Particles

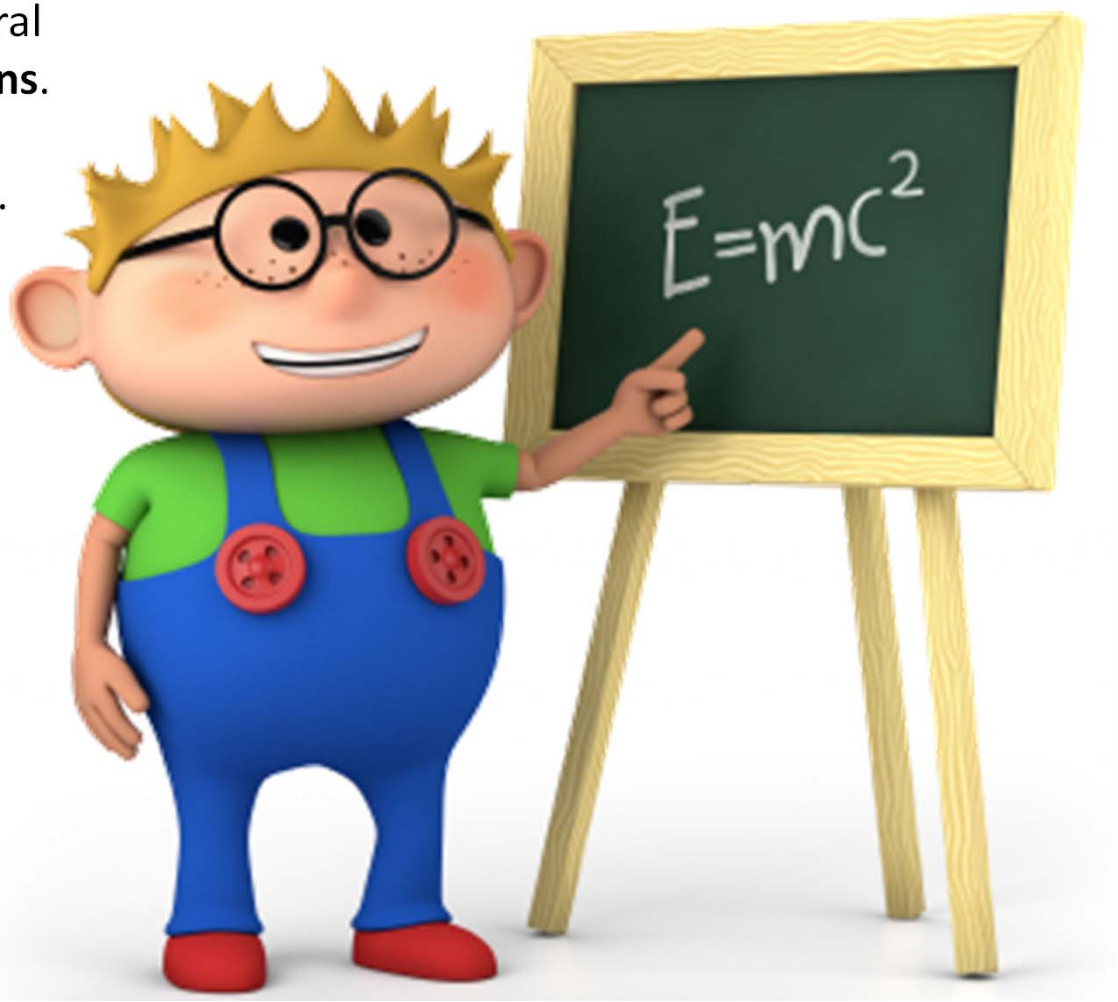
Year 9 Extension and Enrichment

1a What is Science?

Science is both a collection of **knowledge** and the **process** for building that knowledge.

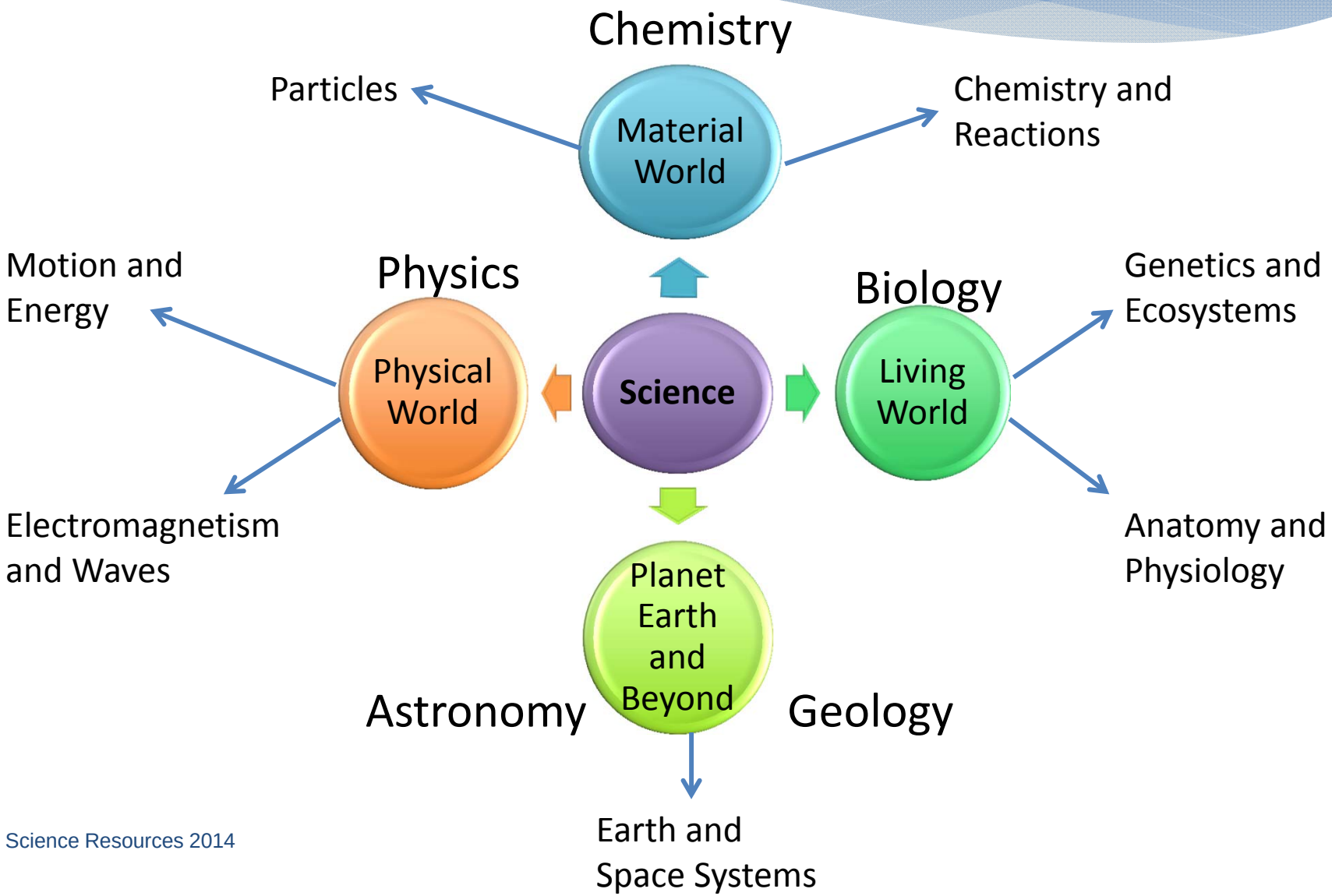
Science asks **questions** about the natural world and looks for natural **explanations**.

Science works only with **testable** ideas.

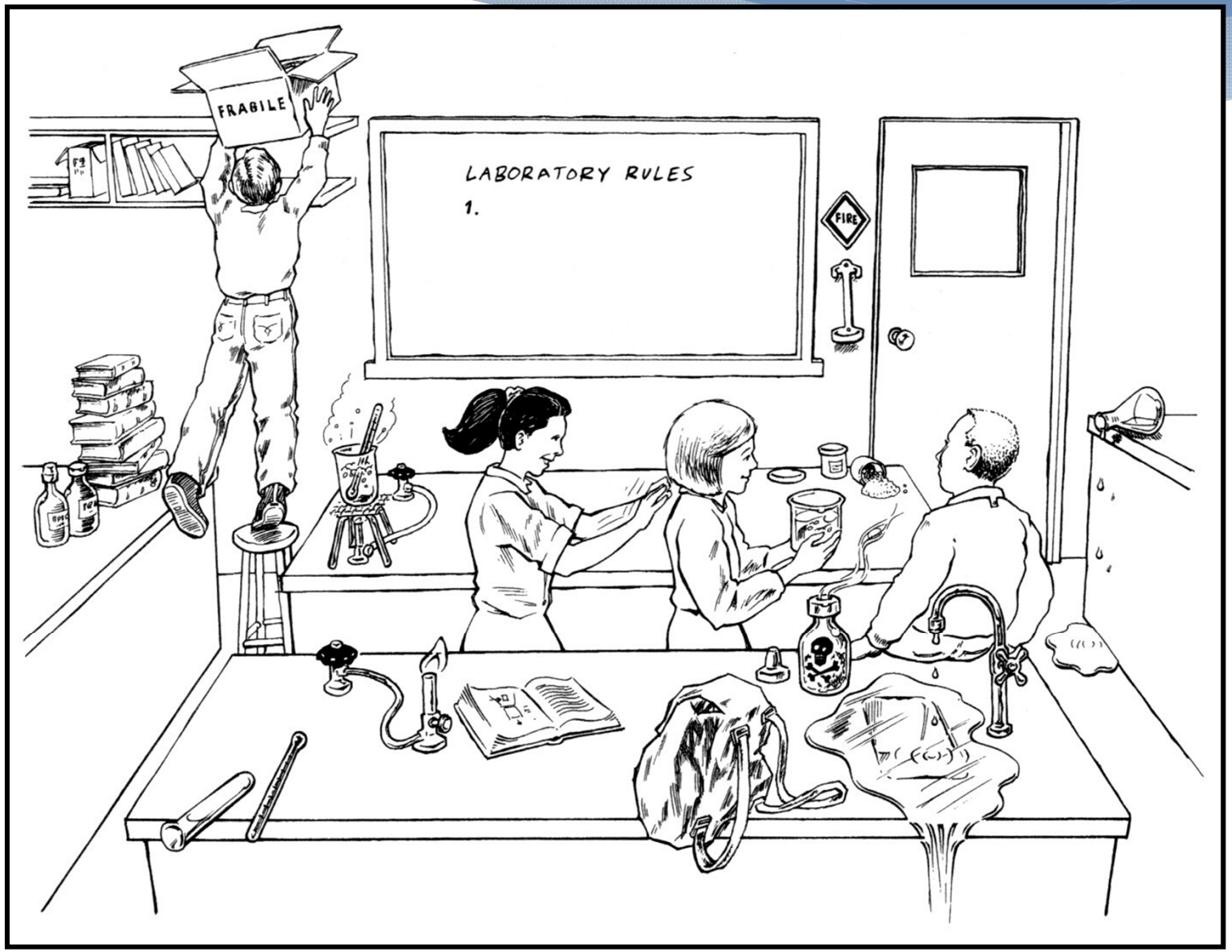


Moral judgments, decisions about how to use science discoveries, and conclusions about the **supernatural** are outside the area of science.

1a Areas of Science studied this year



2a Spot the Dangers in the lab



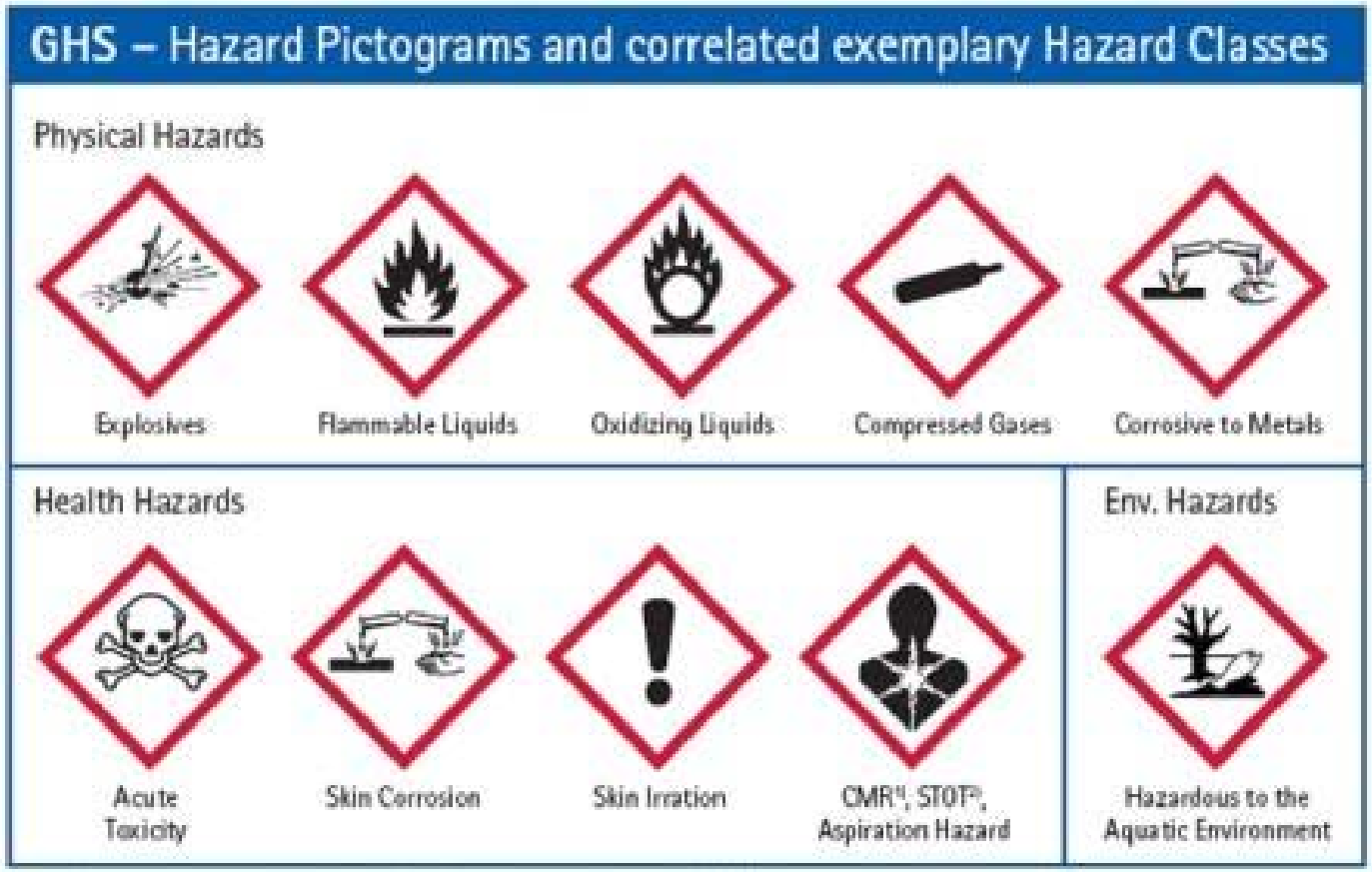
2a

Laboratory Rules

1. Don’t smell or taste chemicals.
2. Place bags under your desks.
3. Wear safety equipment if asked.
4. Tie long hair back during practicals.
5. No running in class.
6. Tell the teacher if you break equipment.
7. Clean up your work area after practicals.
8. No eating in the class.
9. ……
10. ……..

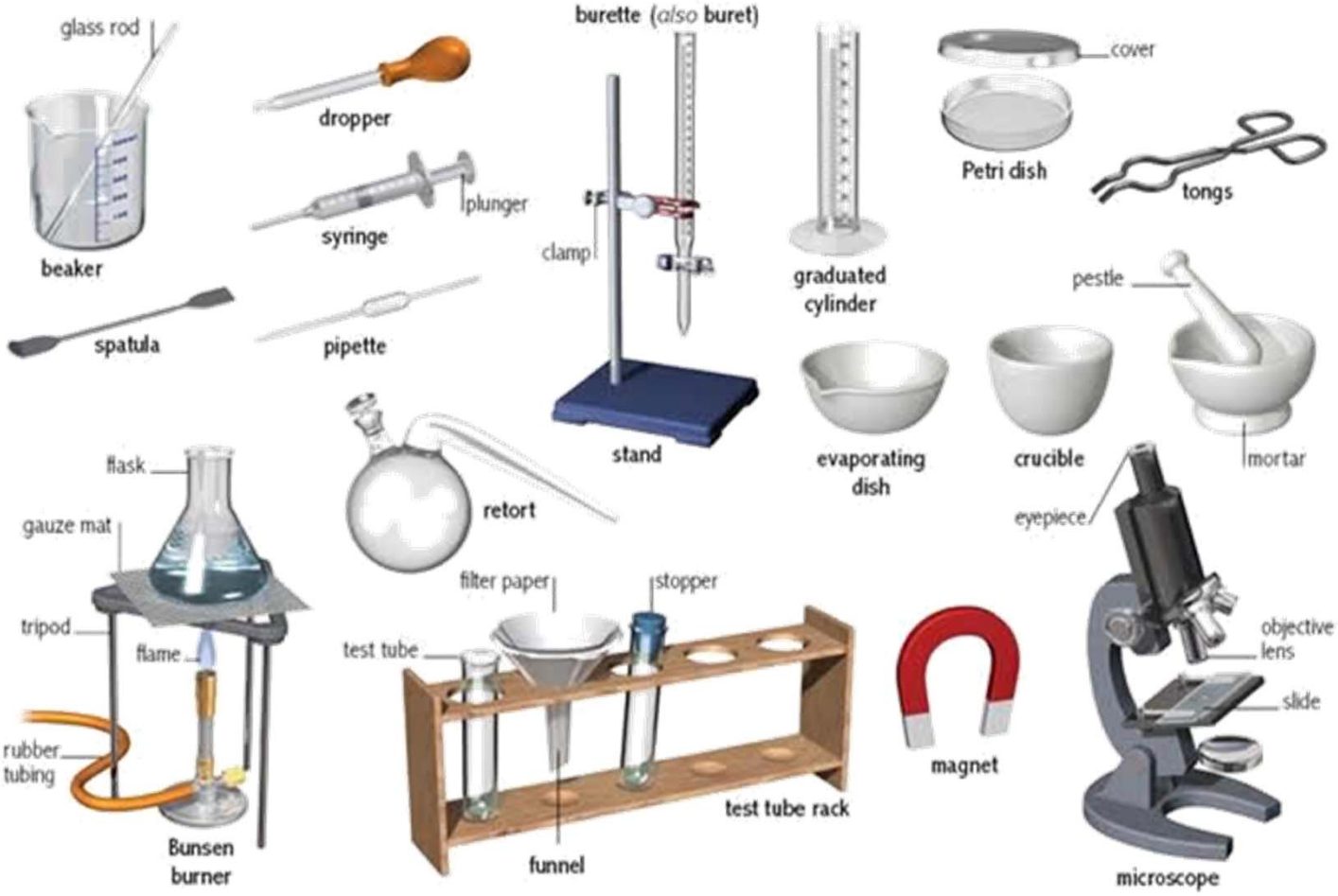
2b Laboratory safety symbols

Easy to recognise safety symbols are often used in Labs and on labels of chemicals when special care is required. A chemical may be poisonous or be explosive or burn when it touches skin. Safety symbols and Lab rules are designed to warn and protect you from dangerous situations.



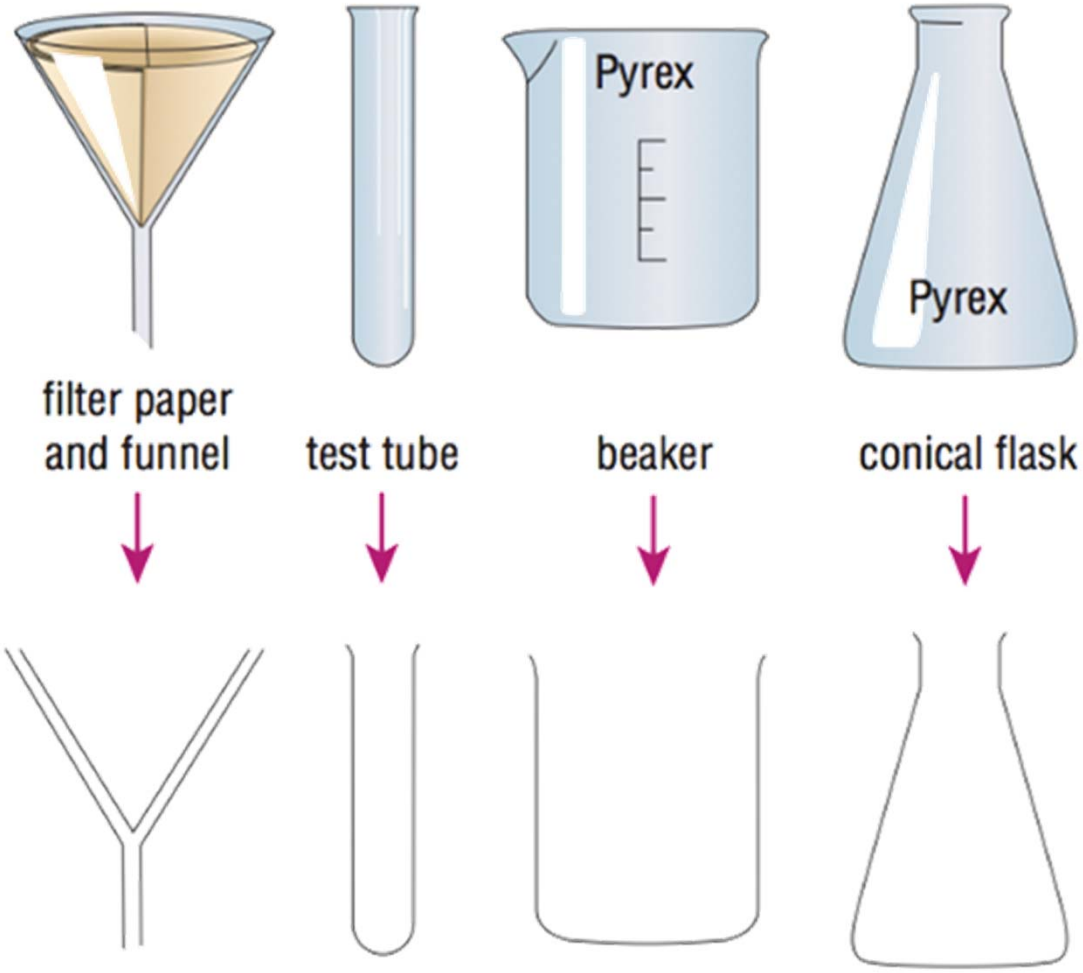
2C Common Laboratory equipment

Science labs contain equipment that is used to carry out investigations and experiments. This equipment may be quite different from what we have in our homes but is often designed for specific uses.
The names and uses of the equipment will need to be learnt along with how to use it.



