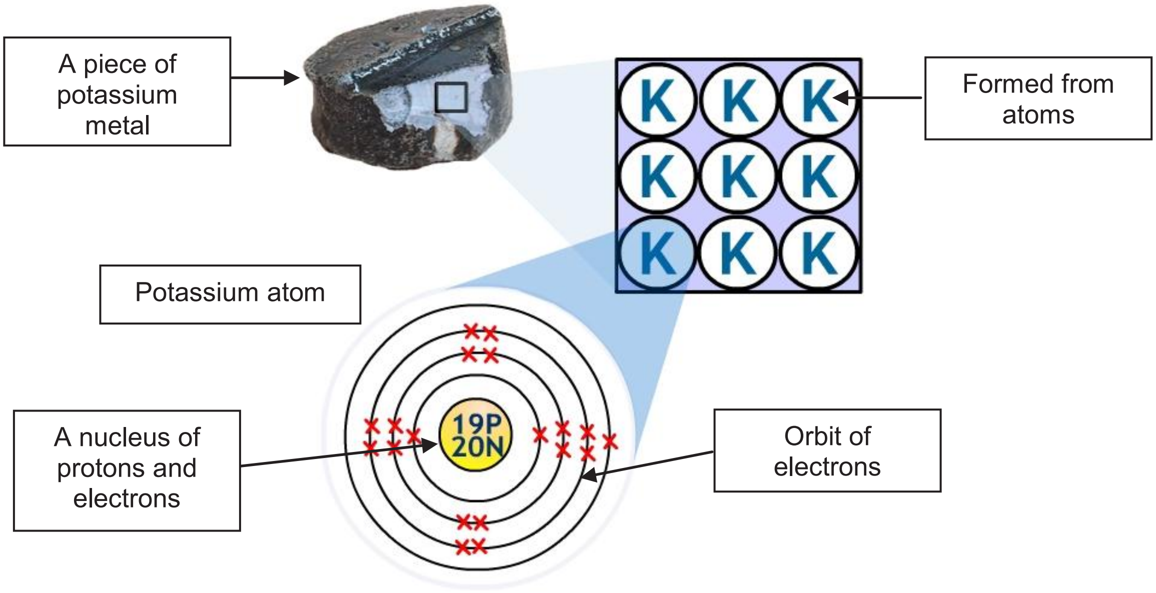
The small central nucleus is made from **protons** and **neutrons**.

Around these are **orbits** (shells) of **electrons**.

Here is a diagram showing an atom of **Lithium**



This diagram shows that a piece of **Potassium** is made up of millions of the same atom.



Atoms of **different** elements are different.

The number of **protons** is always different with different elements.

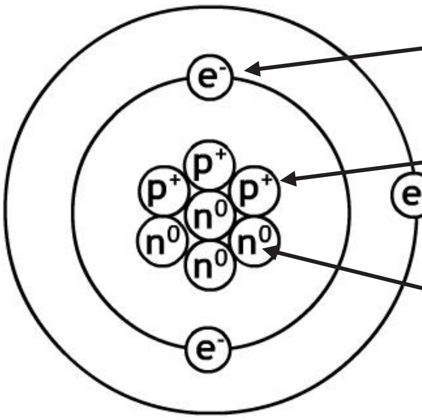
Element	*Lithium*	*Potassium*
Protons	**3**	**19**
Neutrons	4	20
Electrons	3	19

Neutron number for some elements are the same.
Electron number can be the same when the atoms have bonded.

Atoms have no charge.

The number of protons (in the nucleus) is always **the same** as the number of electrons (in shells)

Protons are positively charged. (**+**)
Electrons are negatively charged (**-**)
Neutrons do not have a charge (**0**)



Every electron has a charge of -1

Every proton has a charge of +1

Neutrons have no charge

Therefore an atom of **lithium** has no charge :- +3p + -3e = **0** **no charge**

Ion has **uneven** number of **protons and electrons**

This happens when an **electron is lost**

Or when an **electron is gained**

The proton number does not change**.**

Mass and **Charge** of atoms

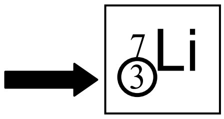
Here are the relative mass of each particle and their electric charge.

	mass	charge
proton	1	+1
electron	0	-1
neutron	1	0

Protons and **neutrons** have similar mass.
Electrons have no mass, or extremely little amount.

Atomic Structure

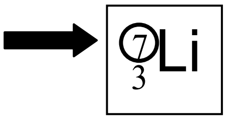
Atomic Number



Number on the **bottom** which means the number of protons or electrons

The number increases across the periodic table

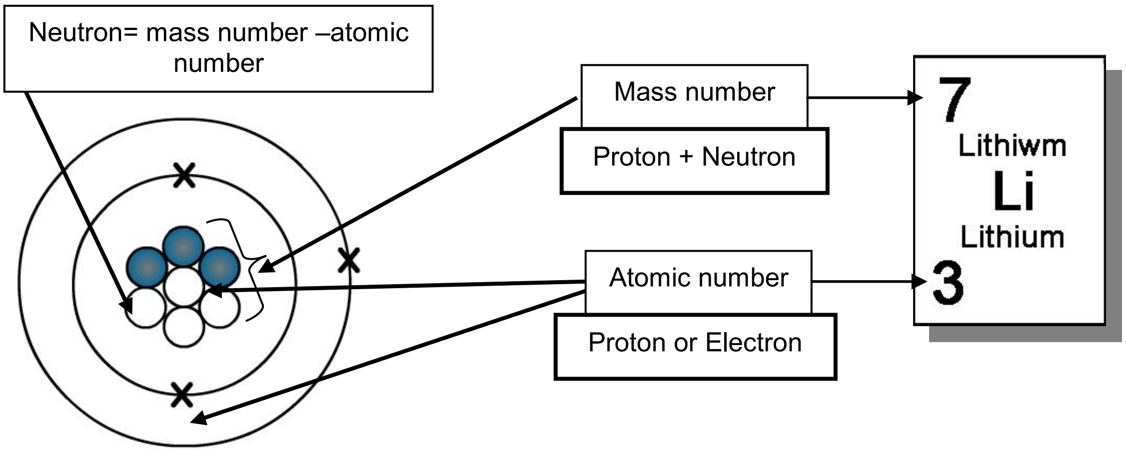
Mass Number



Number on the **top** which means the number of protons and neutrons in the nucleus.

Neutron Number

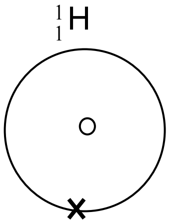
The number of neutrons in an atom is worked out by subtracting the number of protons (Atomic number) from the Mass number.



Isotopes

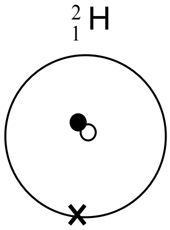
The same element (as it has the same number of protons) but with different number of neutrons (making the mass number different). Hydrogen

Proton = ○
Electron = ✕
Neutron = ●



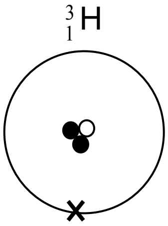
Proton number = 1

Neutron number = 0



Proton number = 1

Neutron number = 1



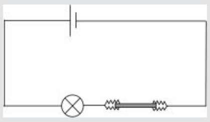
Proton number = 1

Neutron number = 2

Metals

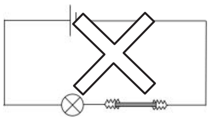
Physical Properties

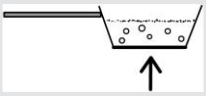
Non-Metals



Conduct Electricity

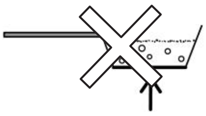
Does not conduct Electricity

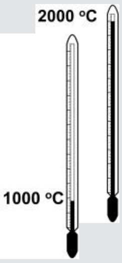




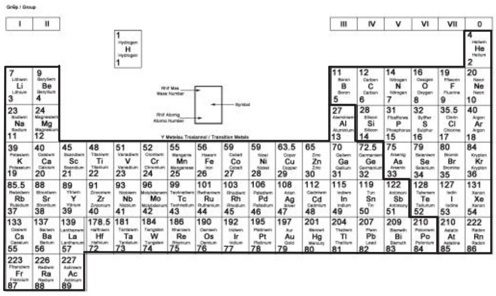
Conduct Heat

Does not conduct heat

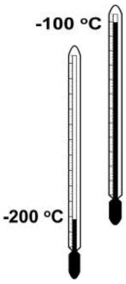


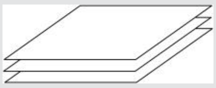


High
Melting point
Boiling point



Low
Melting point
Boiling point

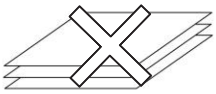


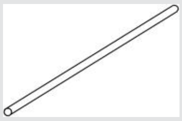


Malleable

Can be hammered into sheets

Not malleable

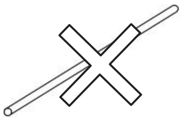




Ductile

Can be pulled into wires

Not ductile



Group 1

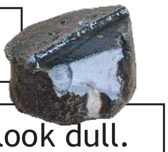
Alkali Metals

1 electron on the outer shell

Physical Properties

7 Lithiwm Li Lithium 3
23 Sodiwm Na Sodium 11
39 Potasiwm K Potassium 19
85.5 Rwbidiwm Rb Rubidium 37
133 Cesiwm Cs Caesium 55
223 Ffranciwm Fr Francium 87

All metals look dull on the outside.



Over a short period of time a layer of oxide makes the metal look dull.

The inside of every metal is shiny

It is possible to cut every metal with a knife

They are kept in **oil** to prevent them from reacting with oxygen and moisture in the air.

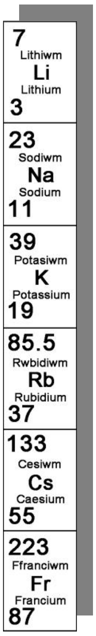
Their **density** is low therefore most float

The boiling point and melting point are lower than many other metals

Group 1 **Alkali Metals**

Chemical Properties

They react with **oxygen** and water.



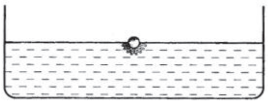
Alkali metals with **oxygen** and **water**

Oxygen causes the surface of the metal to turn dull by forming a layer of oxide

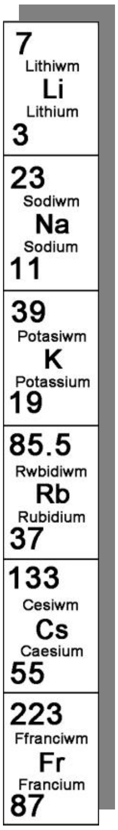
eg. potassium + oxygen → potassium oxide

$$4K(s) + O_2\ (g) \longrightarrow 2K_2O(s)$$

The oxide layer forms quicker as we go down the group



Alkali metals with **water**



The metal creates alkali as it reacts water (purple with universal indicator)

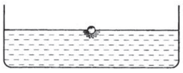
The metal with water creates hydrogen

The metal **floats, moves** and **fizzes.**

eg. lithium + water → lithium hydroxide + hydrogen

$$2Li(s) + 2H_2O\ (l) \longrightarrow 2LiOH\ (aq) + H_2\ (g)$$

Sodium



In addition this **moves quicker** and has a **ball shape.**

Potassium

In addition it **moves quickly** and has a **lilac flame.**

Safety Precautions

Use safety goggles
Use a small piece of metal in the water
Use tongs to hold the metal

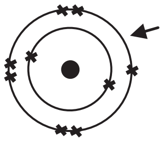
Group 7

Halogens

Physical Properties

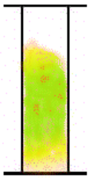
They react with **group 1 metals and salts**

19	Fflworin	F	Fluorine	9
35.5	Clorin	Cl	Chlorine	17
80	Bromin	Br	Bromine	35
127	Iodin	I	Iodine	53
210	Astatin	At	Astatine	85

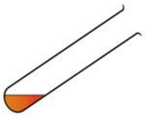


7 electrons on the outer shell

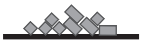
Chlorine – Yellow Green Gas



Bromine – Orange Red Liquid

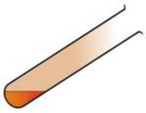


Iodine – Shiny Grey Solid



State and appearance

Poisonous Vapours



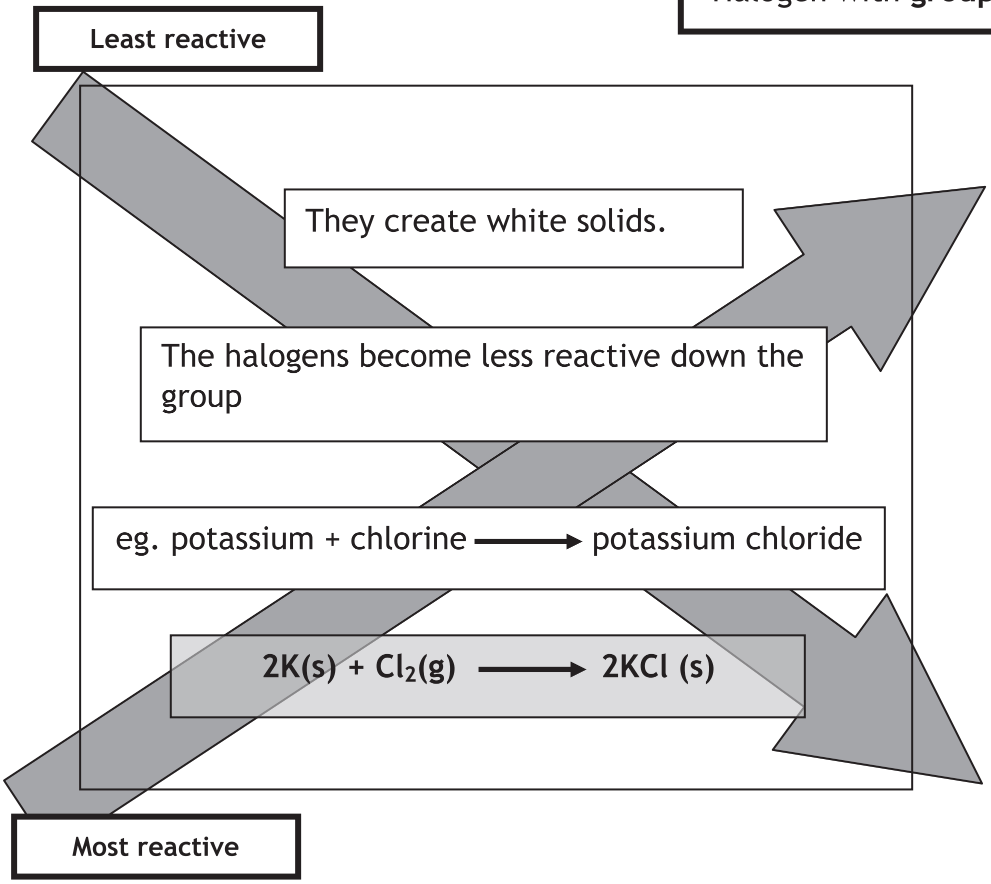
Bromine
Orange gas

Iodine
Purple gas

Vapours With colour

Halogen with **group 1 metals**

7	Lithiwm	Li	Lithium	3
23	Sodiwm	Na	Sodium	11
39	Potasiwm	K	Potassium	19
85.5	Rwbidiwm	Rb	Rubidium	37
133	Cesiwm	Cs	Caesium	55
223	Ffranciwm	Fr	Francium	87



Least reactive

They create white solids.