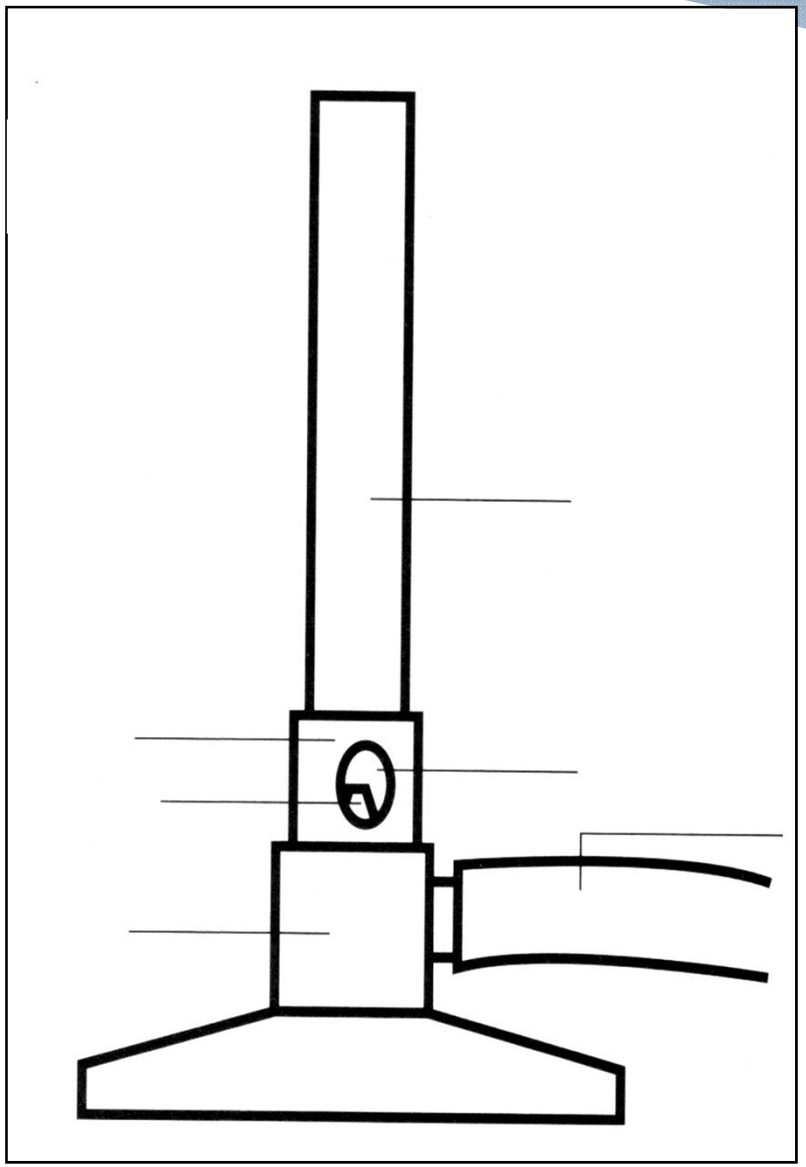
2d

Drawing equipment in Science



In the science lab we use special equipment. Often we have to draw the equipment. We use diagrams to show the equipment, which saves us time drawing. The scientific diagrams are recognised world wide.

2e Draw and label the Bunsen Burner



Air-hole barrel base

collar jet gas-hose

Part of the Bunsen Burner	Function
	To raise the flame to a suitable height for heating and burning
	To control the amount of air entering the burner
	To open or close the air hole
	To allow air to enter the burner
	To support the burner and make it more stable
	To force the gas into he burner

3a

Measurements in Science

The process of science involves observation, investigation and testing. Scientific observations can be made directly with our own senses or may be made indirectly through the use of equipment to collect data. Being able to take **accurate** measurements is important. The units and type of equipment used depends on whether you are measuring length, volume, temperature or mass.

3a Measuring in Science

Quantity	Unit	Symbol	Equipment used
Volume	litre	L	Flask
	Millilitre	mL	Measuring cylinder
Temperature	Celsius	°C	thermometer
Mass	kilograms	Kg	Scales
	grams	g	Scales
Length	Metres	m	Metre ruler
	millimetres	mm	Hand ruler

Note: **Weight** is the result of force (gravity) acting on mass and is measured in Newtons using a spring balance. Weight and Mass are often confused.

3b Converting measurements

Quantities are often measured in different **scales** depending upon what is most appropriate for the original size. In Science (and Mathematics) we use common **prefixes** to indicate the scale used.
We sometimes want to convert scales from one to another to compare data or to place the measurements into equations.

Prefix		**Scale**
Kilo	=	1000
Centi	=	$1/10^{th}$
Milli	=	$1/1000^{th}$

So 1 kilometre = 1000 metres
1 metre contains 10 centimetres
1 metre contains 1000 millimetres

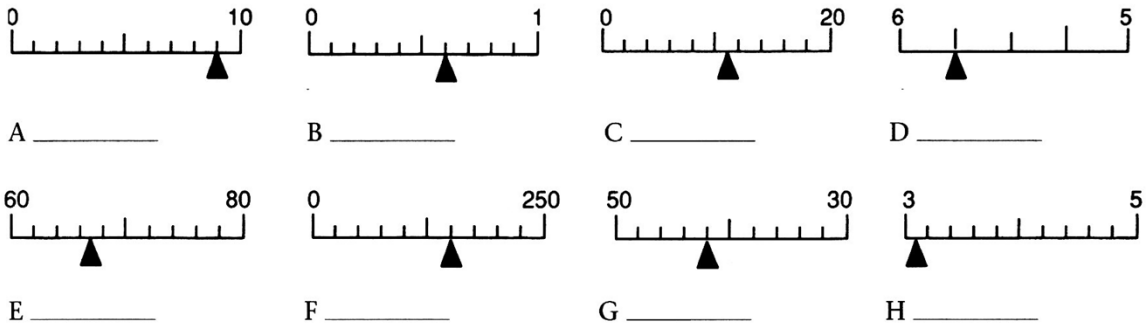
To convert from grams to kilograms **divide** by 1000
(or metres to kilometres and millilitres to litres)

To convert from kilograms to grams **multiply** by 1000
(or kilometres to metres and litres to millilitres)

3C

Measurements in Science

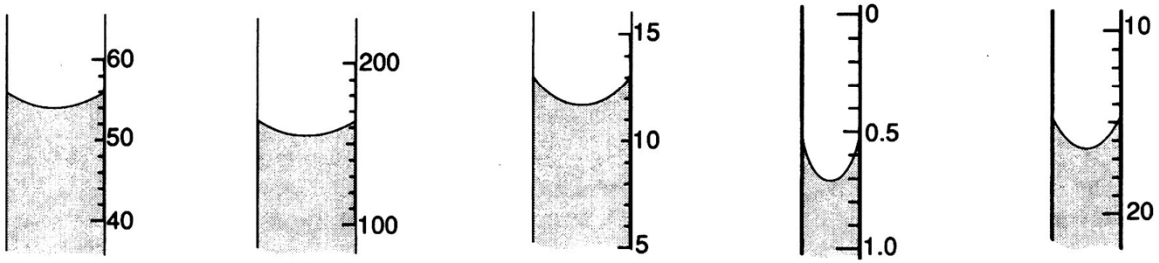
1 Fill in the readings on the scales shown.



A _____ B _____ C _____ D _____

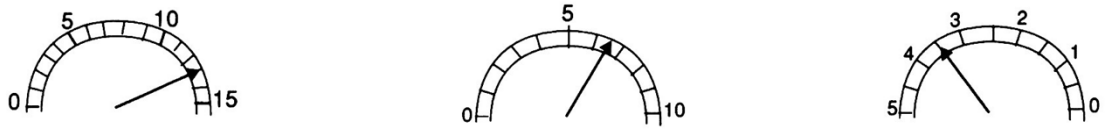
E _____ F _____ G _____ H _____

2 What do these measuring cylinders and pipettes read?



a _____ b _____ c _____ d _____ e _____

3 What amounts do these meters read?



a _____ b _____ c _____

As well as recording the number what must we also record?

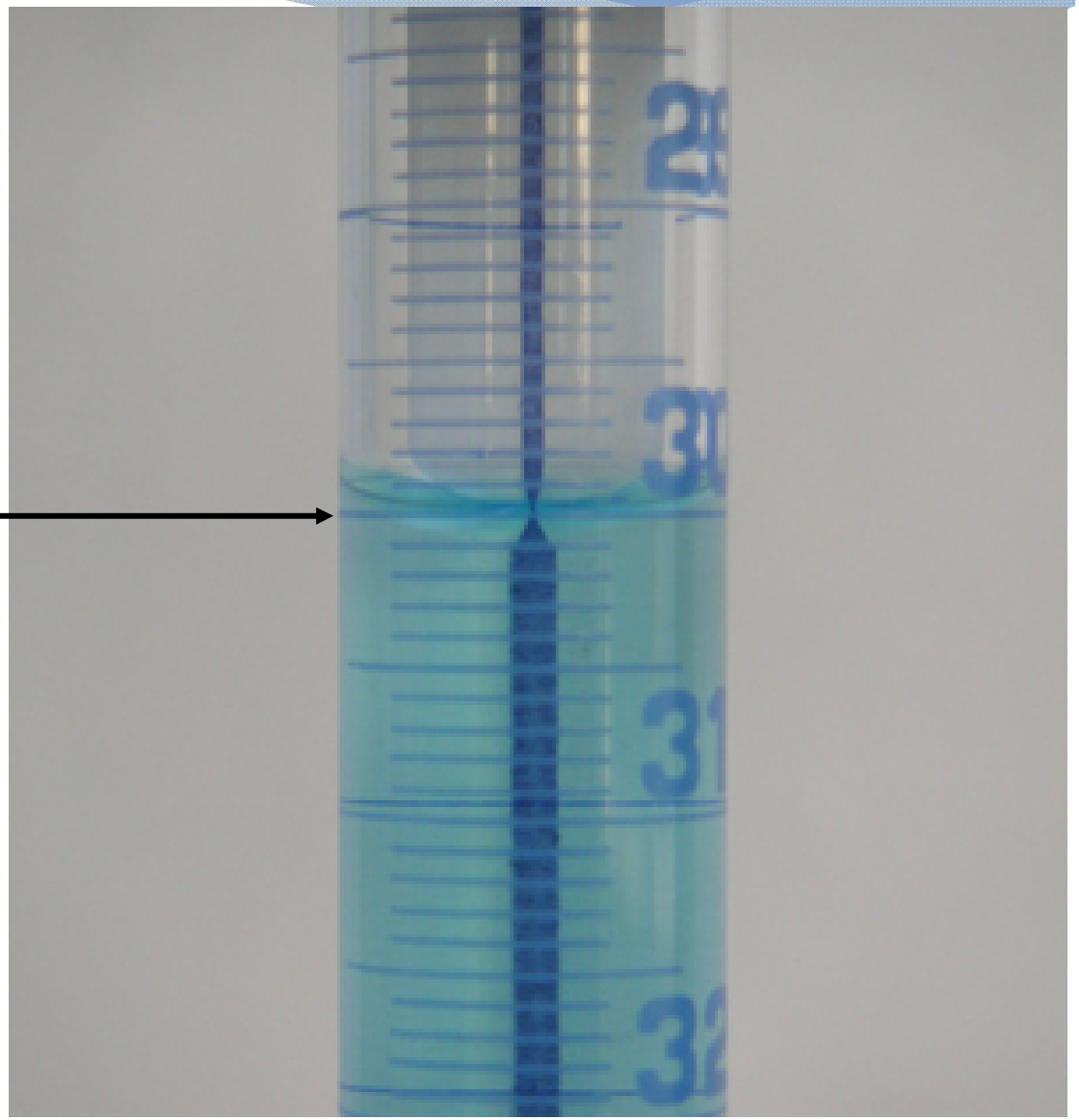
Where do we look from when reading measuring cylinders and pipettes?

Why is the surface of the liquid not flat?

3c

Measuring volume

Water is a liquid that "sticks together". In a narrow tube or measuring cylinder the water surface tends to curve up the sides. This is called a **meniscus curve**. A measurement reading is to be taken from the **bottom** of the meniscus curve because only a very small volume of liquid is actually around the side.



4a An investigation is used to collect data for evidence

Scientists ask questions to help work out what is occurring in the natural world around them. They then create testable ideas which they think may answer the question.
Scientists test their ideas by predicting what they would expect to observe if their idea were true (called a **hypothesis**) and then seeing if that prediction is correct.
Scientists look for patterns in their observations and data.
Analysis of data usually involves putting data into a more easily accessible format (graphs, tables, or by using statistical calculations).

The process of creating a question, developing a hypothesis and carrying out a test to collect data which is then analysed to see if their hypothesis is proved or disproved is called a **scientific investigation**.

4a A 'fair test' is one in which you only change one thing (variable).

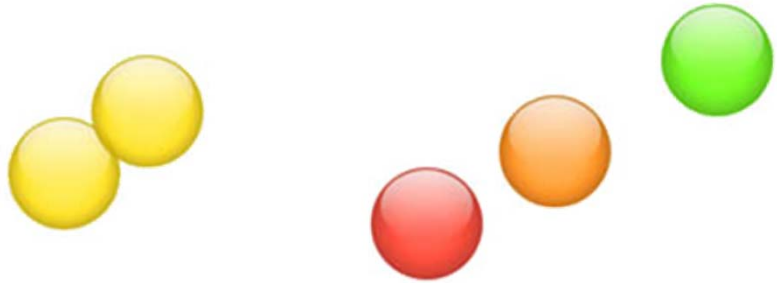
Variables are all the things that could change during an investigation.

In a bouncing ball investigation, where the height a ball bounces to is measured after it is dropped at different heights, many things could affect the results from one experiment to the next such as using a different ball, a different drop height or a different surface which the ball is dropped on.

You should only change one thing at a time in your investigation. This called the **independent variable**.(The height the ball is dropped at)

During your investigation you should be able to measure something changing which is called the **dependent** variable. (How high the ball bounces after being dropped)

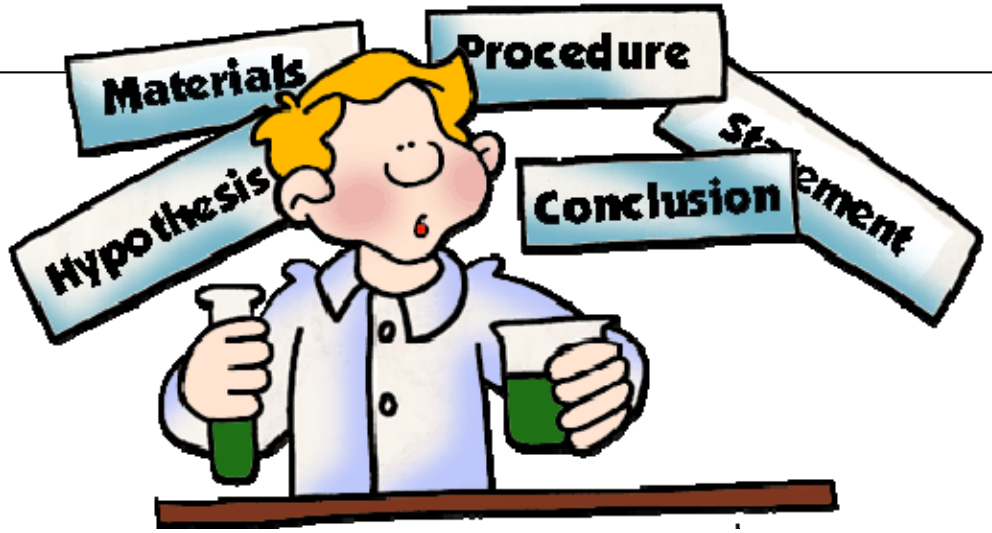
The factors you keep the same in your experiments (fair test) are called **control variables**



4a The typical way that scientists work is called the Scientific method.

Scientific investigations are typically written up in a standard way under the following headings:

Aim (focus question): what you are trying to find out or prove by doing the investigation
Hypothesis: what you think will occur when an investigation is carried out
Equipment (or materials): the things that you need to do the investigation
Method : A simple, clear statement of what you will do – and can be repeated by another person
Results : data, tables and graphs collected from investigation
Conclusion : what your results tell you – linked back to the aim and hypothesis
Discussion : Science ideas to explain your results, possible improvements to the investigation, how you managed to control the other variables.



4a Focus Question / Aim

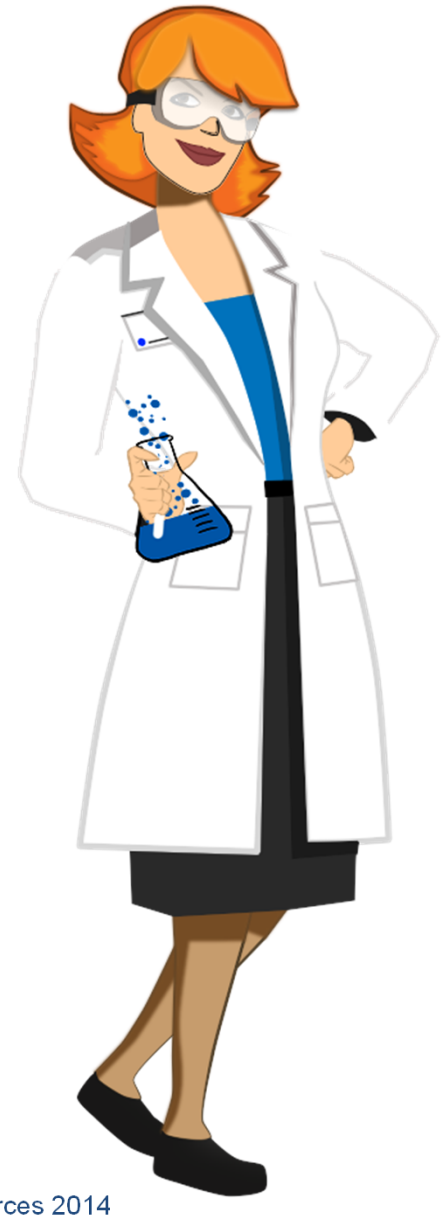
Your Aim or focus question must include both variables.
For example: If I change (independent variable) how will it affect (dependant variable)

Such as: If I change the temperature of the water (independent) how will it affect how much sugar I can dissolve into the water (dependant)

Independent variable – amount of light a plant receives
Dependant variable - height that plant grows

Focus Question: How does the amount of light a plant receives affect the height it grows to

4a Writing the Method



A method must be written so that an investigation is **repeatable** by another person.

In order for results from an investigation to be **reliable** an investigation must be able to be repeated exactly the same way following the method. The results gained from each repeat must show the same pattern each time for the conclusion to be valid (or if not an explanation or fault in following the method given)

4b Collecting Data

Data that is collected from an investigation can be analysed easier if placed into a clearly labelled and laid out **data table**.
The table must have:
A heading linked to the aim/hypothesis
Labelled quantities, units and symbols
Values (often numerical) of data collected

Data tables can also contain processed data such as results from multiple trials that have been averaged to give a more reliable value.