The halogens become less reactive down the group

eg. potassium + chlorine ⟶ potassium chloride

$$2K(s) + Cl_2(g) \longrightarrow 2KCl\ (s)$$

Most reactive

19	Fflworin	F	Fluorine	9
35.5	Clorin	Cl	Chlorine	17
80	Bromin	Br	Bromine	35
127	Iodin	I	Iodine	53
210	Astatin	At	Astatine	85

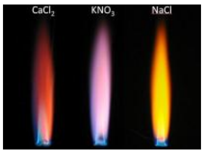
Safety Precautions

Use safety goggles
Use a fume cupboard
Use plastic gloves

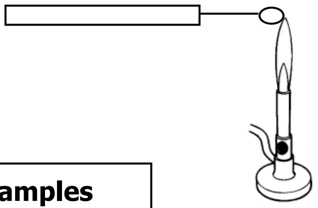
Identifying compounds

Metal	**Flame test**
Lithium	Red
Sodium	Yellow-orange
Potassium	Lilac

Barium	Apple green
Calcium	Brick red



Non-metal	**Silver Nitrate test**
Chloride	white
Bromide	cream
Iodide	yellow



Flame Test
(to identify the metal)

Silver Nitrate Test
(to identify non metal ions)

Examples
Lithium Chloride
Sodium Iodide
Potassium Bromide

Red
due to lithiwm

Yellow-orange
due to sodium

Lilac
due to potassium

White precipitate
due to chloride ions

Yellow precipitate
due to iodide ions

Cream precipitate
Due to bromide ions

Higher Tier: Silver Nitrate ionic equation:
e.e. Ag^+ (aq) + Cl^- (aq) $\rightarrow$ AgCl (s)

Atomic Spectroscopy (Higher Tier): This method is used to identify and show the amount (concentration) of specific atoms/ions present in the sample.

Non metals

Physical Properties

Seawater compounds

e.g.
Sodium chloride
Magnesium chloride
Magnesium sulfate
Sodium Iodide

the concentration of chlorine compounds is **more than** iodine compounds.

Chlorine and Iodine can be produced from seawater compounds.

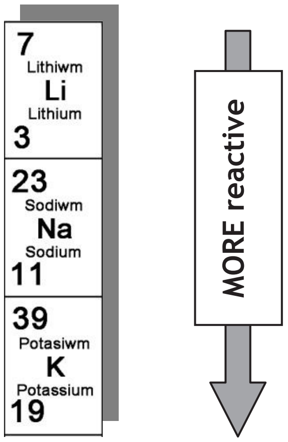
Today improved methods that are more economic mean that iodine is not extracted from sea water.

Element	Use	Properties
Chlorine	treatment of water supplies	poisonous/toxic, kills bacteria
	treatment of swimming pool 	
	 making household cleaners	
Iodine	 antiseptic following hospital procedures 	poisonous/toxic, kills bacteria
Helium	 To fill weather balloons	low density, very unreactive
Argon	 To fill light bulbs	very unreactive inert atmosphere
Neon	 Advertising lights	emits light when electric current passes through it

Quantities of chlorine **controlled** and **monitored** to kill bacteria and sterilise the water, without causing any harm to us.

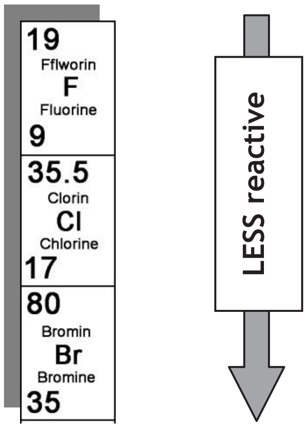
Higher Tier

Alkali Metals	Group 1 metals become more reactive down the group.

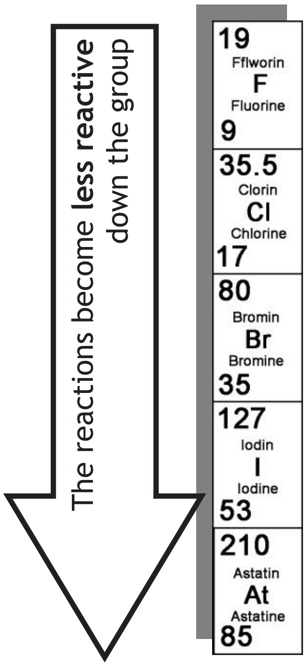


- **Group 1 metals react by <u>losing</u> 1 electron**
- There are more orbits as you go down the group.
- The outer electron becomes further from the nucleus.
- Due to less attraction it is easier to lose an electron.

The Halogens	Group 7 non-metals become less reactive down the group.

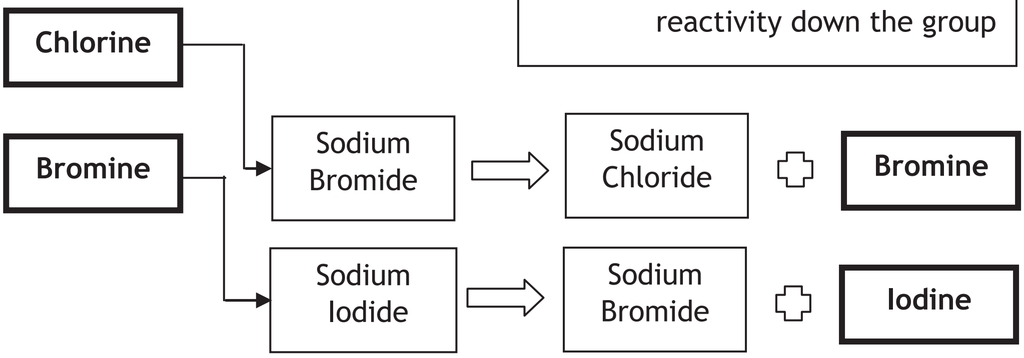


- **Group 7 non-metals react by <u>gaining</u> 1 electron**
- As you go down the group there are more orbits, because of this it is harder to attract an electron, they become less reactive



Displacement reactions

This reaction shows the trend in reactivity down the group



Chlorine → Sodium Bromide ⇒ Sodium Chloride + **Bromine**

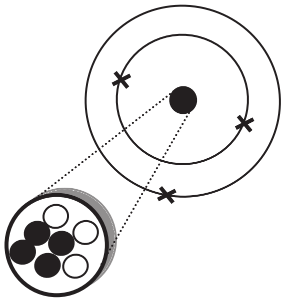
Bromine → Sodium Iodide ⇒ Sodium Bromide + **Iodine**

$$Cl_2(g) + 2NaBr(aq) \longrightarrow 2NaCl\ (aq) + Br_2(aq)$$

Chemical Calculations

Every atom has different mass. This is determined by the number of protons and neutrons in the nucleus.

A lithium atom has a mass of **7**.



3 protons and 4 neutrons

Relative atomic mass (A_r) is a way of saying how heavy different atoms are compared to each other.

The $\mathbf{A_r}$ of Lithium is 7 and that of Carbon is 12. We use the top number to determine this; this is called the mass number

Relative formula mass or **relative molecular mass** ($\mathbf{M_r}$) is the mass for a compound (e.g. $MgCl_2$) so the masses for each element are

Mass numbers → **Mg** **Cl** **Cl**

24 + 35 + 35 = **94**

What is the molecular mass of ammonium sulphate $(NH_4)_2SO_4$?

(N=14, S=32, O=16, H=1)

Calculate $(NH_4)_2$ first = 14+1+1+1+1 = 18 x 2 = 36

S= 32

4 oxygen atoms 16 x 4 = 64

Mr= ***132***

Calculating % composition

After calculating M_r it is possible to calculate % composition, this shows how much of a specific element is in a compound in percentage form

e.g. % Mg in $MgCl_2$ =

$$\frac{\text{total } M_r \text{ of Mg in } MgCl_2 \text{ x } 100}{M_r\, MgCl_2}$$

$$\frac{24}{94} \text{ x } 100 = 25.5\ \%$$

Calculating the Relative Atomic Mass of an Element

Worked Example

Chlorine has two isotopes: chlorine-35 and chlorine-37

A typical sample of chlorine will be 75% chlorine-35 atoms and 25% chlorine-37 atoms.

The relative atomic mass is calculated as follows:

Total mass of 100 atoms = (75 × 35) + (25 × 37) = 3550

Mean mass of one atom = (3550 ÷ 100) = 35.5

A_r of chlorine is 35.5

Worked Example 2

The isotopes of magnesium and their percentage abundances are:

Magnesium-24 78.6%; magnesium-25 10.1%; magnesium-26 11.3%

Total mass of 100 atoms = (78.6 × 24) + (10.1 × 25) + (11.3 × 26) = 2432.7

Mean mass of one atom = (2432.7 ÷ 100) = 24.327

A_r of magnesium is 24.3 (to one decimal place)

Most elements have isotopes and hence their relative atomic masses will not be a whole number. However, for the sake of simplicity, most relative atomic masses quoted in the Periodic Table are given to the nearest whole number.

The mole

The **mole** is a measure of the **amount of substance.**

One mole (1 mol) is the amount of substance that contains 6 × 10^{23} particles (atoms, molecules, or formulae) of the substance.
6 × 10^{23} is known as the **Avogadro number.**

For example:

1 mol of sodium (Na) contains 6 × 10^{23} **atoms** of sodium

1 mol of hydrogen (H_2) contains 6 × 10^{23} **molecules** of hydrogen

1 mol of sodium chloride (Na*Cl*) contains 6 × 10^{23} **formulae** of sodium chloride

Sodium chloride is an ionic compound and therefore does not contain any molecules. This is why it is important to refer to a certain number of **formulae**, and not **molecules**, being present *(see Chapters 6 and 7).*

Calculating the mass of one mole

The mass of one mole of atoms is easily calculated. It is simply the relative atomic mass (A_r) expressed in grams.

Worked Examples

Element	Symbol	A_r	Mass of one mole of atoms
Hydrogen	H	1	1 g
Carbon	C	12	12 g
Oxygen	O	16	16 g
Sodium	Na	23	23 g
Chlorine	*Cl*	35.5	35.5 g

Calculating Reacting Masses

By using relative atomic masses and (Ar) and relative molecular masses (Mr) it is possible to calculate how much of a product is produced or how much reactants are needed.

e.g. (product calculation)

What is the mass of **magnesium oxide** is produced when 60g of magnesium is burned in air?

Symbol Equation

$$\mathbf{2Mg} + O_2 \rightarrow \mathbf{2MgO}$$

Mr = 2×24 2 (24+16)
48 80

Therefore 48g (or tonnes) will produce 80g

1g 80 ÷ 48 = 1.67g

60g will produce 60 × 1.67 = 100.2g

e.g. (reactant calculation)

What is the mass of **magnesium** needed to produce 90g of magnesium oxide?

$$\mathbf{2Mg} + O_2 \rightarrow \mathbf{2MgO}$$

Mr = 2×24 2 (24+16)
48 80

Therefore 48g (or tonnes) will produce 80g

Or *80g of MgO will be produced with 48g of Mg*

1g 48÷80=0.6g

90g will produce 90 × 0.6 = 54g

Determining the formula of a compound from experimental data

When 4 g of copper oxide is reduced in a steam of hydrogen, 3.2 g of copper remains.

1. Work out how much oxygen was contained in the compound

$$4 - 3.2 = 0.8 \text{ g}$$

	Cu	O
Divide with Ar	$\frac{3.2}{64}$	$\frac{0.8}{16}$
Divide with smallest	$\frac{0.05}{0.05}$	$\frac{0.05}{0.05}$
Whole number	1	1
	1 Cu	1 O

Formula = CuO

Example 2

Find the formula of iron oxide produced when 44.8g of iron react with 19.2g of oxygen. (Ar Fe = 56 and O = 16)

	Fe	O
Mass	44.8	19.2
Divide with Ar	44.8÷56	19.2÷16
	0.8	1.2
Divide with the smallest value	0.8÷0.8	1.2 ÷0.8
	1	1.5

A formula must have whole numbers therefore

	2	3

Formula = Fe_2O_3

Calculating reactants or product masses

	Reactants				Products		
	NaOH	+	HCl	⇨	NaCl	+	H_2O
	23+16 + 1		1 + 35		23+35		1+1+16
	40		36		58		18
	76				76		
Units	g / tones				g / tones		

Calculating the percentage yield

When we want to create a chemical, the aim is to work carefully and to produce the maximum amount possible.

The amount formed or yield is calculated in percentage. It is very unlikely that 100% yield will be achieved e.g. some might be stuck in filter paper, evaporating dish, the product might react with the air.

Example

Magnesium metal dissolves in hydrochloric acid to form magnesium chloride.

$$\mathbf{Mg_{(s)} \quad + \quad 2HCl_{(aq)} \qquad MgCl_{2(aq)} \quad + \quad H_{2(g)}}$$

24g **95g**

(24 + 35.5 + 35.5)

(a) What is the **maximum theoretical mass** of magnesium chloride which can be made from 12g of magnesium?

12g 95/2 = **47.5g**

(b) If only **47.0g** of purified magnesium chloride was obtained after crystallising the salt from the solution, what is the % yield of the salt preparation?