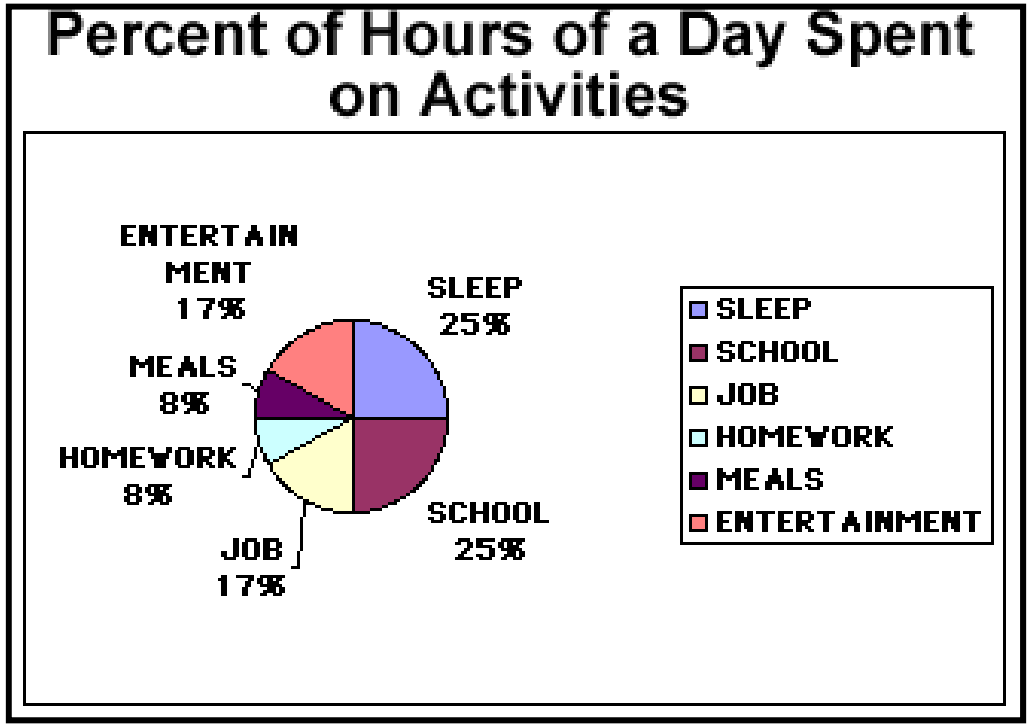
Plant Growth in Soils with Different pH Values

Plant Group	pH of Soil	Average Plant Growth (cm)
1	6.0	25.4
2	6.2	33.0
3	6.4	50.8
4	6.6	53.3
5	6.8	53.3
6	7.0	30.5
7	7.2	22.9

4b Looking for patterns in results - Graphs

Pie Graph or Chart

A circle that shows parts of a whole

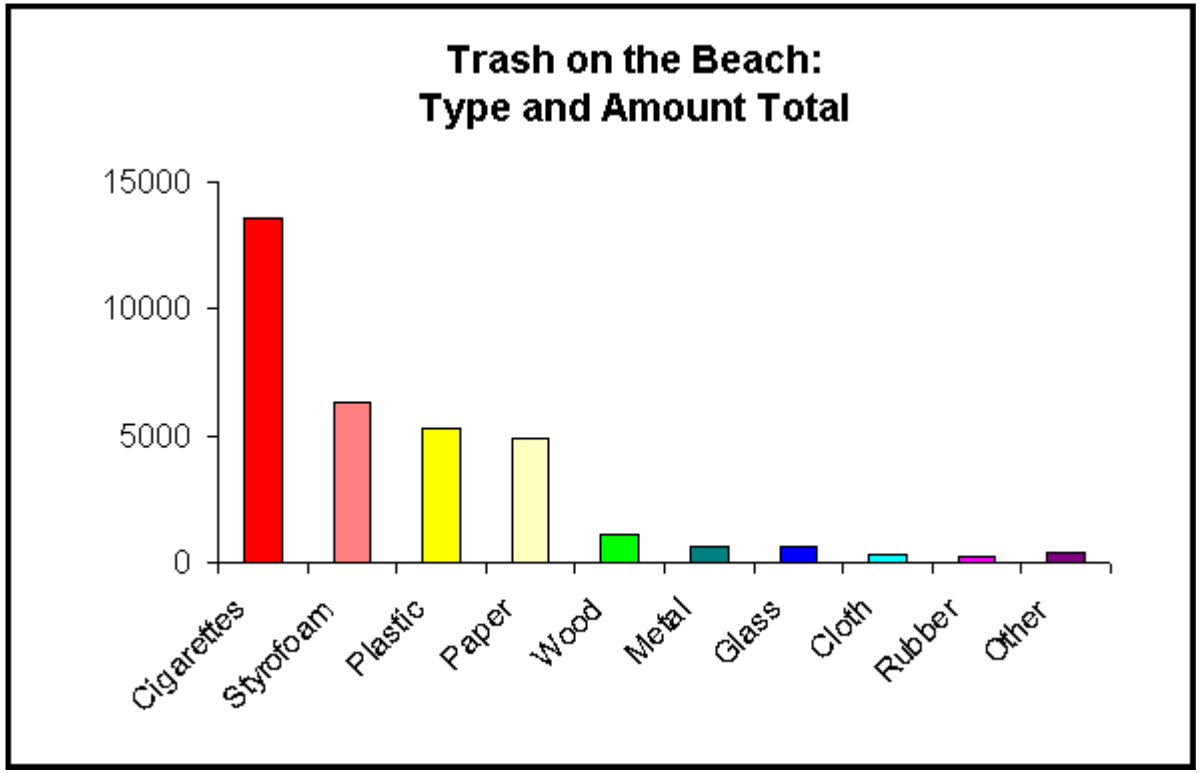


What are other examples where a pie graph could be used to show results?

4b Looking for patterns in results - Graphs

Bar Graph

A bar graph is used to show changes in a **discrete variable**. The columns do not touch each other.



What does discrete mean?

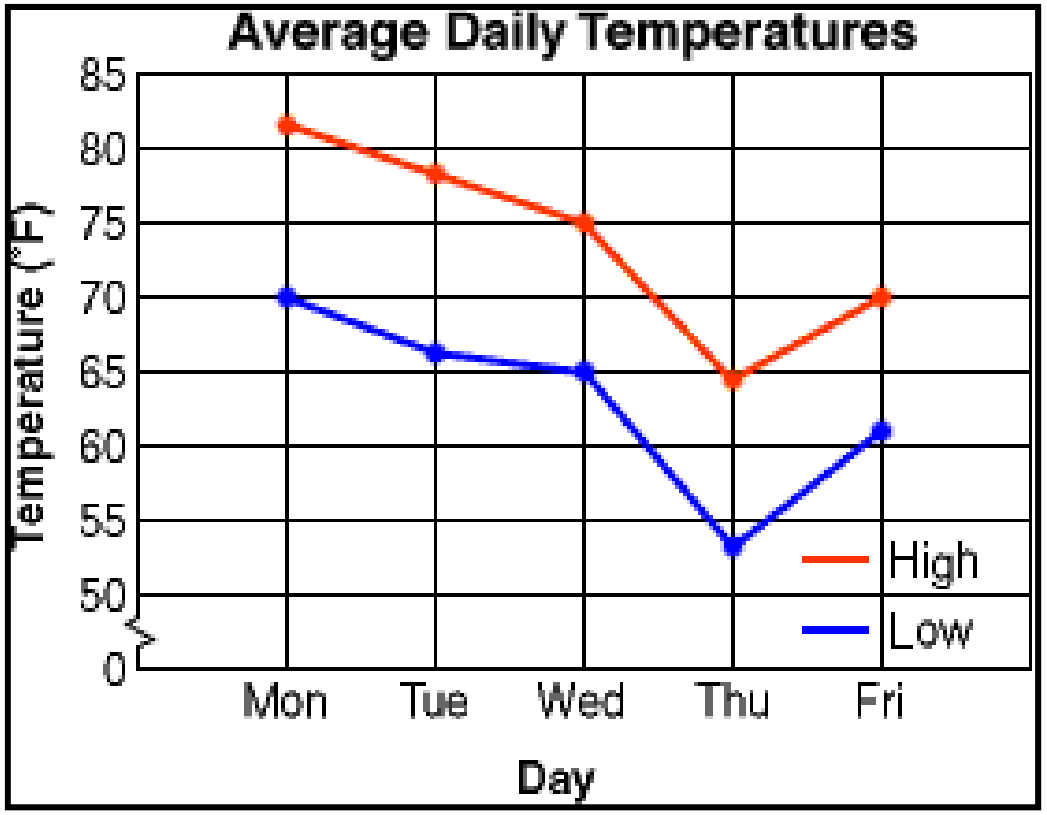
This graph has an X and Y axis, which is which?

Give other examples where a bar graph could be used to show results?

4b Looking for patterns in results - Graphs

Line Graph

A line graph is used to show changes in a **continuous variable**. More than one set of data can be graphed to make comparisons.

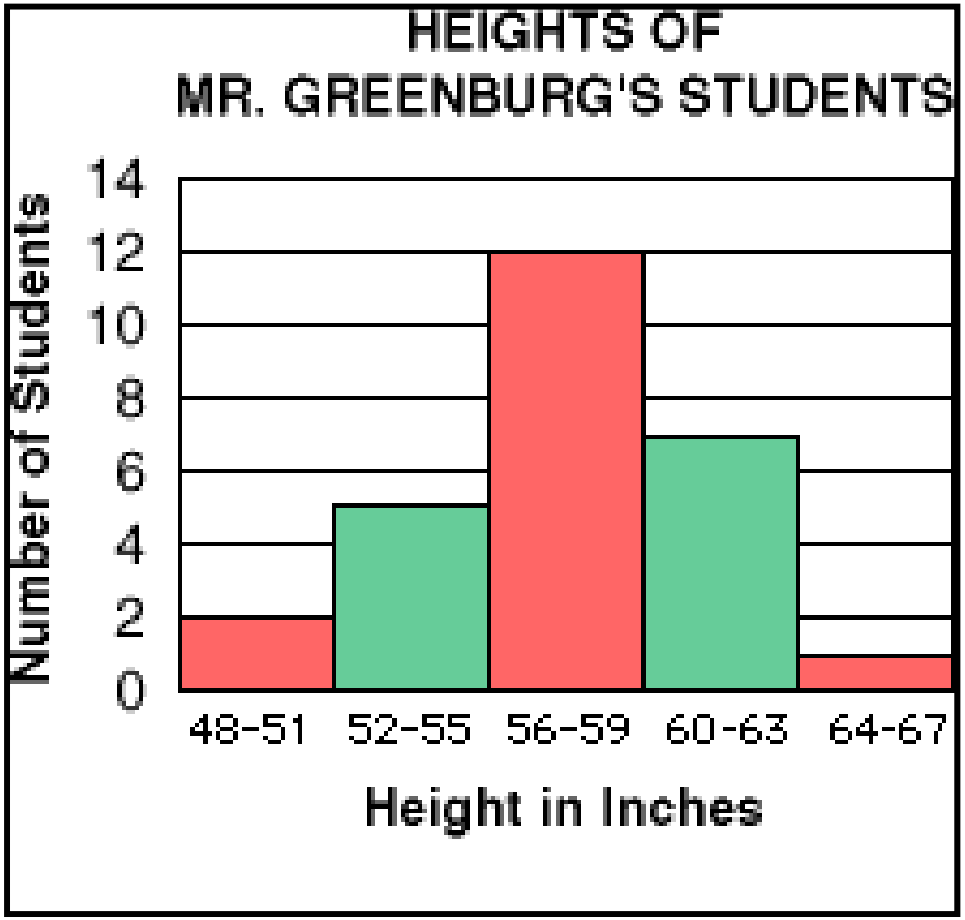


When would you use a line graph rather than a bar graph?

4b Looking for patterns in results - Graphs

Histogram

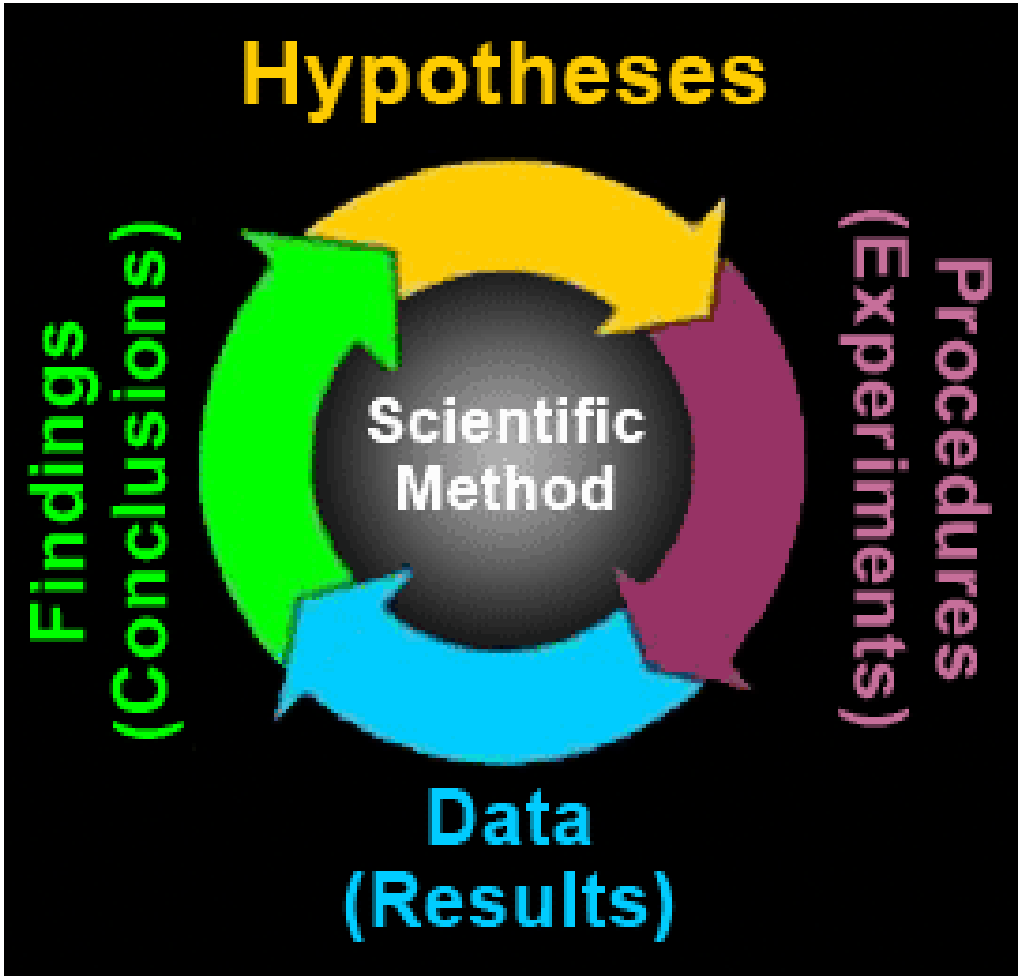
Has columns that touch each other, shows comparisons between **continuous data**.



What is the difference between a bar graph and a histogram?

4c Writing a conclusion

A conclusion looks for patterns in collected data from an investigation and uses it to agree or disagree with the hypothesis.
Both the variable that is changed (independent) and the variable that is measured (dependant) must be included in the conclusion statement.
The data is used as evidence in the conclusion.
The conclusion can also be used to answer the original Aim (focus question)



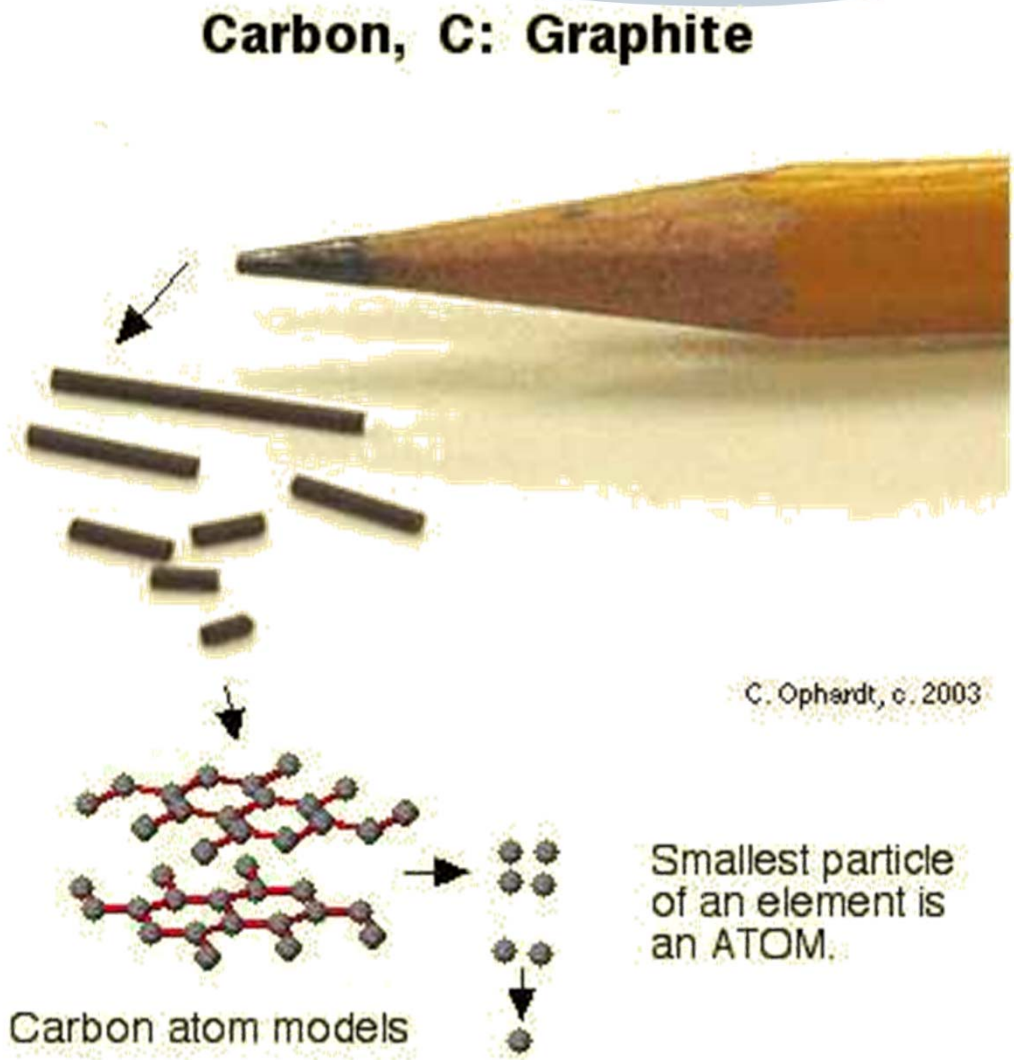
4d Reliability and Validity

Reliability means that that any results produced in a scientific investigation must be more than a one-off finding and be repeatable.
Other scientists must be able to perform exactly the same investigation using the same method and generate the same results.
Validity is the extent to which a investigation measures what it is supposed to measure. In a valid investigation the results gained will be as close to reality as possible if only one variable is changed and all other variables are kept the same.

5a Understand that matter, is made up of particles /atoms

An **atom** is the smallest neutral particle that makes up matter.

The type of atom and the way these atoms are arranged and connected to each other determines the type of matter – and therefore the **physical** and **chemical** properties of the matter.



5a Matter is made up of particles /atoms

Matter
(everything)

Elements
Substances made up of only one type of atom

Mixtures
combinations of elements and/or compounds that can be separated by physical means

Compounds
Combinations of two or more elements that are bonded together

Atom
The smallest neutral particle all matter is formed from

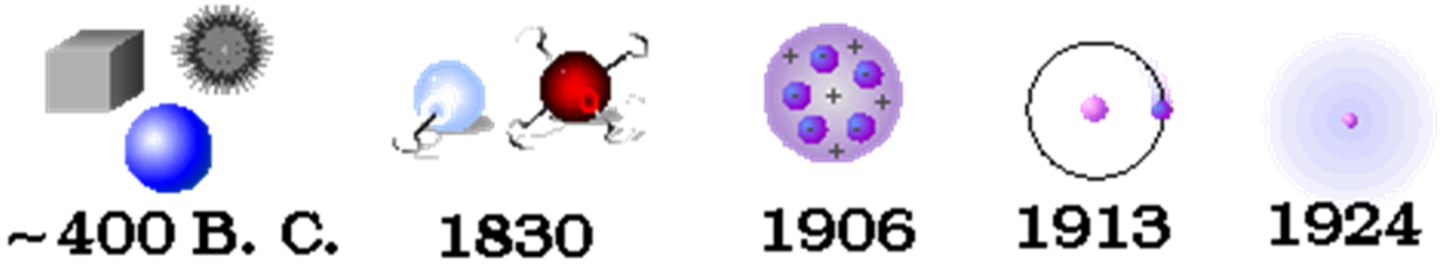
Molecule
Two or more atoms bonded forming the smallest unit

5a

Scientists use models to show the relationship of protons, electrons and neutrons within atoms and ions

Scientists and philosophers have used **models** to represent their ideas of what an atom looks like. As more discoveries have been made the model of the atom has changed.

The History of Atomic Theory



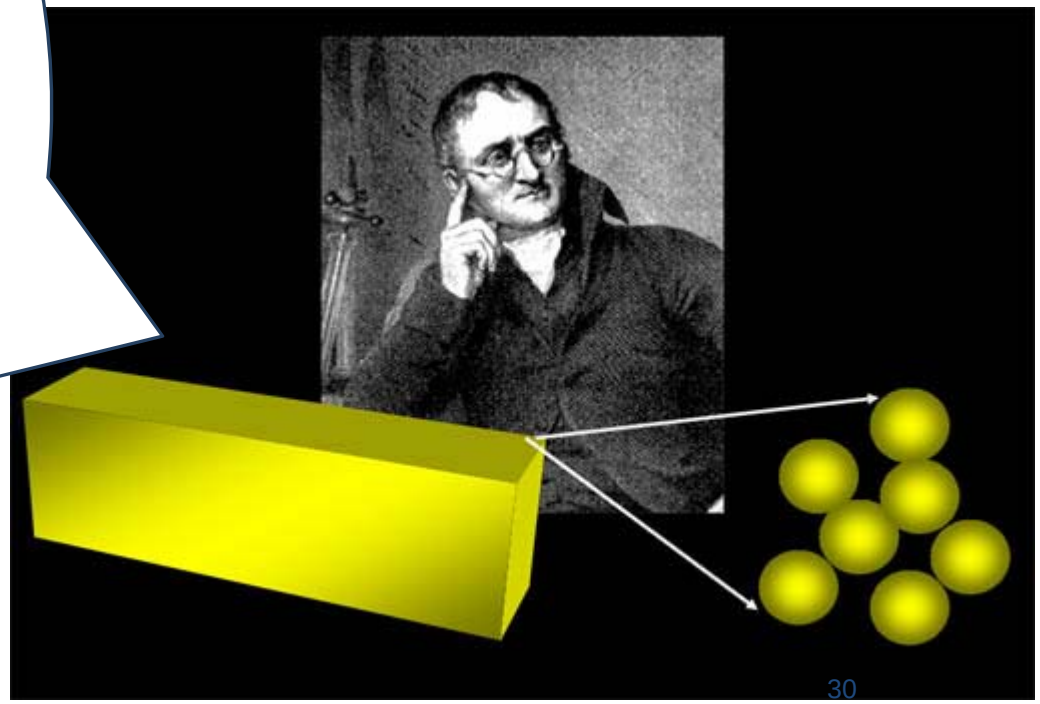
5a

Scientists use models to show the relationship of protons, electrons and neutrons within atoms and ions

My Theory States:

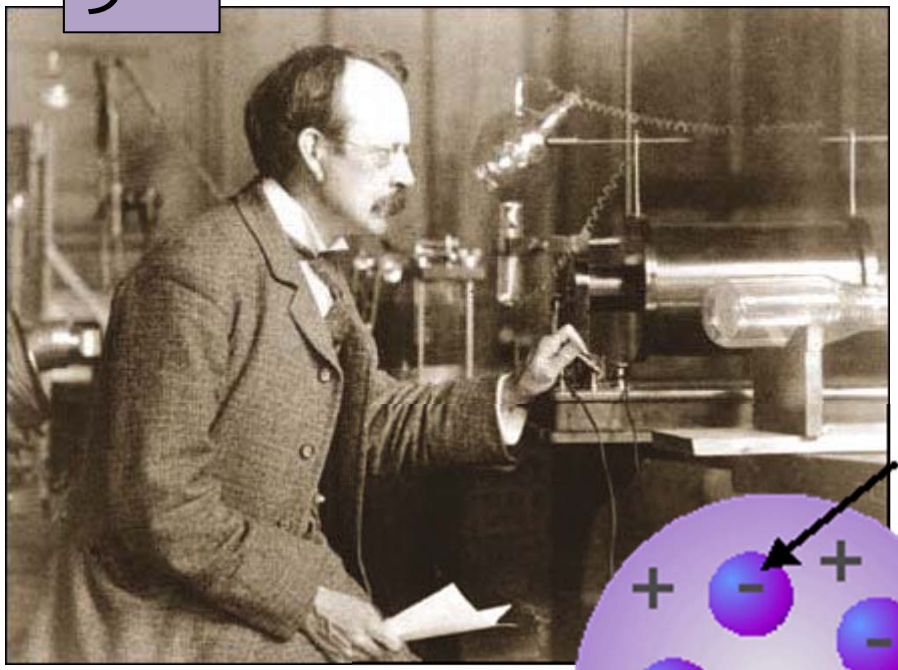
1. All Elements are made up of tiny particles called atoms.
2. Atoms of a given element are alike
3. Atoms of different elements are different
4. Chemical changes take place when atoms link up with or separate from one another
5. Atoms are not created or destroyed by chemical change

John Dalton (1766–1844) was a British chemist and physicist. In 1803 he announced his atomic theory. His atom models where represented by solid spheres.

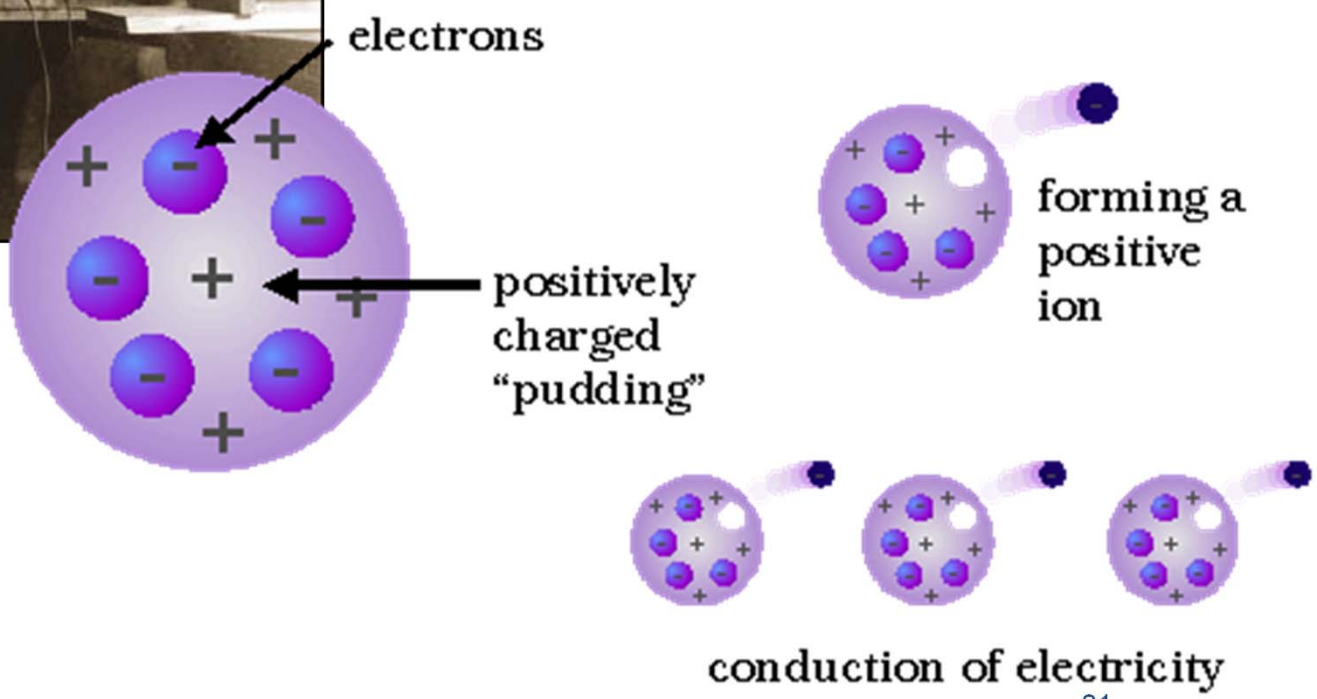


5a

Scientists use models to show the relationship of protons, electrons and neutrons within atoms and ions.



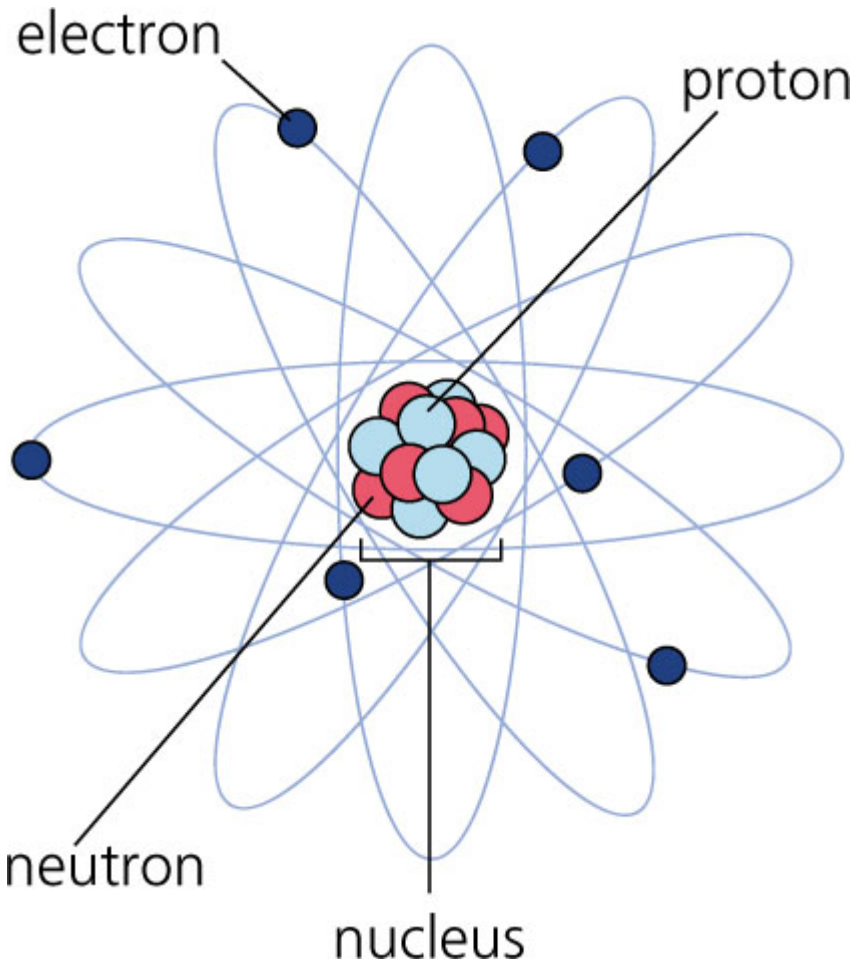
Sir Joseph John Thomson, who had discovered (1897) the electron, and came up with a model of the atom known as the plum-pudding model.



Scientists use models to show the relationship of protons, electrons and neutrons within atoms and ions

5a

Ernest Rutherford was a New Zealand Scientist. In 1911 he announced his new atomic model based on what he observed from his famous 'gold foil' experiment.

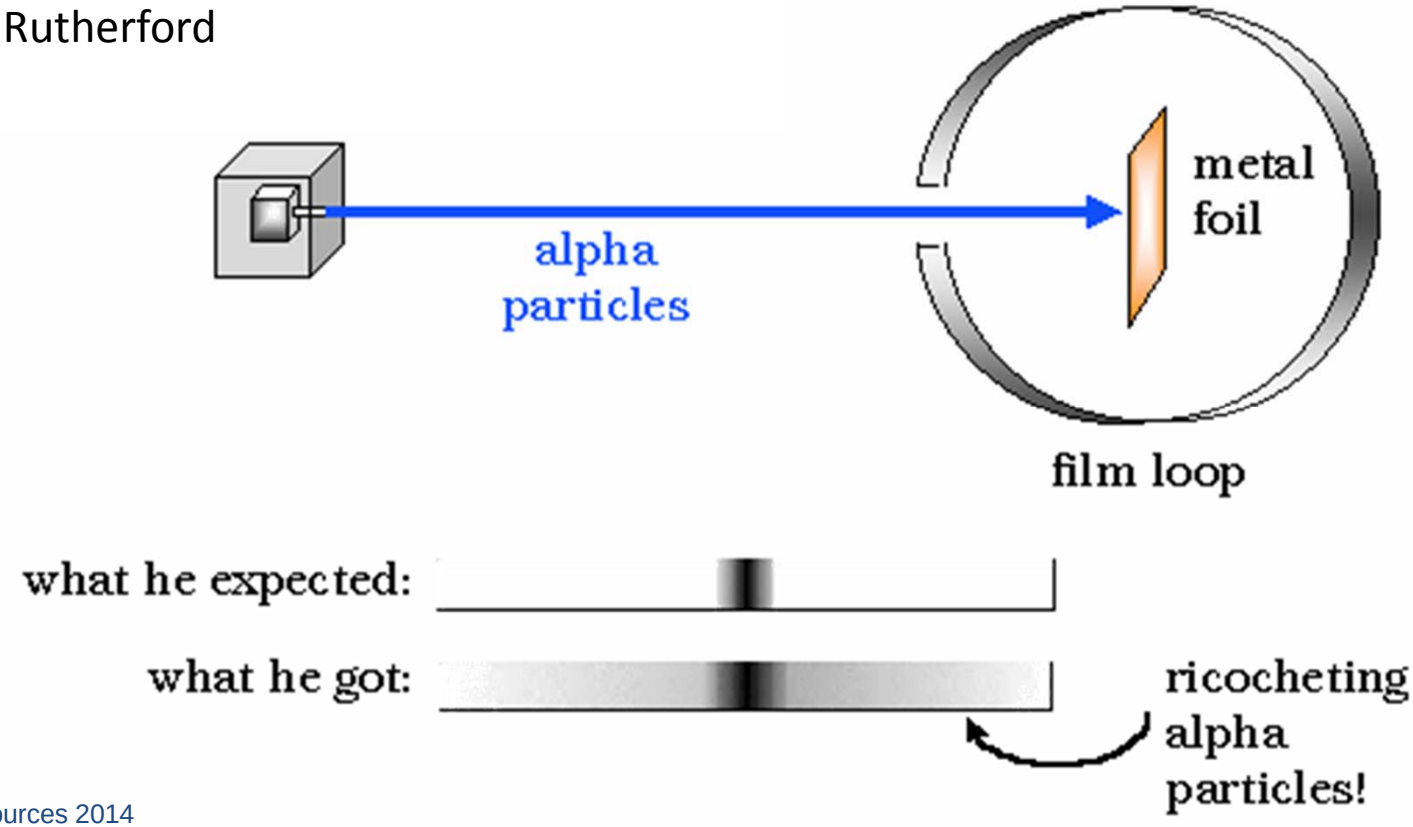


Scientists use models to show the relationship of protons, electrons and neutrons within atoms and ions

5a

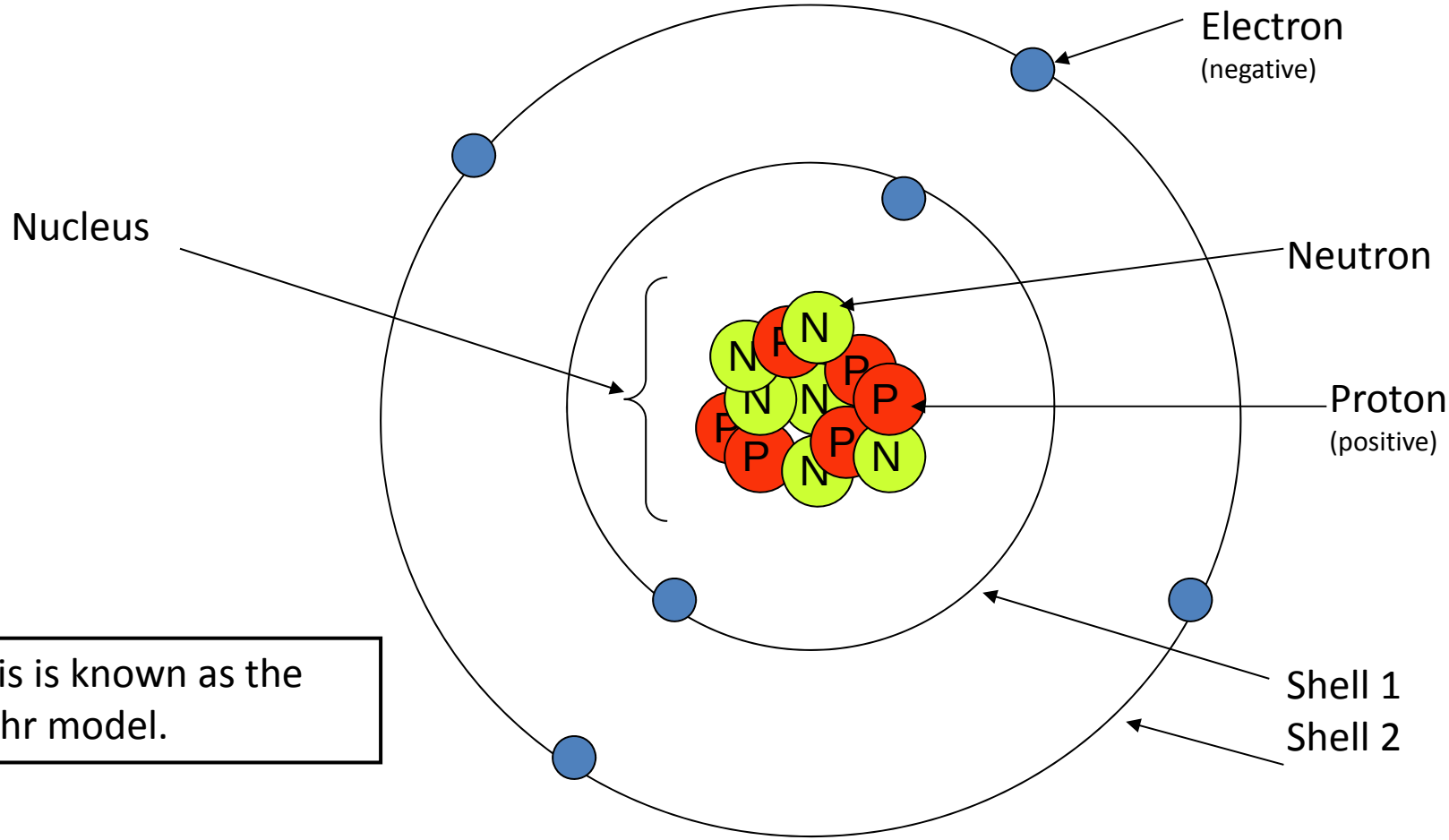
Ernest Rutherford's Gold Foil experiment

" It was the most incredible event that has ever happened to me in my life. It was almost as incredible as if you fired a cannon-ball at a piece of tissue and it came back and hit you."
- Ernest Rutherford



5b Atoms have a particular structure – protons, electrons and neutrons

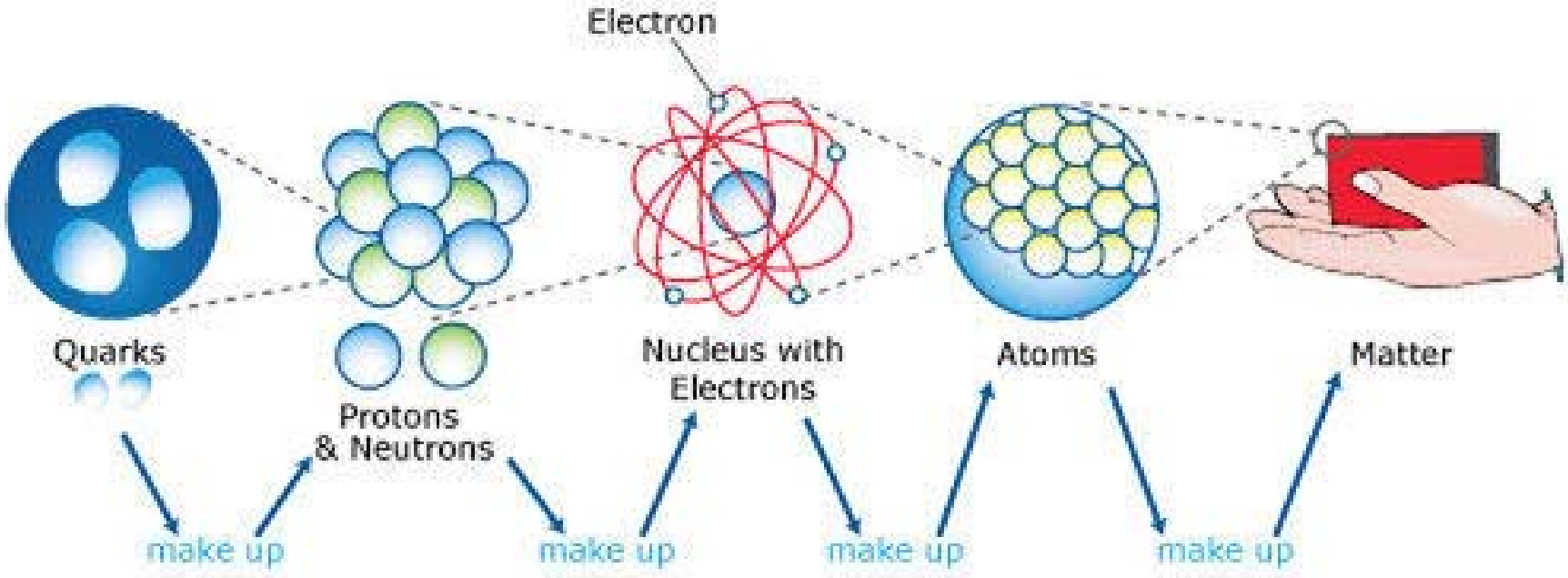
Atoms have a central nucleus. The nucleus contains protons (p) and neutrons (n). Electrons (e) orbit the nucleus, arranged in shells or energy levels.



This is known as the Bohr model.

5b Atoms have a particular structure – protons, electrons and neutrons

Atoms are very small. Very special microscopes are required to see them. Many billions of atoms are required to produce this full stop.

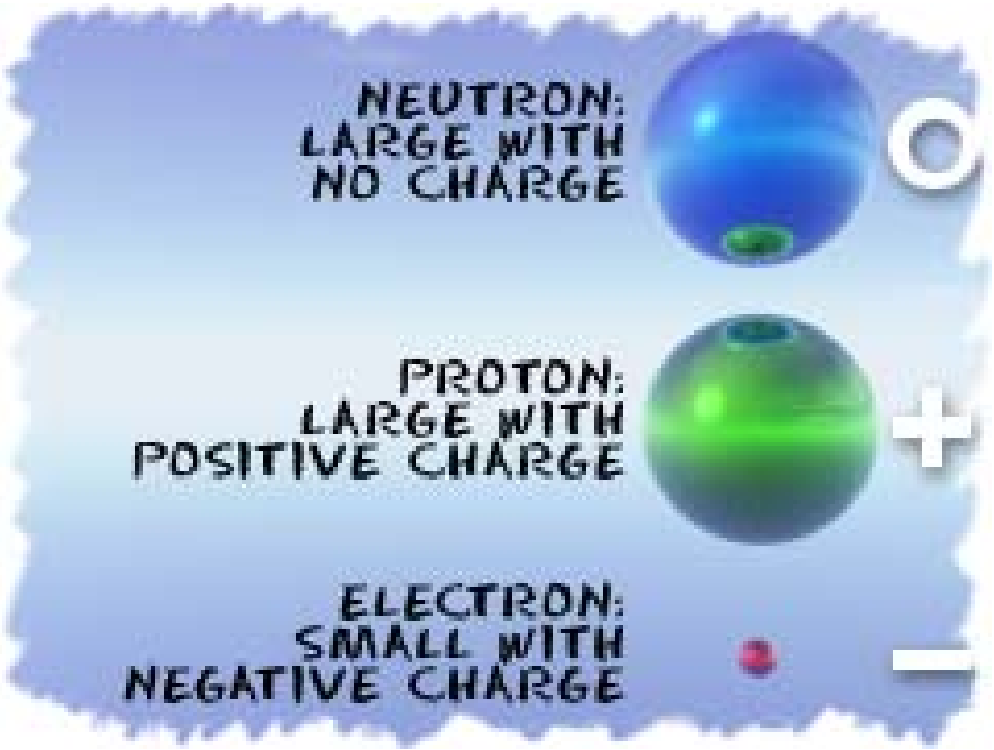


5c Atoms have equal number of protons and electrons

Protons are positively charged; electrons are negatively charged; neutrons have o electrical charge.
Atoms have no overall charge because the number of protons = number of electrons.