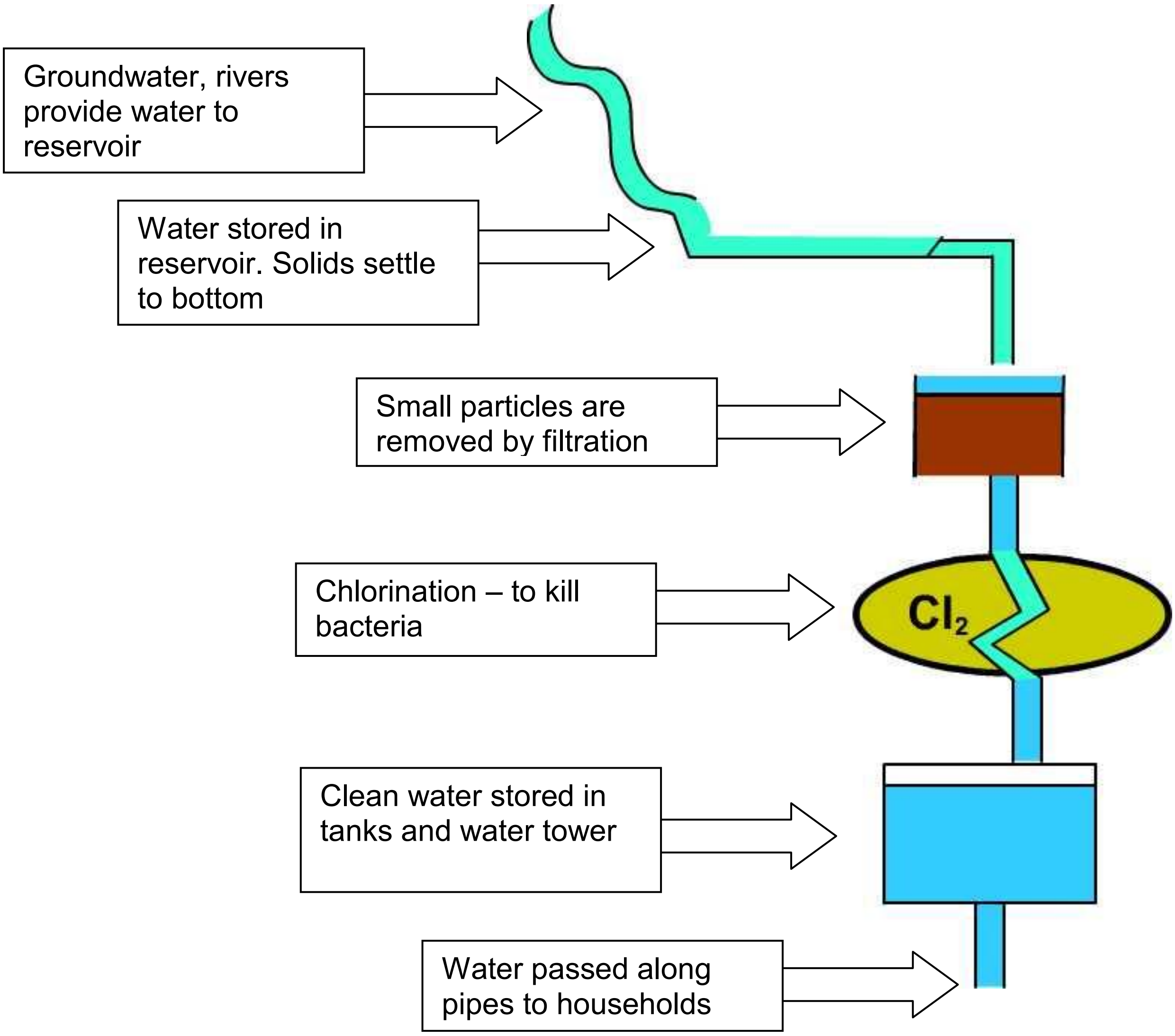
$$\textbf{\% yield} = \frac{\text{actual amount obtained x 100}}{\text{maximum possible}}$$

$$\textbf{\% yield} = \frac{47.0 \times 100}{47.5} = \mathbf{98.9\%} \text{ (to 1 decimal place)}$$

Water

Water is necessary for life to exist. The quality of life depends on the availability of clean water. Water in this country is made drinkable by treating rainwater.

Here are the steps involved in making water drinkable.



Groundwater, rivers provide water to reservoir

Water stored in reservoir. Solids settle to bottom

Small particles are removed by filtration

Chlorination – to kill bacteria

Clean water stored in tanks and water tower

Water passed along pipes to households

Fluoride ions are added to water to strengthen children’s teeth in some areas.

Fluoride is not added to water supplies in Wales.

Water Preservation

Although there is ample water on Earth, only a very small fraction is safe for drinking. With an increasing population and developing industry our need for water is larger than ever.

The need for water

We use 150 litres of water each on average every day. The water comes from natural underwater storage, rivers and different reservoirs. During dry conditions when there is not enough rain there is a strain on the water supply – areas will experience drought.

Shortage of water problems arise when there is more demand than supply of water, which is a threat to life and the environment. Water cost may increase if future climate changes cause shortage of water in the UK. Using less water in the future is very important.

Here are some ways of decreasing our use of water.

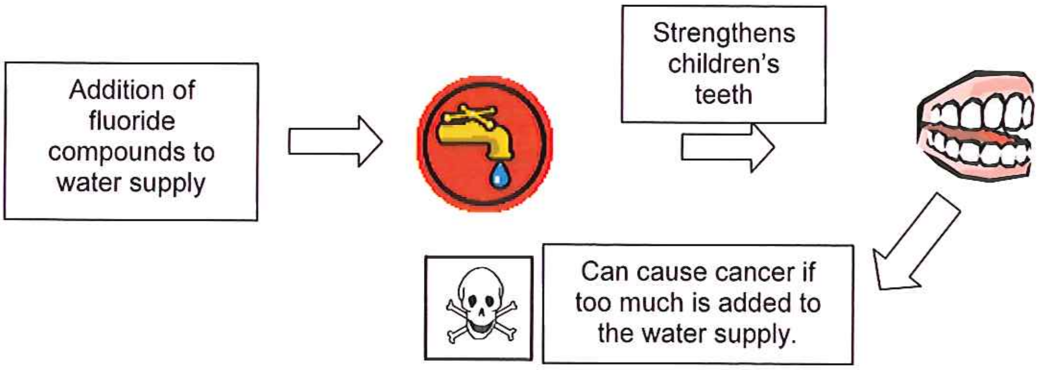
- Use washing machines and dish washers only when they are full.
- Having a shower instead of a bath.
- Use waste water for plants and to wash the car.
- Repair dripping taps.
- Do not allow the water to run excessively (e.g. when brushing teeth)

Fluoridation of tap water

There is a difference of opinion for the addition of fluoride to water supplies.

Scientific studies show that its addition helps **strengthen children's teeth from decay** (there are reduced number of fillings in areas that have extra fluoride added)

The problems;
(1) high concentrations of fluoride can be poisonous and may cause cancer (bone and teeth).
(2) It can cause discolouring or decay of teeth (fluorosis) and
(3) it can cause infertility.
(4) Some people oppose it because they feel it is not right to force everyone to consume fluoride without the individual's consent.



Collecting evidence

Questionnaire - data of the state of children's teeth are collected by counting the number of fillings, loss of teeth and decayed teeth children of all ages have.

The data is reliable because all the children of the school are tested with exception of absent pupils.

The comparison of areas which have been fluoridated with unfluoridated areas can be unfair without the consideration to other factors (e.g. social and economic) which are important for those areas.

Fluoride is normally in toothpaste, mouthwash and sometimes it is added to special milk

Desalination - It is possible to desalinate sea water to supply drinking water.