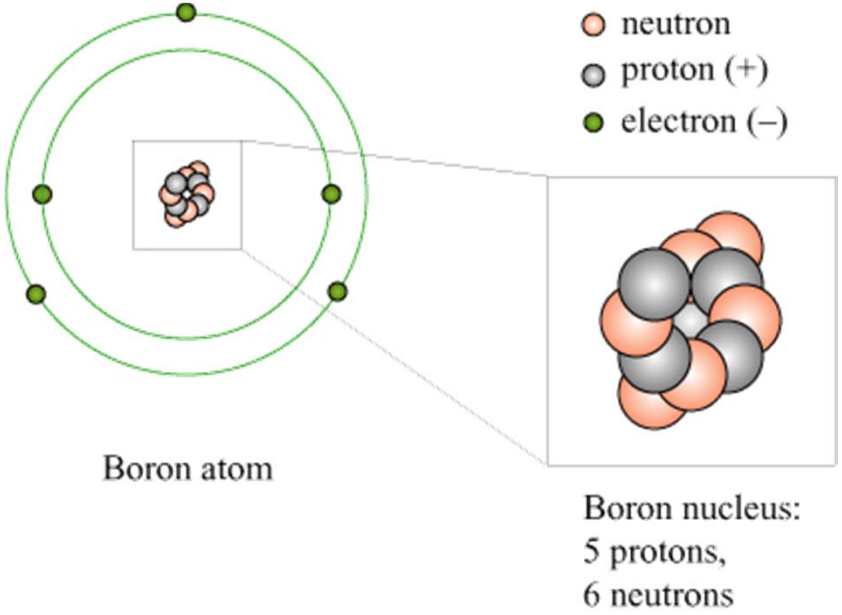
Summary

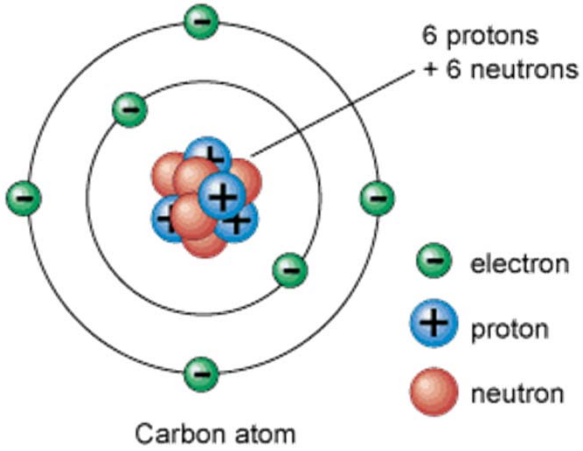
- All matter is made up of atoms. Atoms consist of protons, neutrons and electrons.
- The charges of protons and electrons are equal and opposite.



6a

Each different type of element has a different number of protons in its atoms





All Boron atoms have 5 protons in their nucleus.

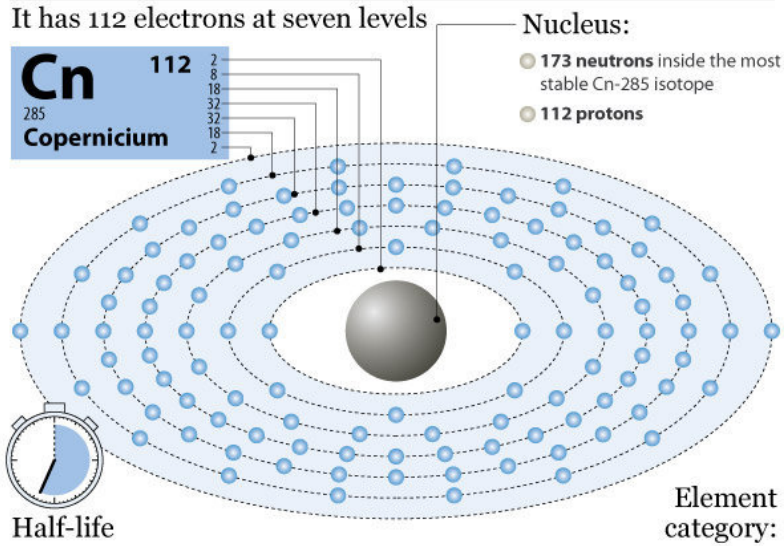
All Carbon atoms have 6 protons in their nucleus.

6a

Elements are arranged on the periodic table according to their atomic number

Copernicium is an element in the periodic table with atomic number 112

The 112th element was initially known as "ununbium," but it was eventually given the official name of "copernicium"



- Copernicium is unstable just like its neighbors in the periodic table. The most stable copernicium isotope obtained to date has a half-life of **34 seconds**

- Transition metal

Hypothetical appearance:

- Silvery fluid

History

- Copernicium was first created on February 9, 1996, at the GSI Helmholtz Centre for Heavy Ion Research GmbH in Darmstadt, Germany,
- and was called ununbium (Latin for 112th) until 2010

The International Union of Pure and Applied Chemistry (IUPAC) named the new element after **Nicolaus Copernicus** "to honor an outstanding scientist, who changed our view of the world."

Each element has an atomic number which tells us how many protons are contained inside each atoms nucleus. This number of protons is matched by an equal number of electrons which move around the nucleus.
The periodic table starts with Hydrogen (H) Atomic number 1 and ends with elements that have over 100 protons such as Copernicium (Cn) Atomic number 112.

6a

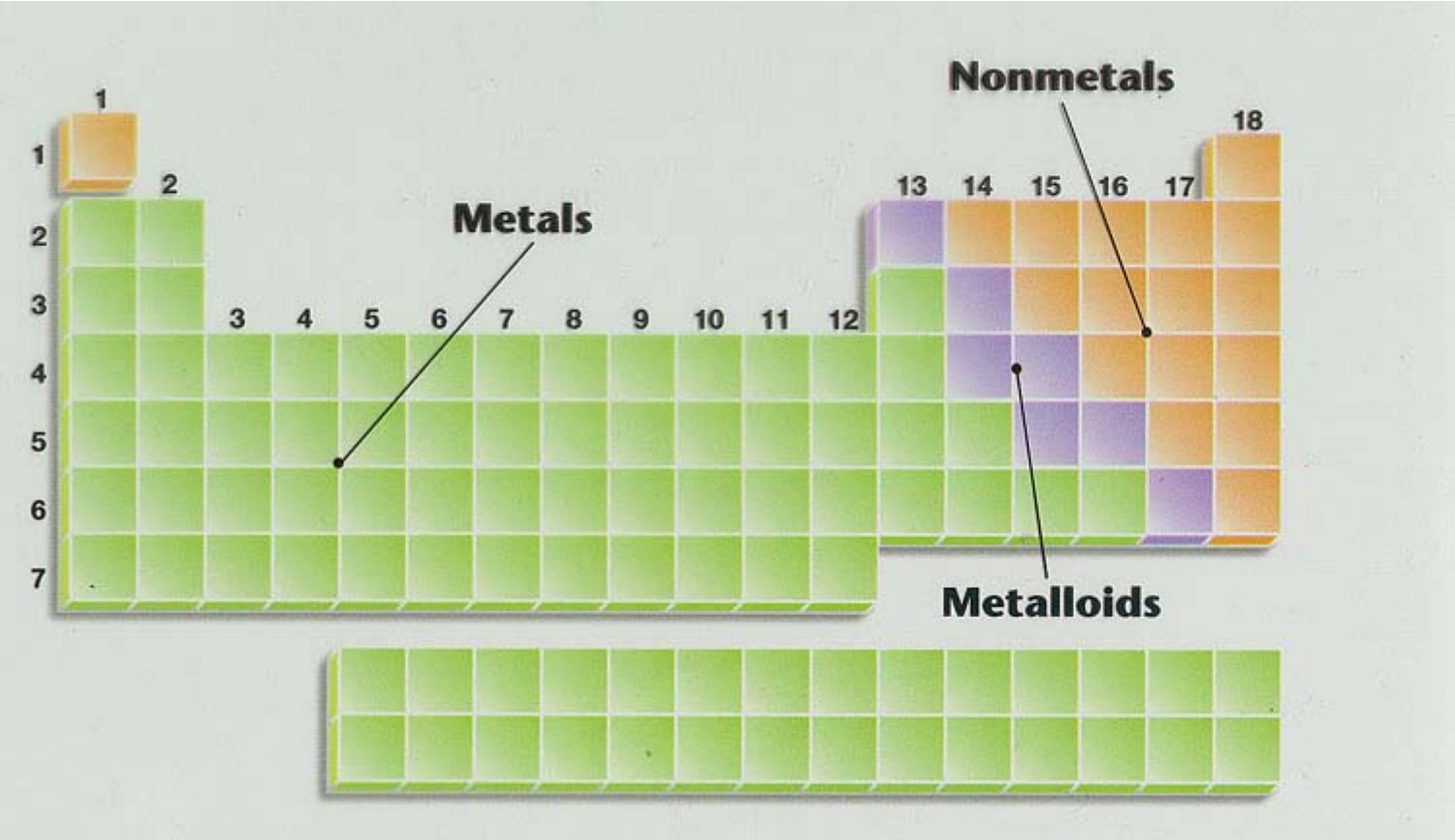
PERIODIC TABLE
ELEMENTS 1–20

HYDROGEN 1 **H** 1.01							HELIUM 2 **He** 4.00
LITHIUM 3 **Li** 6.94	BERRYLLIUM 4 **Be** 9.01	BORON 5 **B** 10.81	CARBON 6 **C** 12.01	NITROGEN 7 **N** 14.01	OXYGEN 8 **O** 16.00	FLOURINE 9 **F** 19.00	NEON 10 **Ne** 20.18
SODIUM 11 **Na** 22.99	MAGNESIUM 12 **Mg** 24.31	ALUMINUM 13 **Al** 26.98	SILICON 14 **Si** 28.09	PHOSPHORUS 15 **P** 30.97	SULFUR 16 **S** 32.07	CHLORINE 17 **Cl** 35.45	ARGON 18 **Ar** 39.95
POTASSIUM 19 **K** 39.10	CALCIUM 20 **Ca** 40.08						

6a

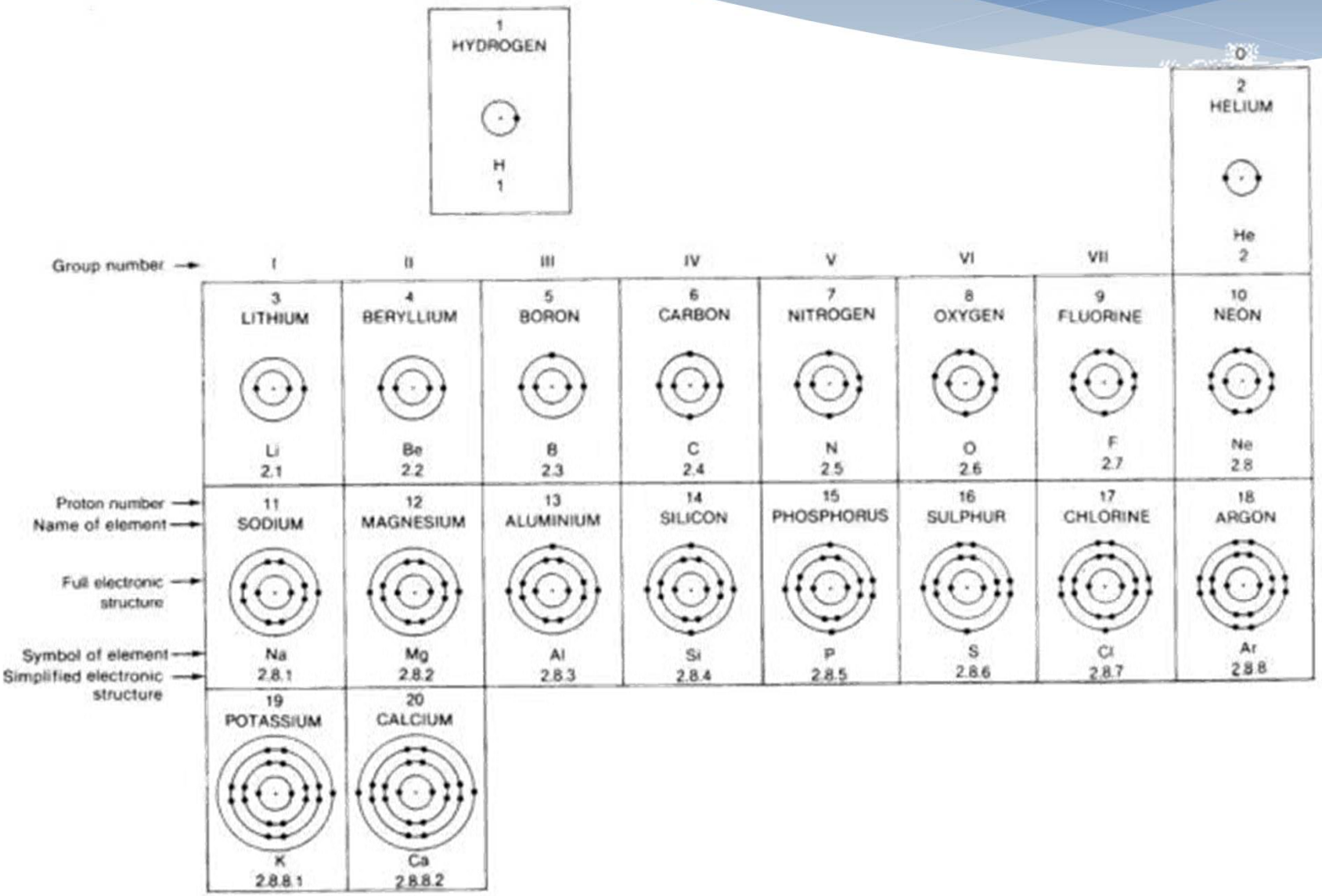
Metals are placed on the left hand side and non-metals are placed on the right hand side of the periodic table

Elements can be classified as metals or non-metals. A few elements are called semi-metals or metaloids (e.g. boron and silicon), because they show some, but not all, of the properties of metals.



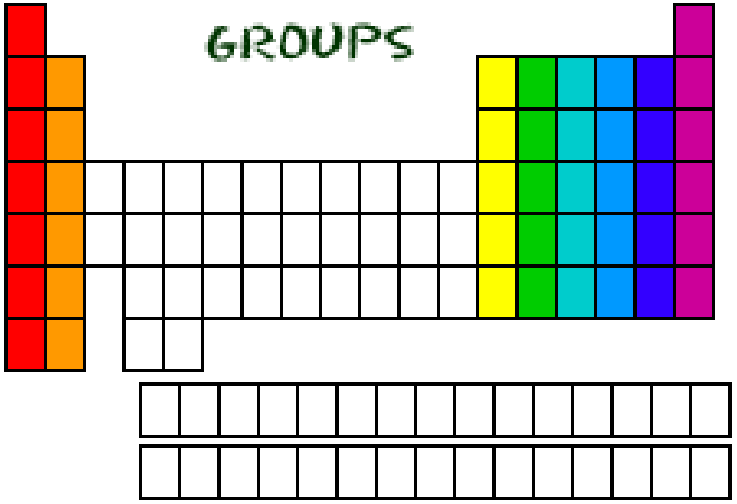
6a

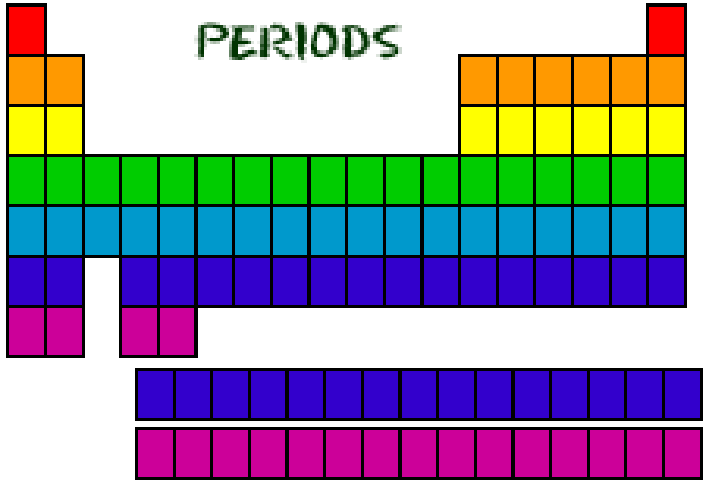
The more protons an atom has the further down the table it is.



6a Groups are numbered vertical columns and periods are horizontal rows

The columns (downwards) of a periodic table are called groups.
The rows (across) of a periodic table are called periods.





Elements in the same group all have the same number of electrons in their outer (or valence) shells.

Elements in the same period all have the same number of shells of electrons in their atoms

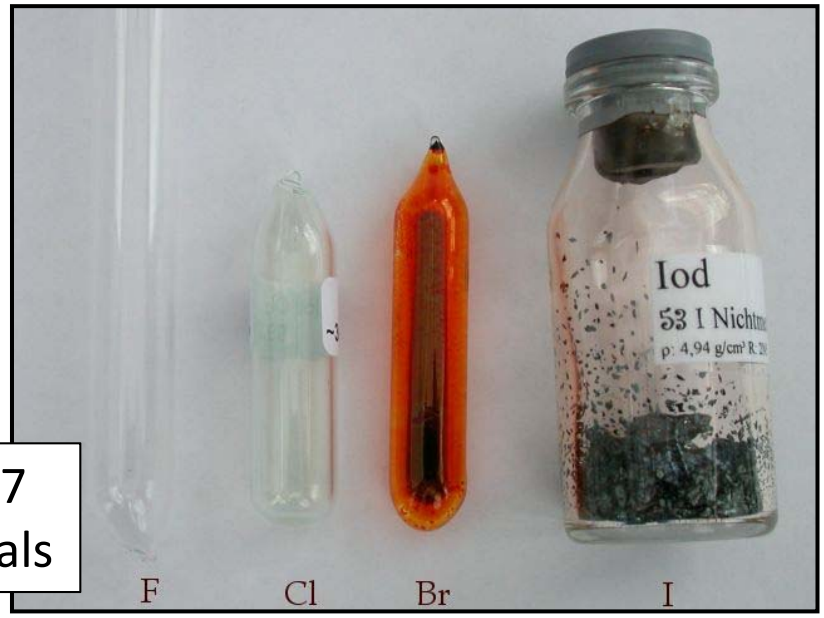
6a

Groups of elements on the periodic table have common physical and chemical properties

Elements that are in the same group show similar types of chemical and physical properties. Their atoms chemically react the same way because their electrons in the outside shell in the atoms are arranged the same way.

Group 1 Metals

The elements in a group also have similar physical properties because of the way the atoms join together and are arranged.



Group 17 Non-Metals

6a

The groups of metals and non-metals have specific defining physical properties

Group	Physical properties
Metals	>Lustre (shiny) >good conductor >High density >High melting point >Malleable (can shape into sheets) >Ductile (can shape into wires)
Semi-Metals	>Solids >Can be shiny or dull >Ductile and malleable >Conduct heat and energy better than Non Metals but not as good as metals
Non-Metals	>No lustre >Poor conductor >Brittle >Not ductile >Low density >Low melting point

6b

Each element is named and has a specific symbol.

Elements consist of only one type of atom.
Each element can be represented by a chemical symbol.

6b There is a correct way of writing element symbols.

Abbr.	Latin	English
Na	Natrium	Sodium
K	Kalium	Potassium
Pb	Plumbum	Lead
Sn	Stannum	Tin
Fe	Ferrum	Iron
Cu	Cuprum	Copper
Ag	Argentum	Silver
Au	Aurum	Gold
Hg	Hydrargyrum	Mercury
Sb	Stibium	Antimony
W	Wolfram (Ger.)	Tungsten

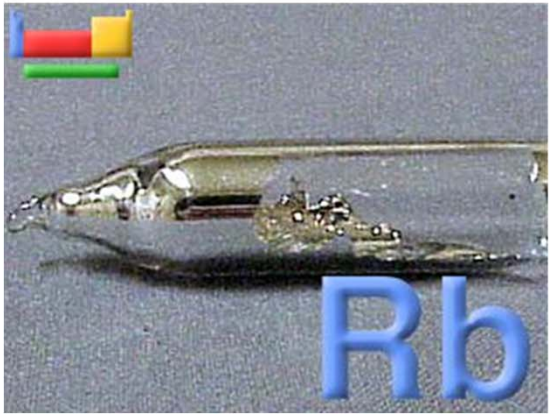
>Most symbols are one or two letters, formed from the name of the element. e.g. Hydrogen H, or Helium He.

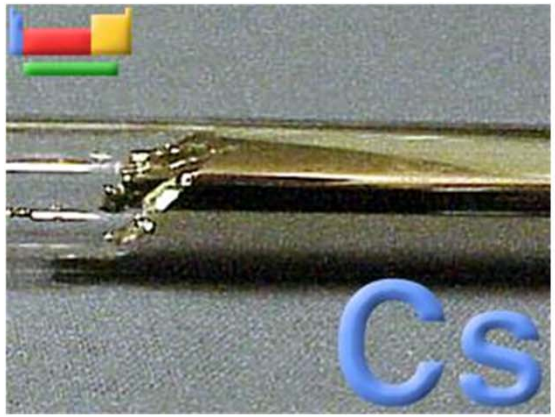
>The first letter of the symbol is always a capital letter. Any other letters are lower case.
e.g. Helium is He not HE

>If the symbols are not based on a elements English name then it is most likely to be based on it's Latin name, the original language of Science.