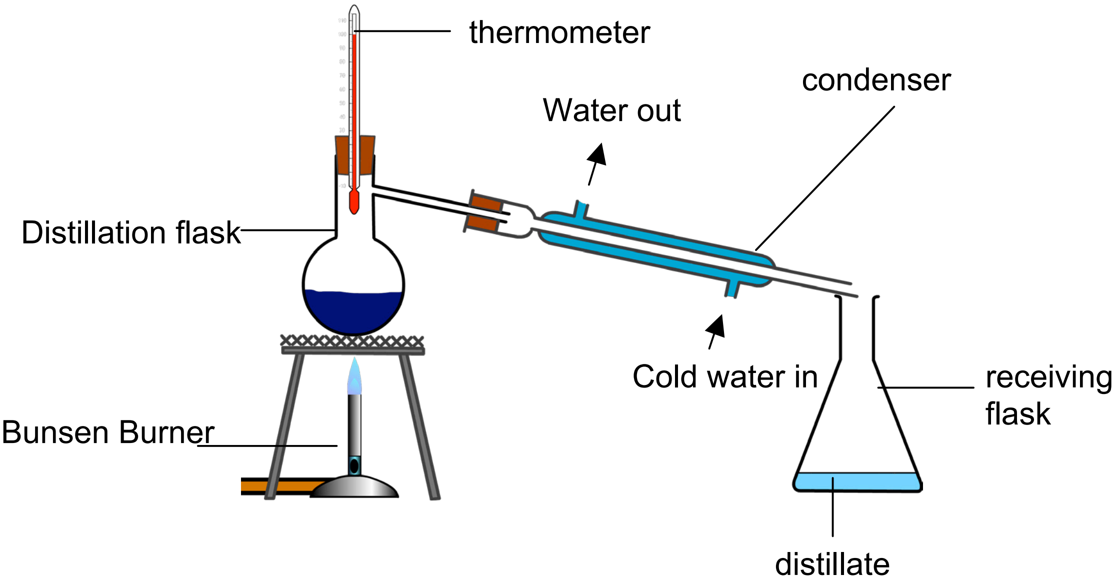
To desalinate sea water distillation of sea water by boiling is used. Boiling uses large amounts of energy which is costly. Due to this the process is not viable in many parts of the world.

If a country is to use desaliantion they need to ensure

- a renewable means of creating heat energy where no carbon dioxde is created (greenhouse effect)
- sea nearby.

Distillation – Separating water and miscible liquids.

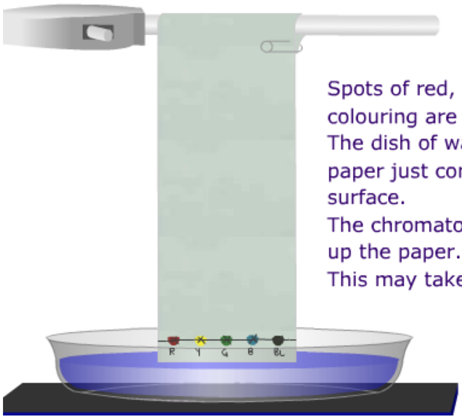
Pure liquids have specific boiling points, e.g. water boils ar 100°C. Ethanol boils at 78°C. Water and ethanol are miscible (when two liquids mix together easily without separating into layers.)



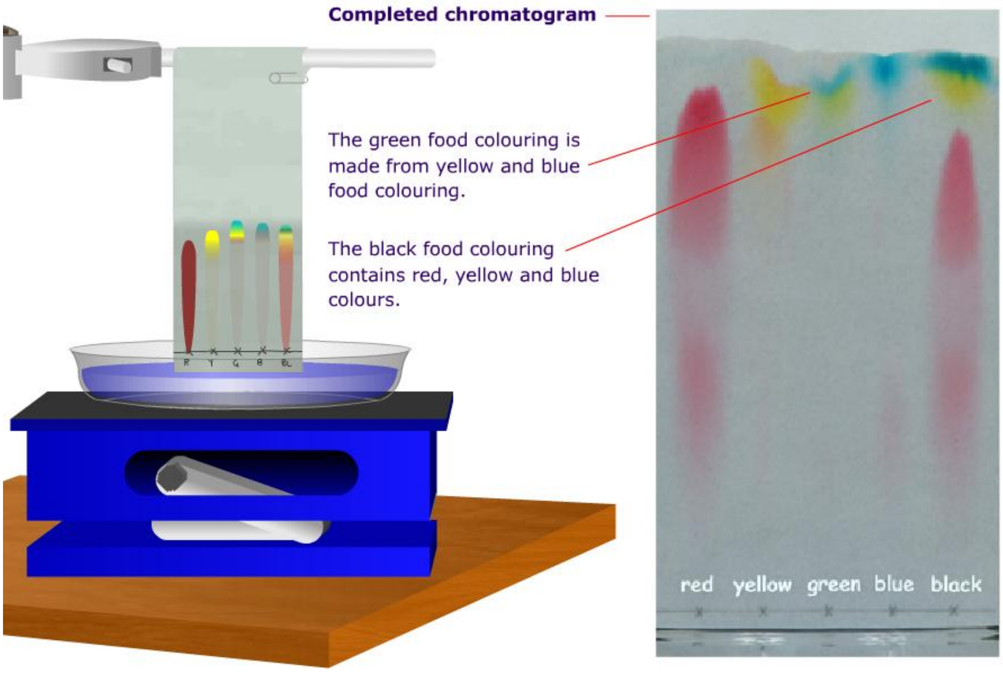
If a mixture of miscible liquids exist it is possible to separate them by distilation. In a mixture of ethanol and water, the ethanol would boil and evaporate first (as it has the lower boiling point) leaving the water behind. The ethanol would condense on the cold wall of the condeser.

Chromatography

Pigments in ink can be separated using paper chromatography.



Spots of red, yellow, green, blue and black food colouring are placed on the pencil line.
The dish of water (solvent) is raised until the paper just comes into contact with the water surface.
The chromatogram develops as the water rises up the paper.
This may take 30 minutes to complete.



Completed chromatogram

The green food colouring is made from yellow and blue food colouring.

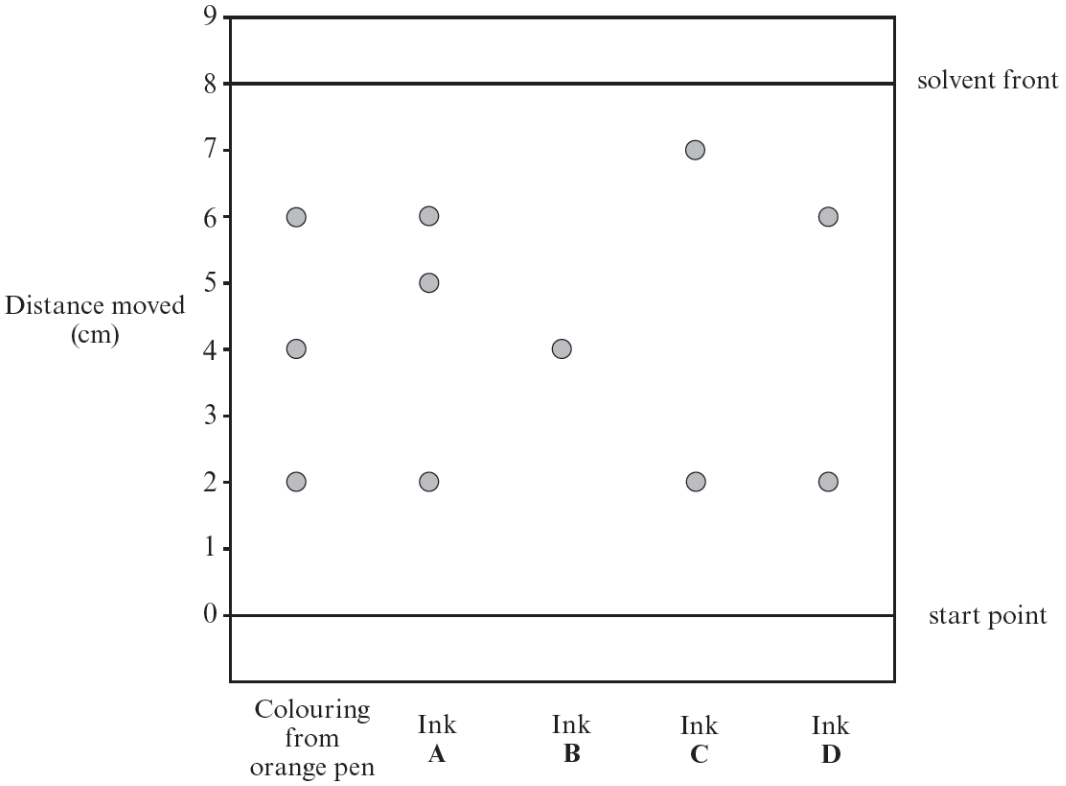
The black food colouring contains red, yellow and blue colours.

The most soluble substance will be transported furthest by the solvent.

Chromatography

The distance that a substance travels allows scientists to recognise a substance. Am R_f value is calculated

$$R_f \text{ Value} = \frac{\text{distance the substance has traveled}}{\text{distance the solvent has traveled}}$$



e.g. The R_f value for ink B = 4/8 = 0.5

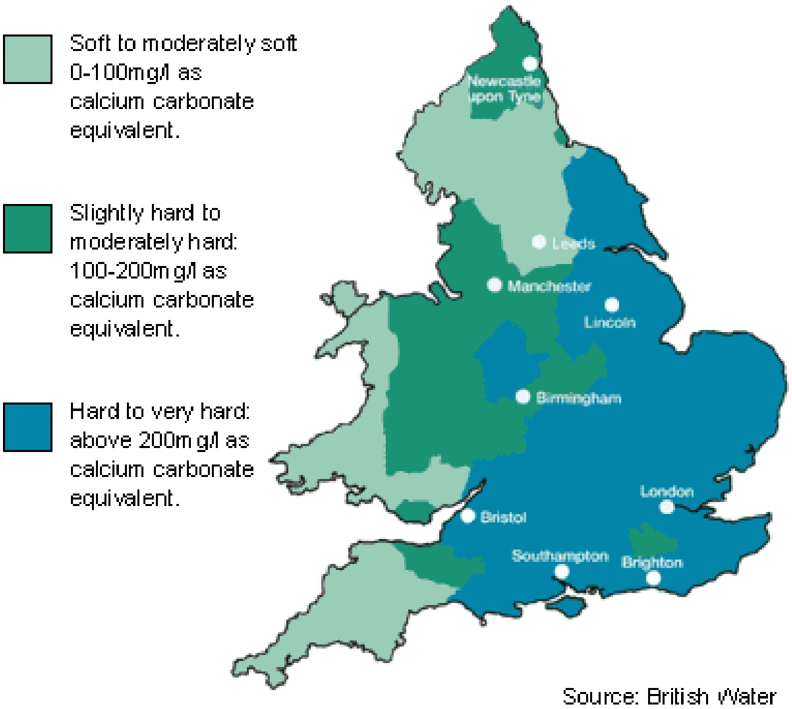
Gas Chromatography (Higher Tier)
This method is very useful as it gives quantitative information - that is the amount of substance present. Chemical analysts use the method to identify e.g. the amount of a pollutant in water or air, it is also used to identify the amount of an illegal drug in blood.

Types of drinking water.

Depending on the type of rocks a region has, water can be of two types :-

Hard water and Soft water

Hard Water Areas in England and Wales



Source: British Water

Hard Water

If rainwater passes along **limestone** (calcium carbonate) rocks on its way to a reservoir, *calcium ions* Ca^{2+} will collect in the water. Other ions such as *magnesium ions* Mg^{2+} can also collect in water. These additional ions make the water hard.

Soap in hard water **does not** readily **lather**, **scum** is formed

Hardness in water is defined as difficulty in producing a lather with soap.

There are two types of hard water:

Temporary hard water and **permanently hard water**

Temporary hard water

Calcium and Magnesium hydrogen carbonates form *temporary hard water* because when this water is **boiled**, hardness is **removed**.

Hydrogen carbonates are decomposed.

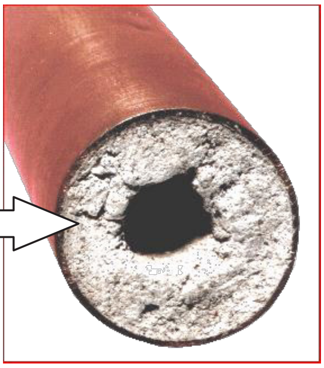
Lime scale furring up a kettle element

Magnesium and Calcium become *magnesium carbonate* and calcium carbonate which are insoluble. This lime scale collects on kettles as 'fur'.

Permanently hard water

When insoluble calcium and magnesium sulfates or carbonate exists in water it is called permanently hard water.

Lime scale clogs up hot water pipe



Treating permanently hard water.

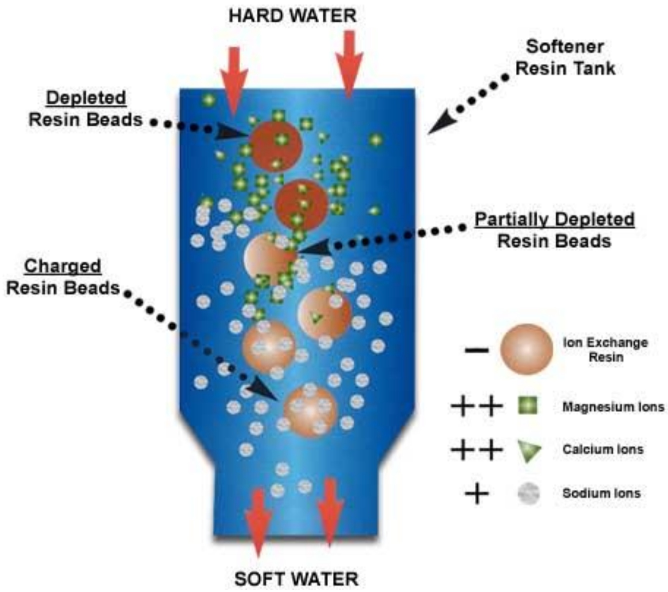
1. Adding **sodium carbonate** (washing soda).

$$\text{sodium carbonate} + \text{calcium sulfate} \longrightarrow \text{calcium carbonate} + \text{sodium sulfate}$$

Calcium ions are removed as solid Calcium carbonate making the water softer

2. Ion exchange column

When hard water is passed along negatively charged particles within a container, the positive ions of magnesium and calcium in hard water are attracted and held there, they are replaced with sodium ions. Water leaves the container soft.