6b

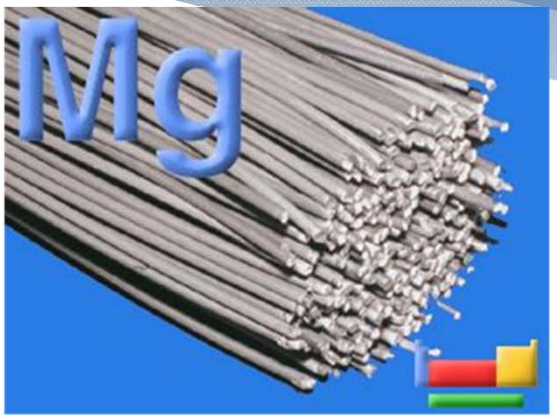
Group One Elements

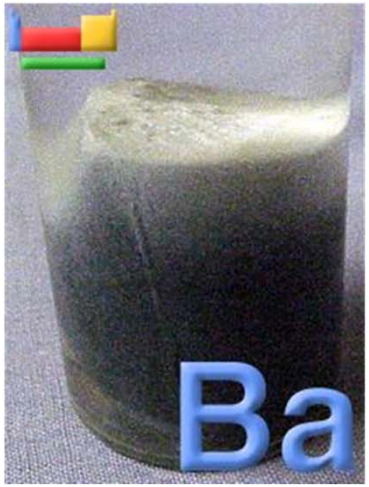


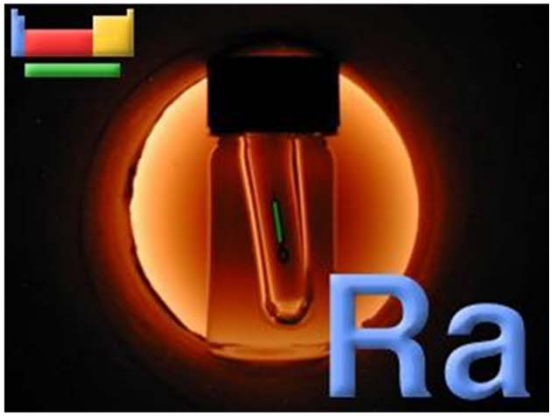


These elements are called the **Alkali Metals**. They are all very reactive with air and, especially so, water. The further down the group the more reactive they are. Hydrogen is not included in this as it does not share similar properties with the rest of the elements.

6b Group two elements



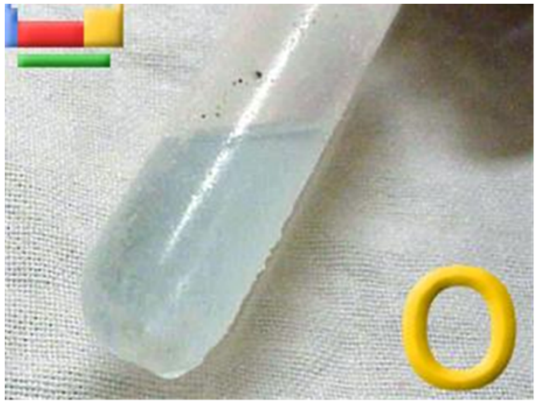




These elements are called the **Alkali Earth Metals**. They all react with air, but are less reactive than group 1.

6b

Group 16 elements



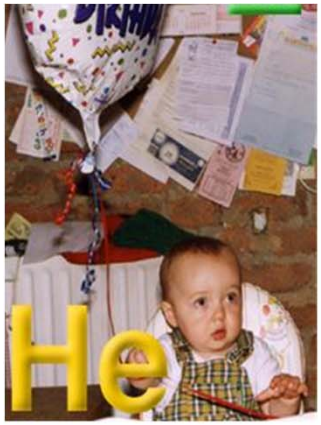
These elements are mostly Non-Metals. As we move down the group the elements show some metallic properties.

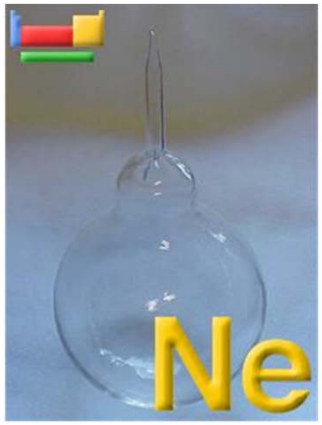
6b

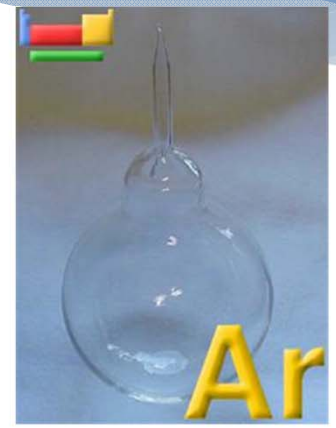
Group 16 Elements

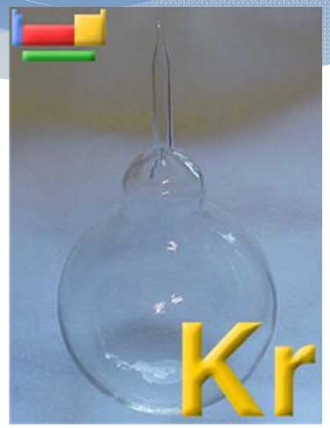
These elements are called the **Halogens**. They are very reactive and change from gas to liquid to solid as you move down the group.

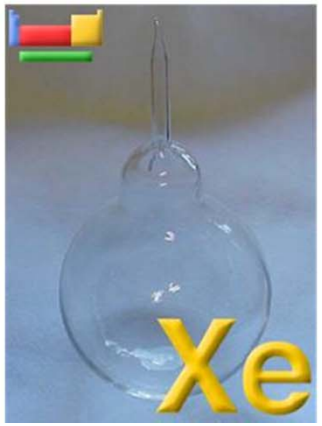
6b Group 18 Elements







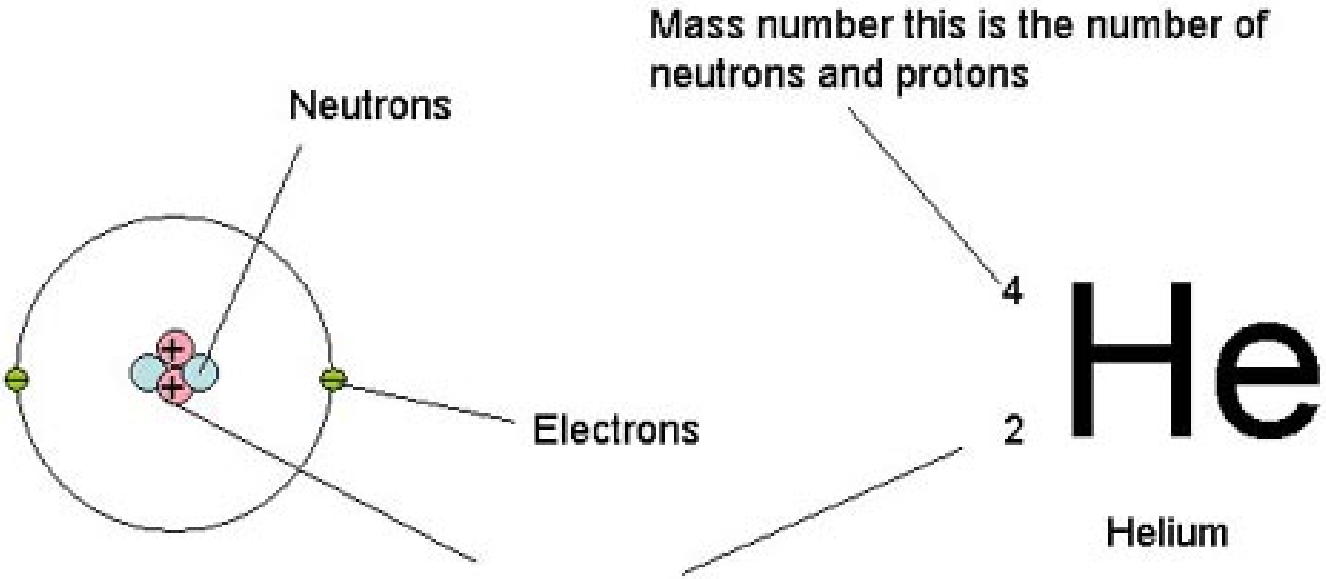




These elements are called the **Inert gases**. They are very non reactive and have only just been discovered relatively recently because of that.

6c The Atomic Number of an atom is equal to the number of protons

The atomic number is unique for each element.
An atom has the same number of electrons as protons.
The periodic table is arranged in order of an elements atomic number.



extension

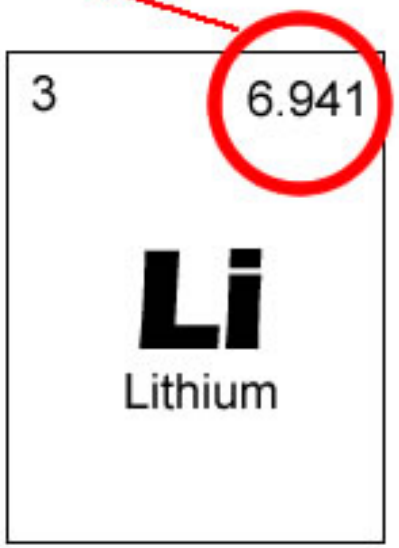
6c The Mass Number of an atom is equal to the number of protons and neutrons in an atom.

The Mass number is the number of protons + number of neutrons.

The Mass number is close to double of the Atomic number.

An isotope is an element with a different Mass number because it has more or less neutrons than normal.

Atomic Mass = Protons + Neutrons



Calculating the Number of Neutrons

1st - round atomic mass to a whole number

6.941 rounds to 7

2nd - subtract 3 (# of protons) from 7 (# of protons + neutrons)

7 - 3 = 4

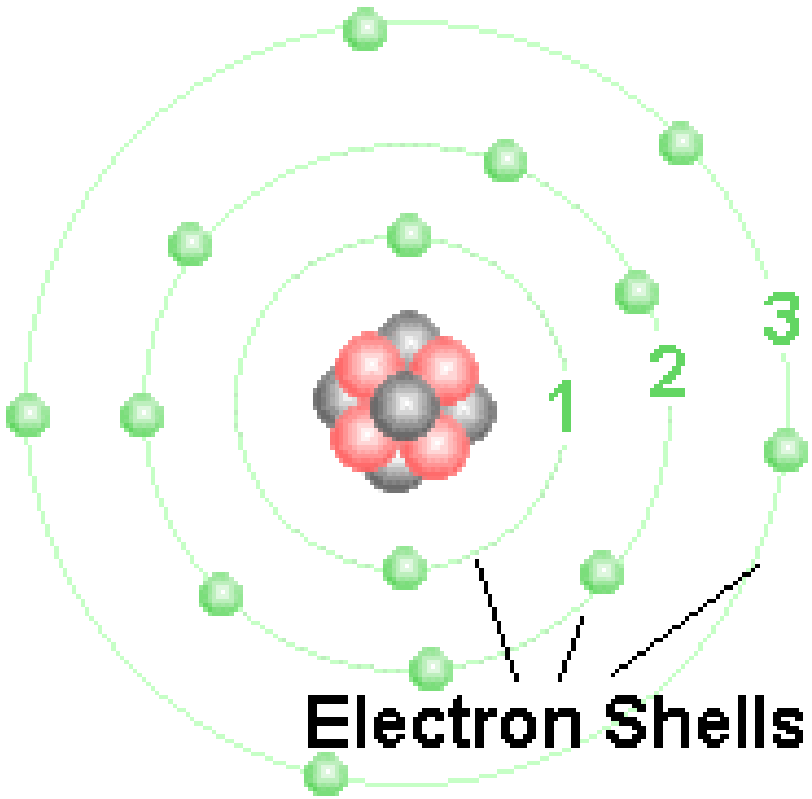
Number of Neutrons = 4

extension

6d The electrons in an atom are arranged in a series of shells.

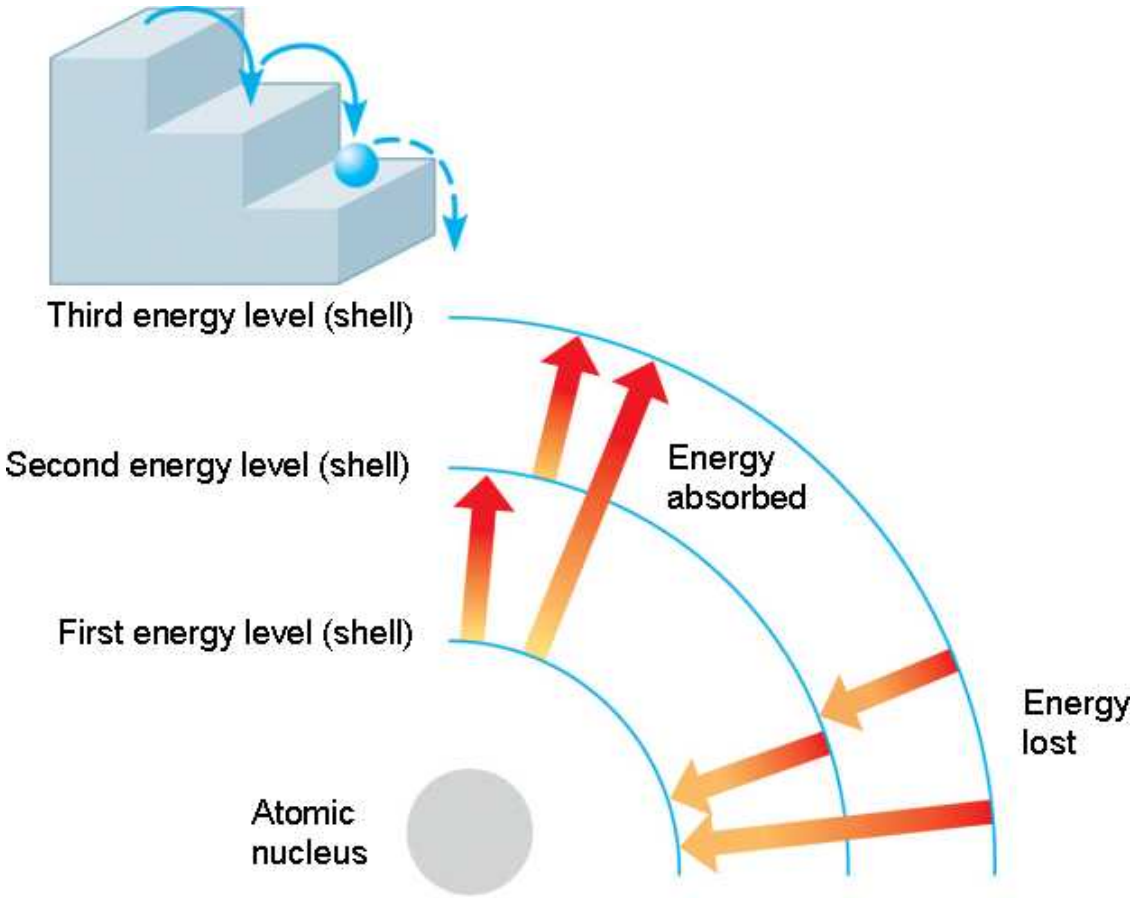
Electrons move or 'orbit' around the nucleus in energy levels or **shells**. The shells further away from the nucleus are able to fit more electrons.
The first shell is filled first, followed by the second and so on until all the electrons (the same number of protons in an atom) have been used.

Maximum numbers of electrons in each shell are:
>2 in the first shell (nearest the nucleus)
>8 in the second shell
>8 in the third shell (before the fourth shell starts to fill)
>18 in the fourth shell



extension

6d Electrons orbit a nucleus of an atom at fixed energy levels.



An electron can only be found in a fixed energy level around a nucleus. A ball bouncing down a flight of stairs provides an analogy for energy levels of electrons because a ball can only rest on each step, not between steps.

An electron can move up an energy level if energy is absorbed, such as light or heat. When the electron moves back down to its lowest possible level the energy is released again, often in the form of light.

extension

6d Electrons orbit a nucleus of an atom at fixed energy levels.

A shorthand way of describing the way electrons are arranged in an atom is called the *electron configuration*. The information for the number of electrons is found by an elements Atomic Number (number of electrons = number of protons in a neutral atom). Each shell is filled to its maximum capacity, starting with the lowest shell first (shell number 1). The shells are separated by a comma. The shells are filled until all the electrons are placed. Shell 1 fits 2 electrons, shell 2 fits 8 electrons, shell 3 fits 8 electrons, shell 4 fits 18 electrons.

12

Mg

24

Atomic number

The total of the electronic configuration must equal the atomic number in an atom

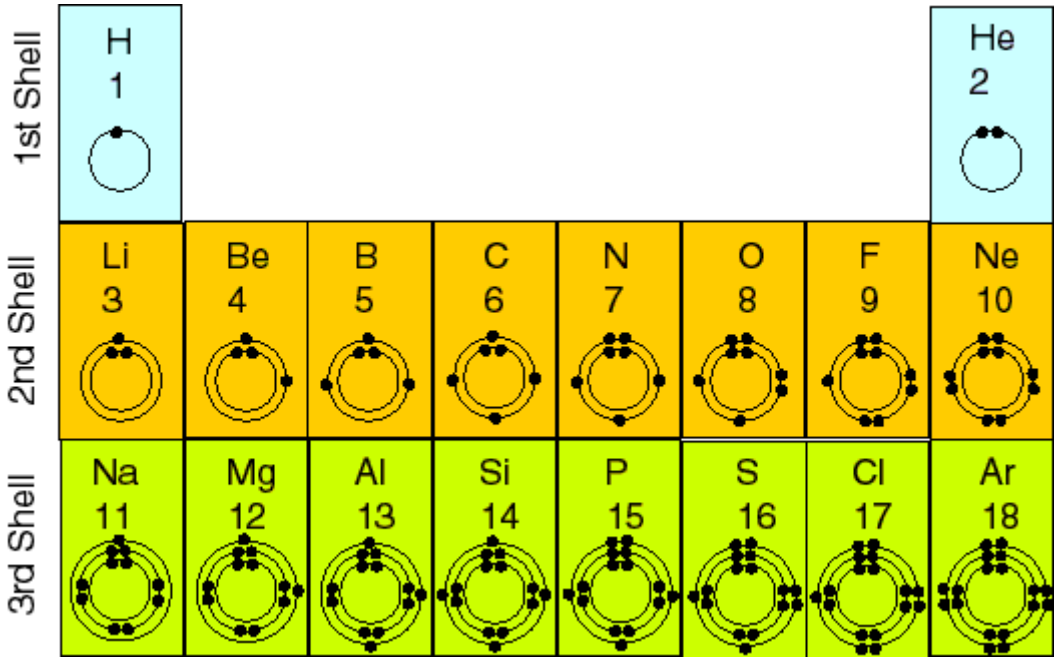
2, 8, 2

First shell, second shell, third shell

extension

6f

There is a relationship between the period number and the number of electron shells an atom has.



At this time, the maximum number of electron shells (or electron orbitals) for any element is seven.

In the periodic table, elements have something in common if they are in the same row. All of the elements in a period have the same number of **electron shells**. Every element in the top row (the first period) has one shell for its electrons) All of the elements in the second row (the second period) have two shells for their electrons. It goes down the periodic table like that..

extension

7a Matter exists in different states – solid, liquid and gases

All matter can be found as either solid, liquid or gas depending upon the temperature. Each type of matter has its own specific temperature ranges that it will exsist in each of these three states. Gases, liquids and solids can be made up of atoms, molecules, and/or ions.

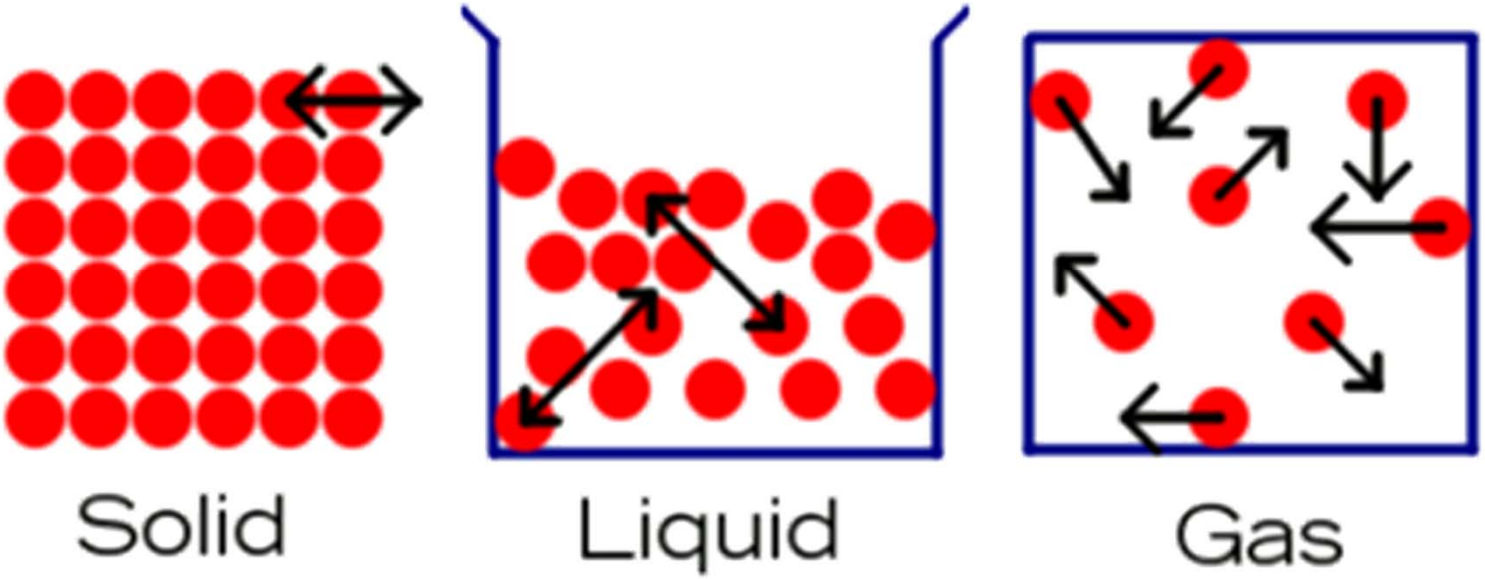
Solid iodine
$I_2(s)$

Liquid bromine
$Br_2(l)$

Gaseous chlorine
$Cl_2(g)$

7b

Matter exists in different states – solid, liquid and gases



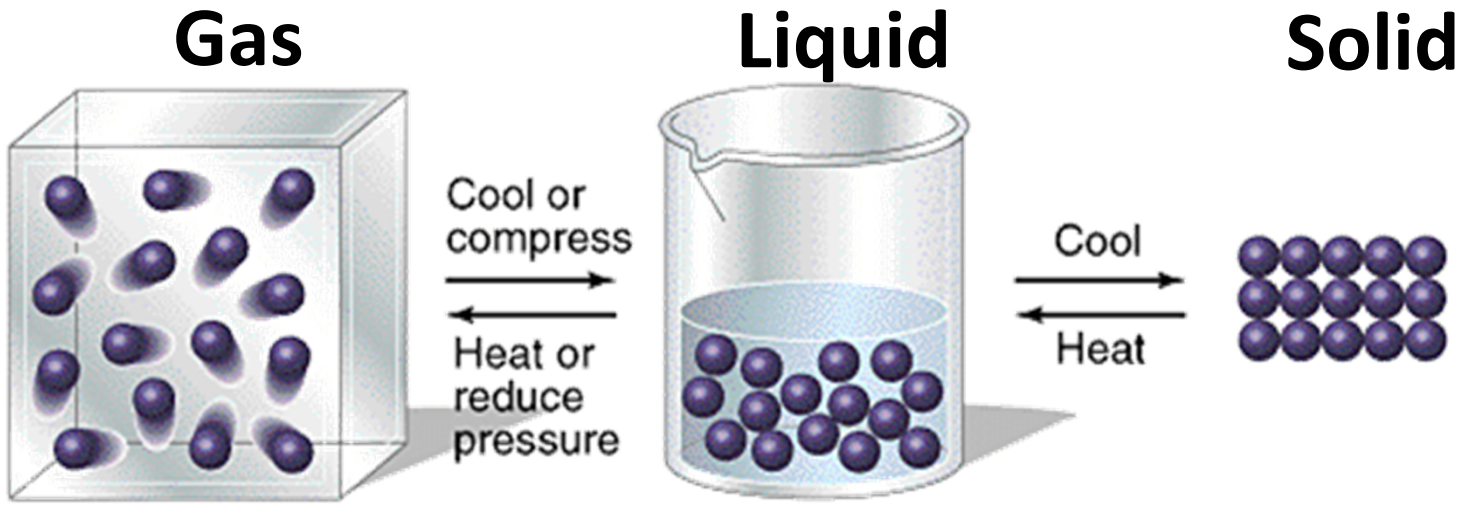
Solids remain in a fixed shape – the particles vibrate but remain tightly bonded to each other.

Liquids take the shape of the container – the particles can move past each other but are still bonded.

Gases fill any container they are in – the particles move fast and are not bonded to each other

7b Particles are arranged and move differently in solids, liquids and gases

Solid particles are packed closely and only vibrate in a fixed position. **Liquid particles** are also packed closely but the particles move around more. **Gas particles** have a lot of space between them and move around quickly.



Total disorder; much empty space; particles have complete freedom of motion; particles far apart.

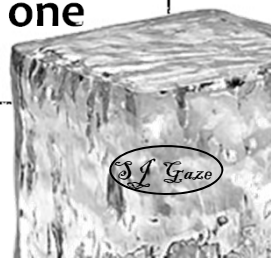
Disorder; particles or clusters of particles are free to move relative to each other; particles close together.

Ordered arrangement; particles are essentially in fixed positions; particles close together.

7b Particles are arranged and move differently in solids, liquids and gases

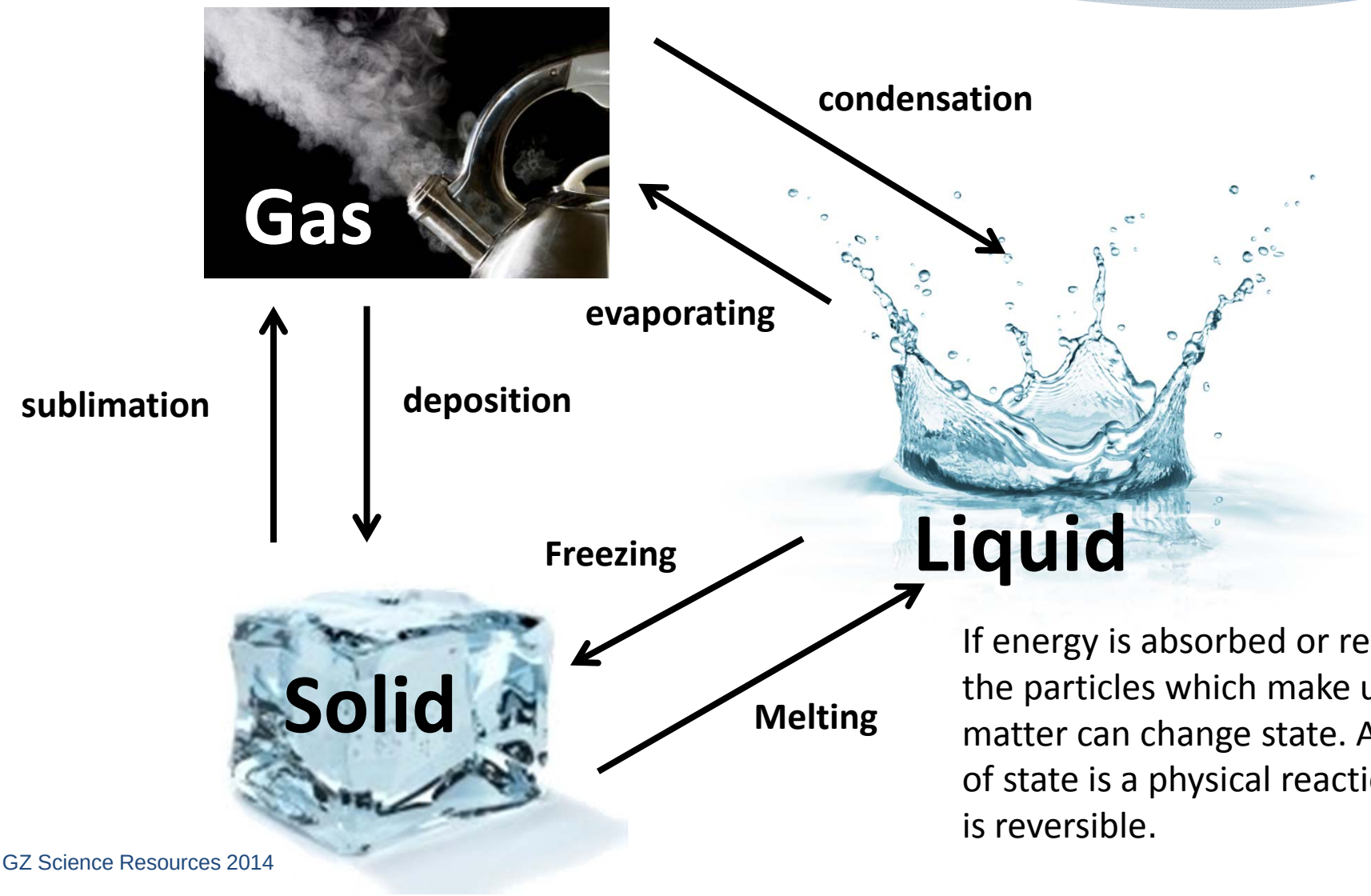
Characteristics of Gases, Liquids and Solids

gas	liquid	solid
assumes the shape and volume of its container **particles can move past one another**	assumes the shape of the part of the container which it occupies **particles can move/slide past one another**	retains a fixed volume and shape **rigid - particles locked into place**
compressible **lots of free space between particles**	not easily compressible **little free space between particles**	not easily compressible **little free space between particles**
flows easily **particles can move past one another**	flows easily **particles can move/slide past one another**	does not flow easily **rigid - particles cannot move/slide past one another**



7c

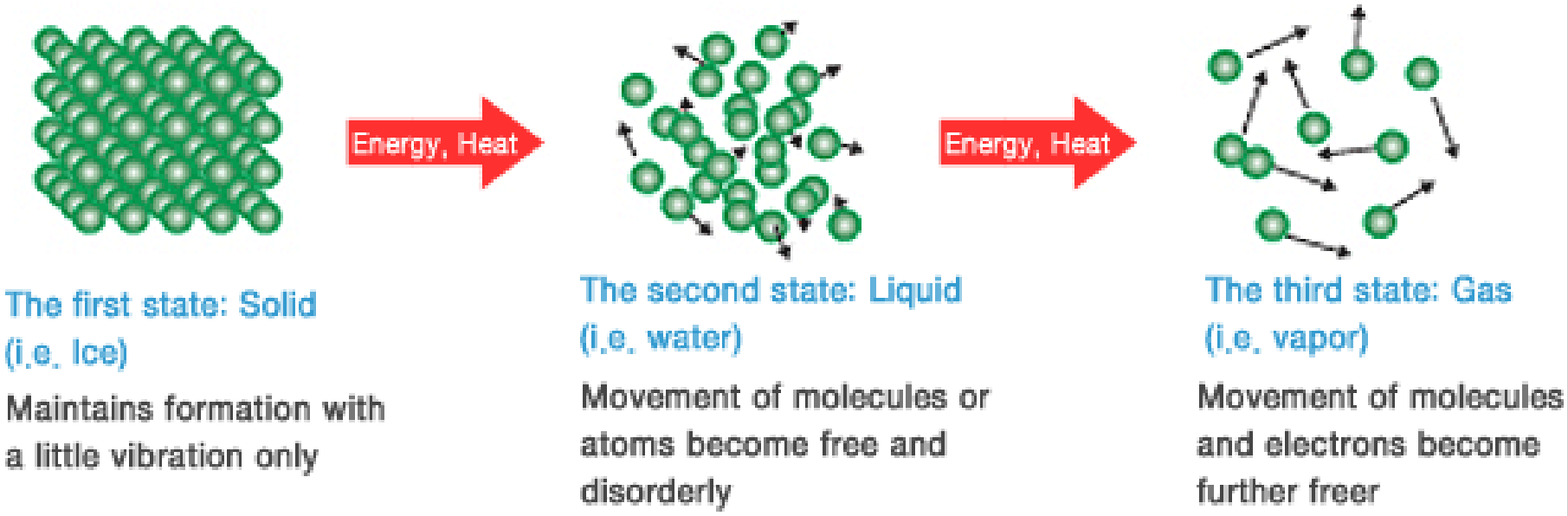
Matter can change from one state to another



If energy is absorbed or released the particles which make up the matter can change state. A change of state is a physical reaction and it is reversible.

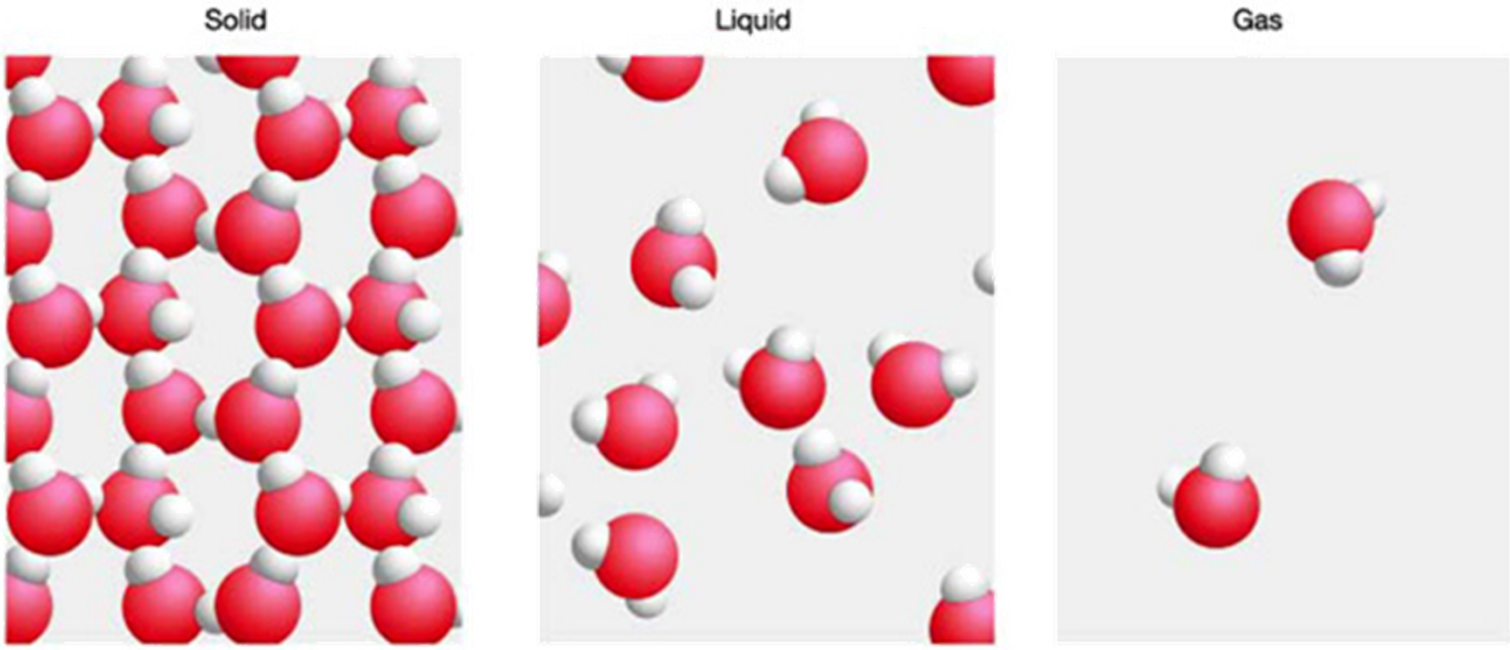
7d The particles of different states have different kinetic energy levels

Kinetic energy causes particles to move. The more kinetic energy a particle has the faster it moves. Kinetic energy can be added to a particle by adding heat energy (and heats up). The heat energy is then **transformed** into the kinetic energy.
Kinetic energy can also be lost from a particle, which slows it down, when it changes back into heat energy and is lost (and cools).



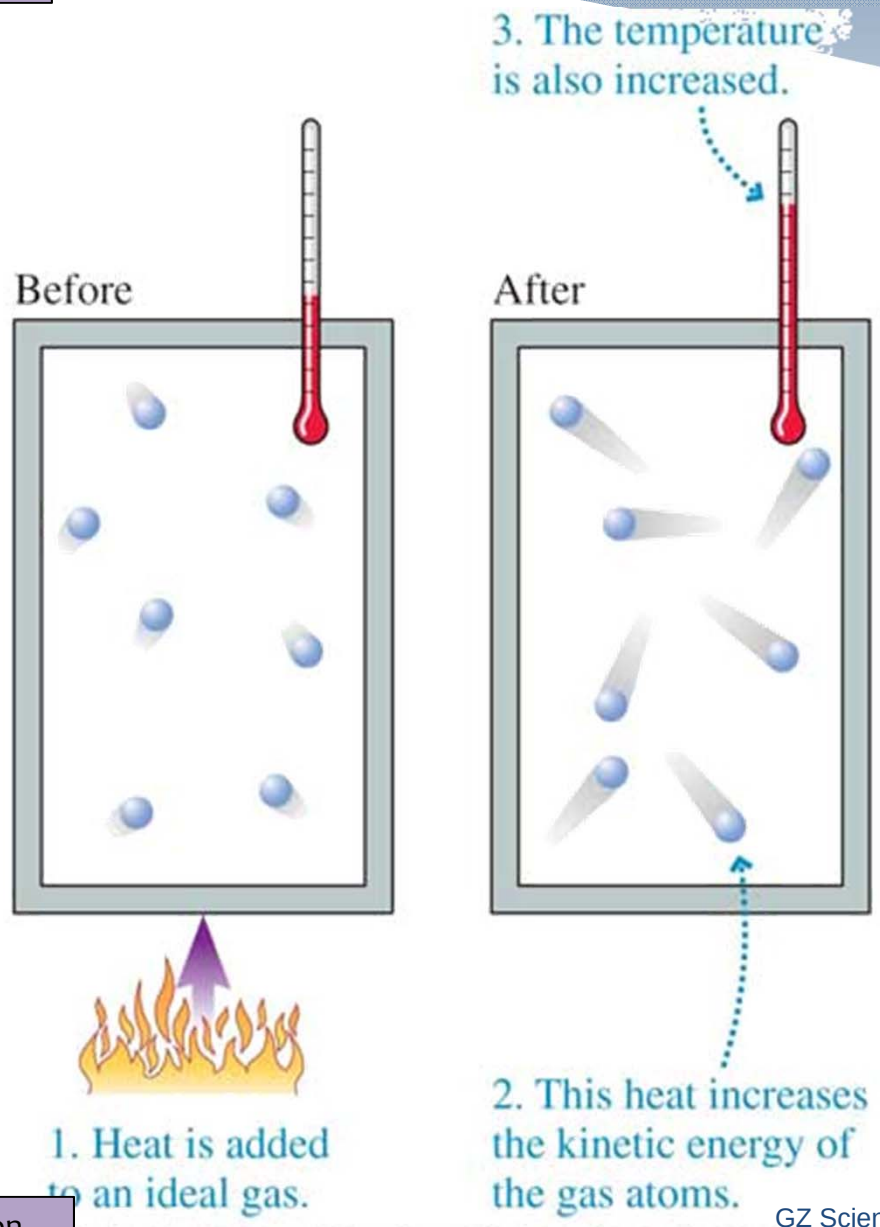
7d The particles of different states have different kinetic energy levels

The **movement of particles** in any state is determined by three factors: How strong the bonds are between the particles, how much energy (kinetic) the particles contain and the mass of the particles.

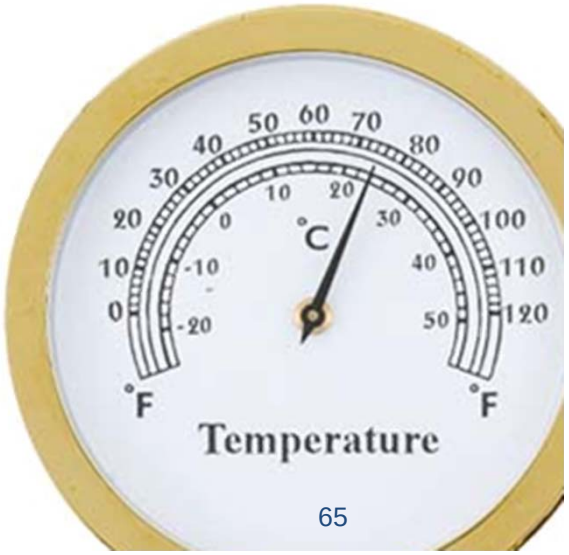


Particles move **faster** when: they have less mass, have weaker bonds between particles and have more energy.
Particles move **slower** when: they have more mass, have stronger bonds between particles and have less energy.

7d Temperature is a measure of the kinetic energy in particles.



The atoms and molecules in a gas are in constant motion. Temperature is a measure of the speed with which they move. (More exactly it is a measure of their **kinetic energy**.) The higher the temperature, the faster the molecules move.



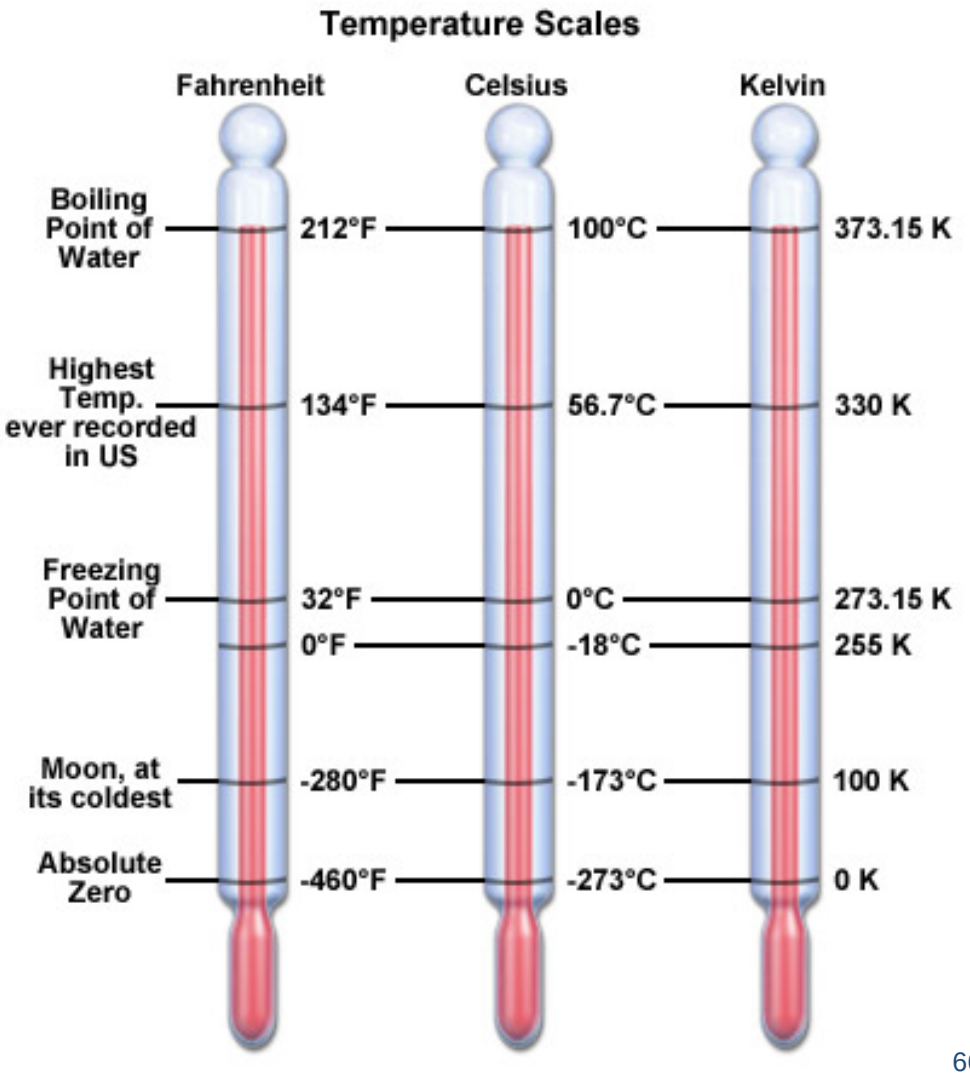
extension

7d

Heat/temperature is linked to particle movement

Heat and temperature are not the same thing. Heat energy is the total kinetic energy of the atoms of a substance. Temperature is the average kinetic energy of the atoms of a substance.