Advantages and Disadvantages of hard water

Advantages

1. Strengthens teeth
2. Reduces the risk of heart disease
3. Some people prefer the taste of hard water

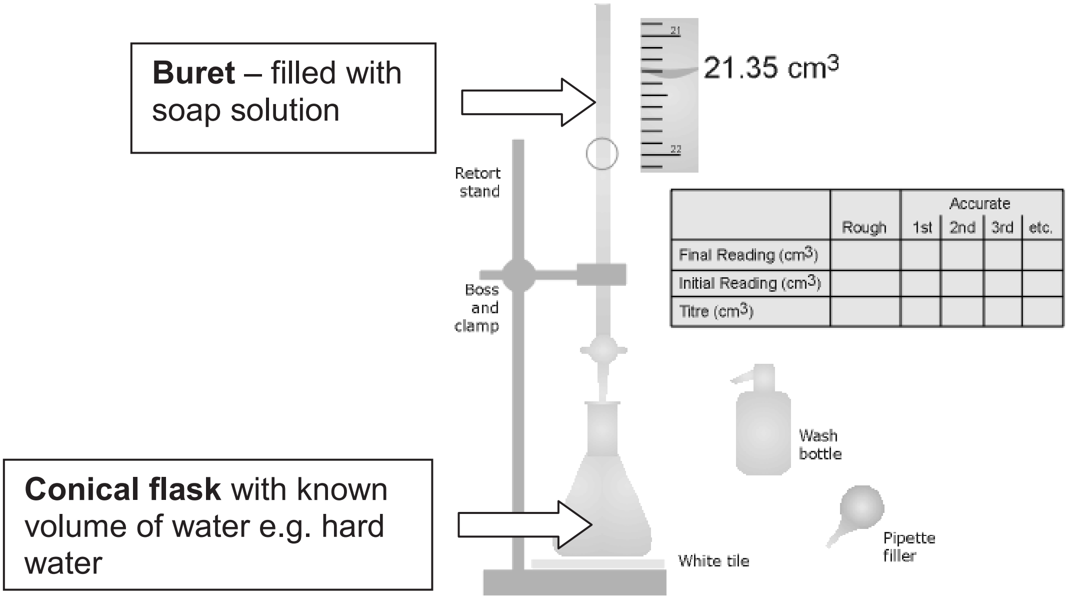
Disadvantages

1. **Lime scale** on kettles make them less efficient at boiling water and therefore waste energy. Hot water pipes can also block up with lime scale.
2. Removing scale can be expensive.
3. More soap is needed with hard water.
4. Ion exchange water softeners release sodium ions which can be unsuitable for some uses.
5. Ion exchange units need to be ‘cleaned’ out of magnesium and calcium ions when it has filled up (usually with sodium chloride (salt))

Experiments to determine the amount of hardness of water.

A **buret** is the apparatus used to measure the amount of soap solution needed.

The amount of water to be tested is kept the same in the **conical flask**.



Buret – filled with soap solution

Conical flask with known volume of water e.g. hard water

	Rough	Accurate			
		1st	2nd	3rd	etc.
Final Reading (cm^3)					
Initial Reading (cm^3)					
Titre (cm^3)					

Soap solution is added every 1 cm^3 to the water and the flask shaken to try and form lather (bubbles). When lather starts to form the soap solution is added every 0.5 cm^3 until it stays permanently. The amount of soap solution can be determined using the buret.

Soft water lathers easily therefore little amount of soap solution is used.

Hard water lathers slowly therefore more soap solution is needed.

Experiment to determine if water is permanently hard or temporarily hard.

If two samples of water seem to be **hard water** from the above experiment, samples of both types of water could be **boiled**.

The same experiment as above could then be undertaken.

If the water is still difficult to lather then the water is permanently hard.

Solubility curves

Soluble solids dissolve more readily when heated.

Every solid has a different rate of solubility. The diagram below shows that potassium nitrate dissolved more readily than copper sulphate at any temperature above 0ºC.

e.g.

The amount of copper sulphate that dissolves at 40ºC is 24 g in 100 cm^3 water.

The amount of potassium nitrate that dissolves at 40ºC is 60 g in 100 cm^3 water.

Notice that the standard amount of water used is 100 cm^3 or 100 g.

This graph shows the maximum amount of solid that will dissolve at any temperature.

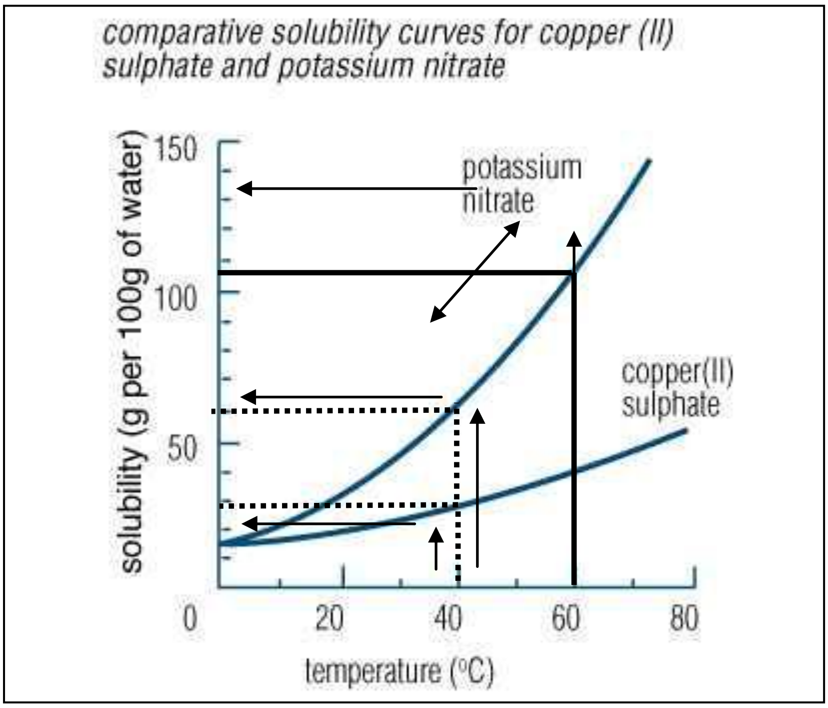
A **saturated solution** is the maximum amount of solid that will dissolve at a particular temperature.

The amount of copper sulphate that dissolves at 60ºC is 107 g in 100 cm^3 water.

If a saturated solution of copper sulphate at 60ºC was to cool down to 40ºC not as much solid would be able to dissolve.

It is possible to work out how much less would dissolve by subtracting:

107 g – 60 g = **47 g** of solid would appear on the bottom of the beaker.



FORMULAE FOR SOME COMMON IONS

POSITIVE IONS		NEGATIVE IONS	
Name	**Formula**	**Name**	**Formula**
Aluminium	Al^{3+}	Bromide	Br^{-}
Ammonium	NH_4^{+}	Carbonate	CO_3^{2-}
Barium	Ba^{2+}	Chloride	Cl^{-}
Calcium	Ca^{2+}	Fluoride	F^{-}
Copper(II)	Cu^{2+}	Hydroxide	OH^{-}
Hydrogen	H^{+}	Iodide	I^{-}
Iron(II)	Fe^{2+}	Nitrate	NO_3^{-}
Iron(III)	Fe^{3+}	Oxide	O^{2-}
Lithium	Li^{+}	Sulphate	SO_4^{2-}
Magnesium	Mg^{2+}		
Nickel	Ni^{2+}		
Potassium	K^{+}		
Silver	Ag^{+}		
Sodium	Na^{+}		

THE PERIODIC TABLE

1	2	Group										3	4	5	6	7	0
						1 H Hydrogen 1											4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	63.5 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
86 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	99 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57	179 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89															

Key

A_r — relative atomic mass
Symbol
Name
Z — atomic number