We measure our temperature on the **Celsius** scale where water freezes at 0°C and boils at 100°C. Other countries use the **Fahrenheit** scale and Scientists often use the **Kelvin** scale.

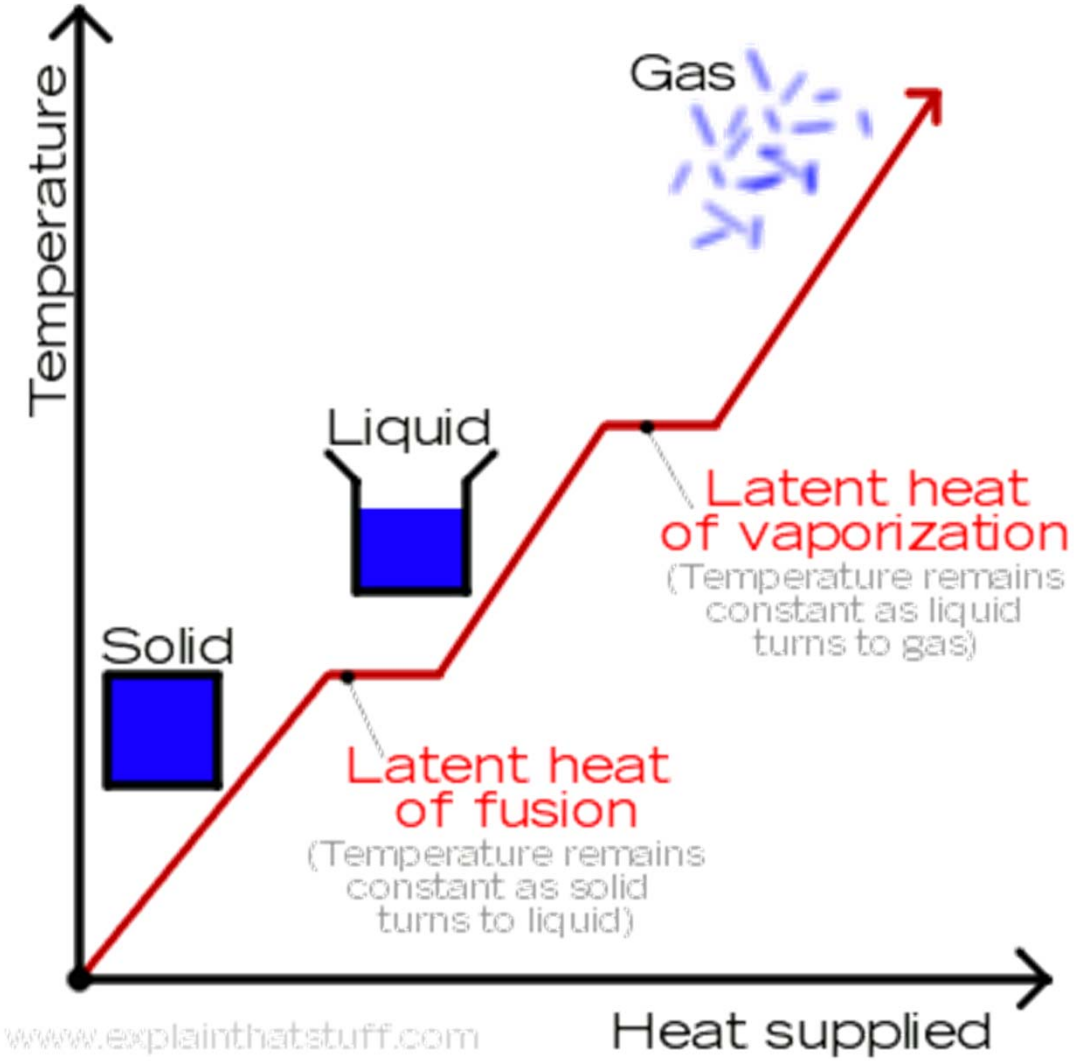


extension

7d

Latent heat is the heat released or absorbed by a material during a change of state without change of temperature.

There is no temperature change during a phase change (change of state), thus there is no change in the kinetic energy of the particles in the material. The energy released (to change from gas to liquid or liquid to solid) comes from the potential energy stored in the bonds between the particles. The energy absorbed (to change from gas to liquid or liquid to gas) comes from the surrounding area.



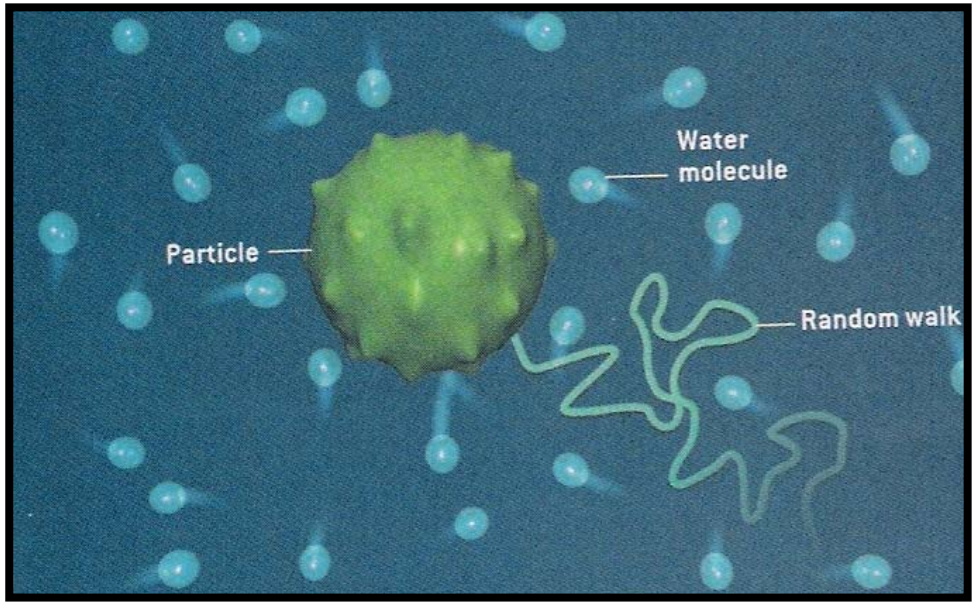
extension

8a

The theory of Brownian motion

Brownian motion is the random movement of particles in a liquid or gas, caused by the particles hitting (or colliding) with molecules they are surrounded by.
Each collision pushes particles in a random direction and is the reason why **diffusion** occurs.

Pollen particles that could be seen moving randomly in water was first described by **Robert Brown** in the early 1800's. Brown was a Scottish botanist.
In 1905 **Einstein** finally came up with an explanation when he realised that the jiggling of the pollen grains seen in **Brownian motion** was due to molecules of water hitting the tiny pollen grains.

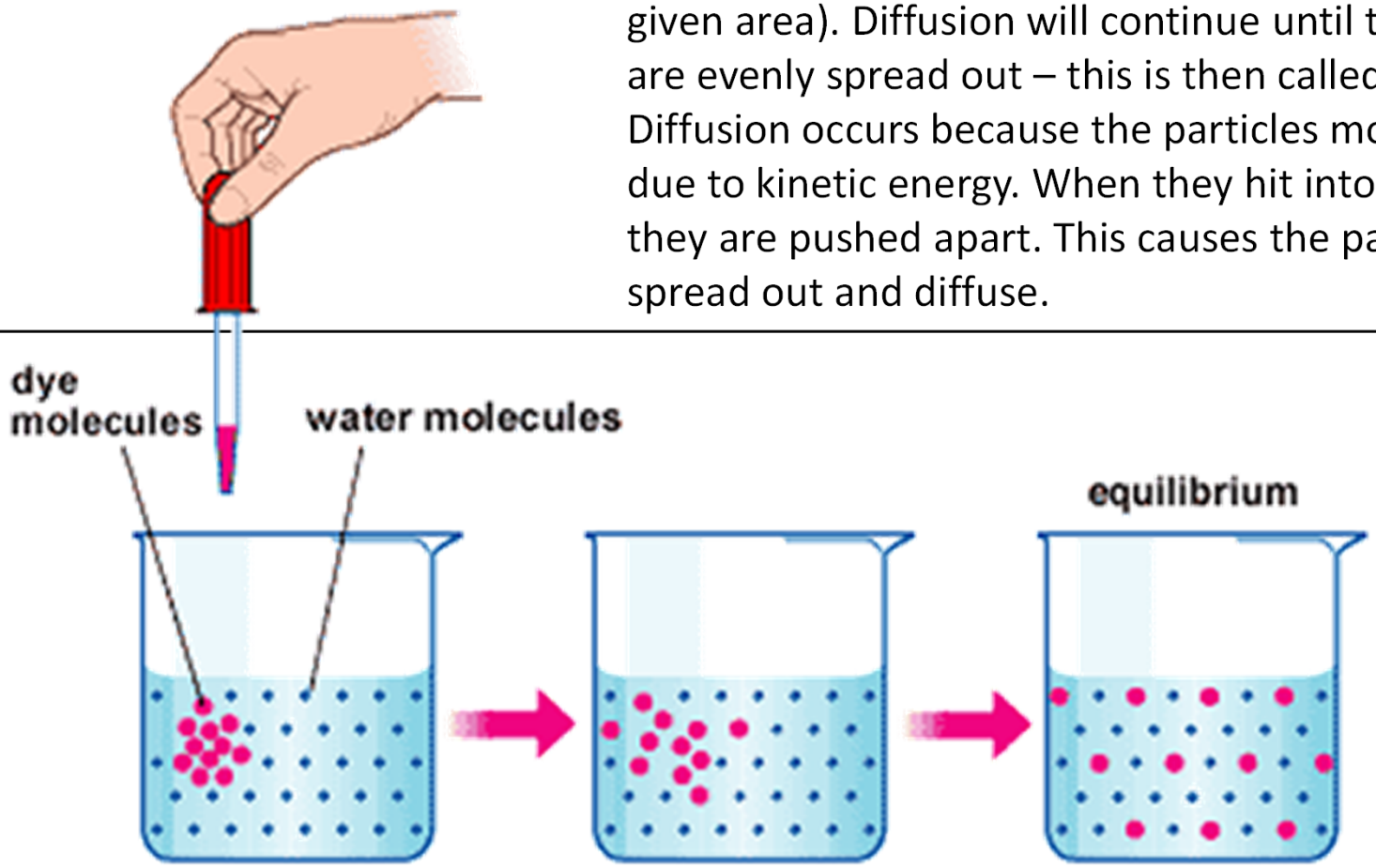


He was also able to use this evidence to prove the existence of atoms which up to that point had only been an idea.

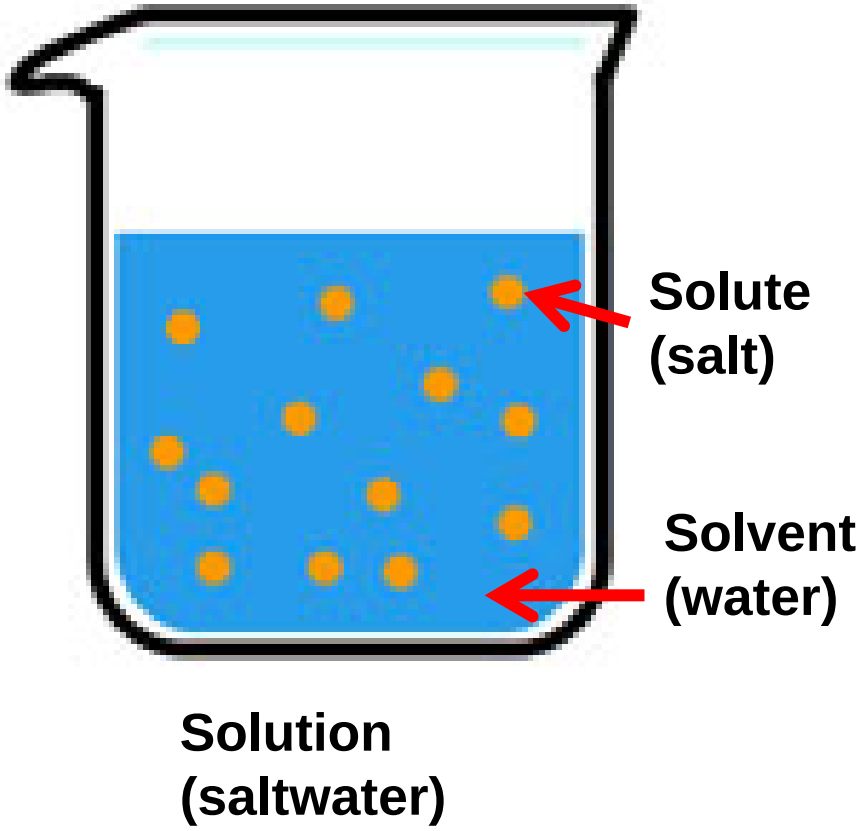
8b

Diffusion occurs because particles mix with and move through another substance

When particles diffuse they move from an area of high concentration (many particles in a given area) spreading out into areas of low concentration (fewer particles in a given area). Diffusion will continue until the particles are evenly spread out – this is then called **equilibrium**. Diffusion occurs because the particles move around due to kinetic energy. When they hit into each other they are pushed apart. This causes the particles to spread out and diffuse.



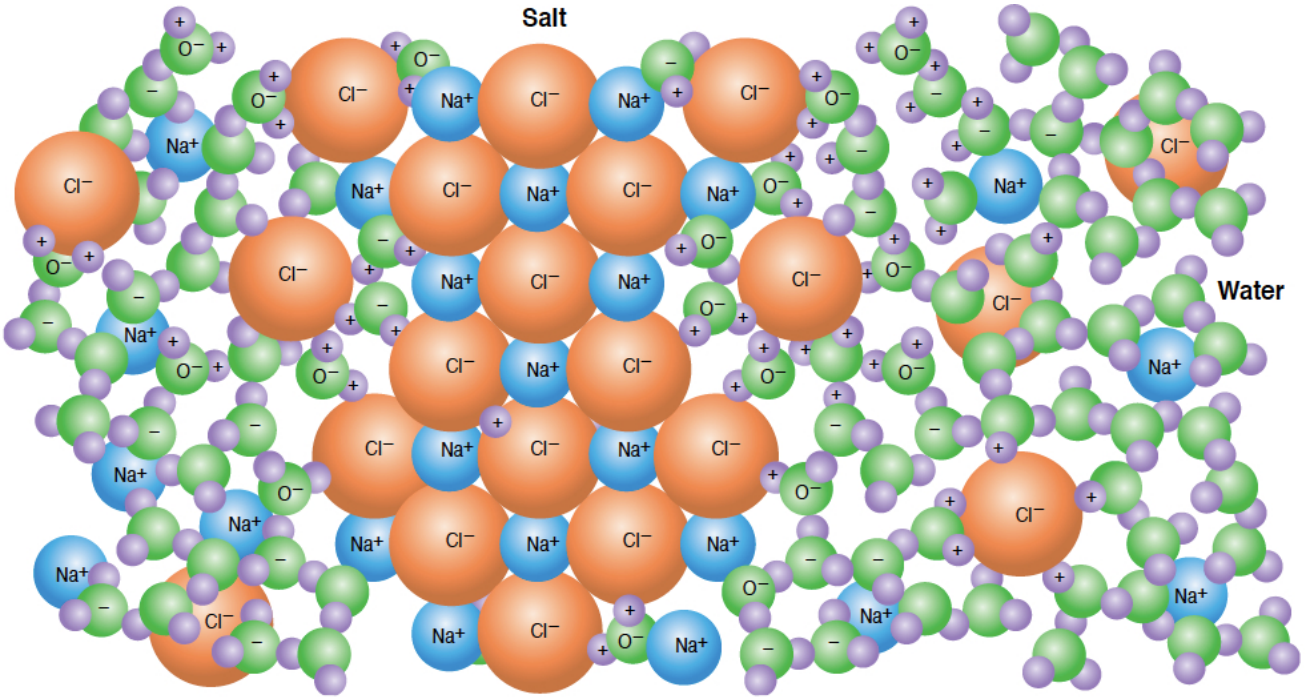
9a Solutions are made from a solute dissolved in a solvent



A **solution** is made up of a **solvent** and a **solute**. A solvent is a substance such as water that is able to dissolve a solute. The solvent 'pulls apart' the bonds that hold the solute together and the solute particles **diffuse** (spread randomly by hitting into each other) throughout the solvent to create a solution. The solution is a **mixture** with evenly spread solvent and solute particles. These particles can be physically separated by **evaporation**.

9b Solutions form when a solute is dissolved in a solvent

When a solid mixes into a liquid and can no longer be seen it has **dissolved**. The liquid is called the **solvent** and it pulls apart the bonds between the solid particles, called the **solute**, and they **diffuse**. A **solution** is then created when the solvent particles (often water) are mixed up with the broken apart solute particles.



9b As a solvent water forms solutions with many different solutes.

Solutions are simply **mixtures** of materials, one of which is a liquid or a gas. The liquid or gas, also called a fluid because it is able to flow.

One of the most common solvents is water. All water found in natural sources on Earth, except in rain water or ice, is in the form of a solution – such as **salt water** in the oceans and **mineral water** in rivers, springs, water and lakes. Minerals from the surrounding rocks are eroded and dissolved into the water.

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9b Some substances are more soluble in water than others.

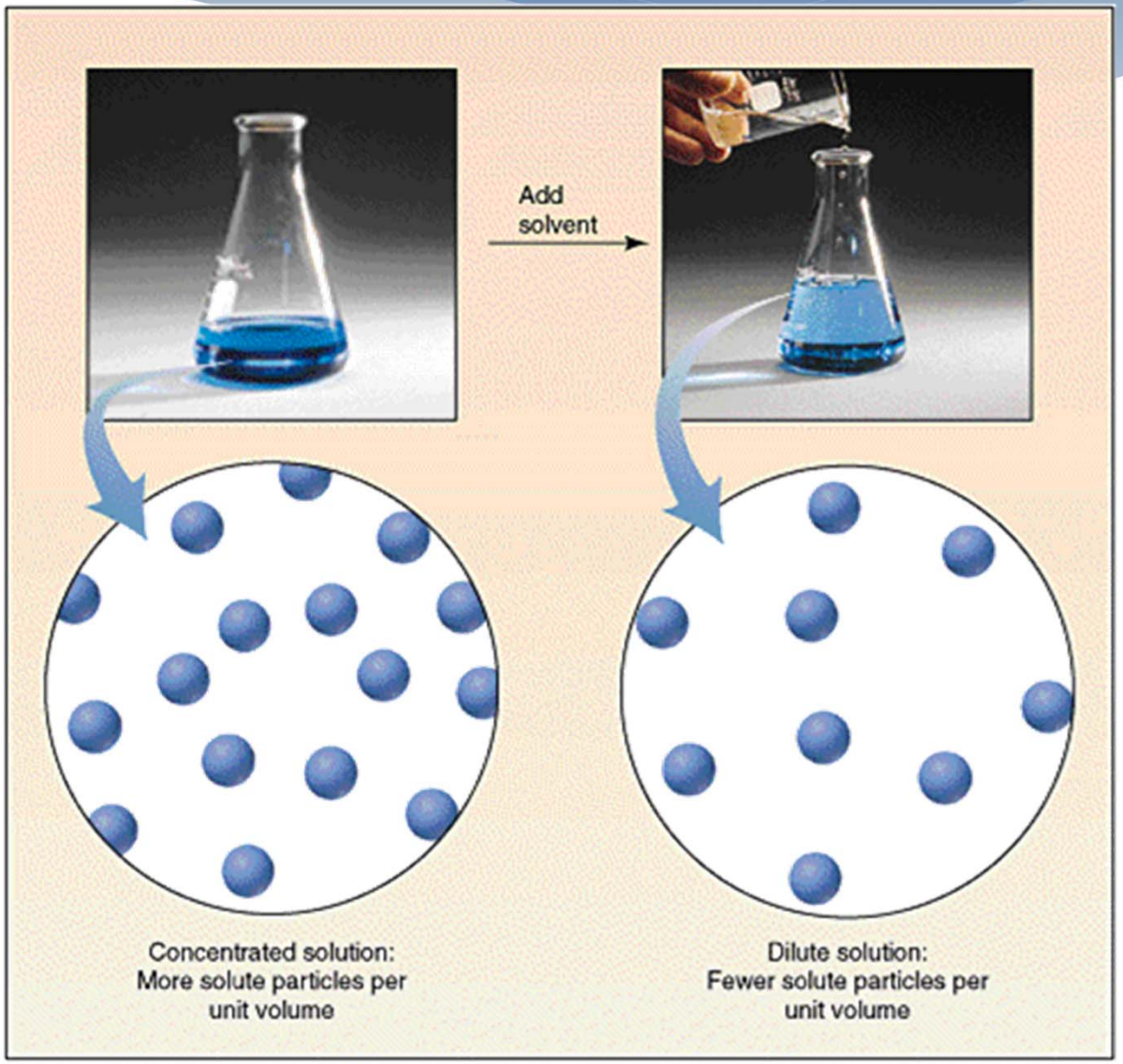
The process of combining the solute and the solvent can also be called **dissolving** the solute in the solvent. The ability to dissolve is called **solubility**. The complete dissolution of one liquid in another liquid is called **miscibility.** When the opposite occurs, the substances are called **immiscible**

miscible: vinegar and water

immiscible: oil and water

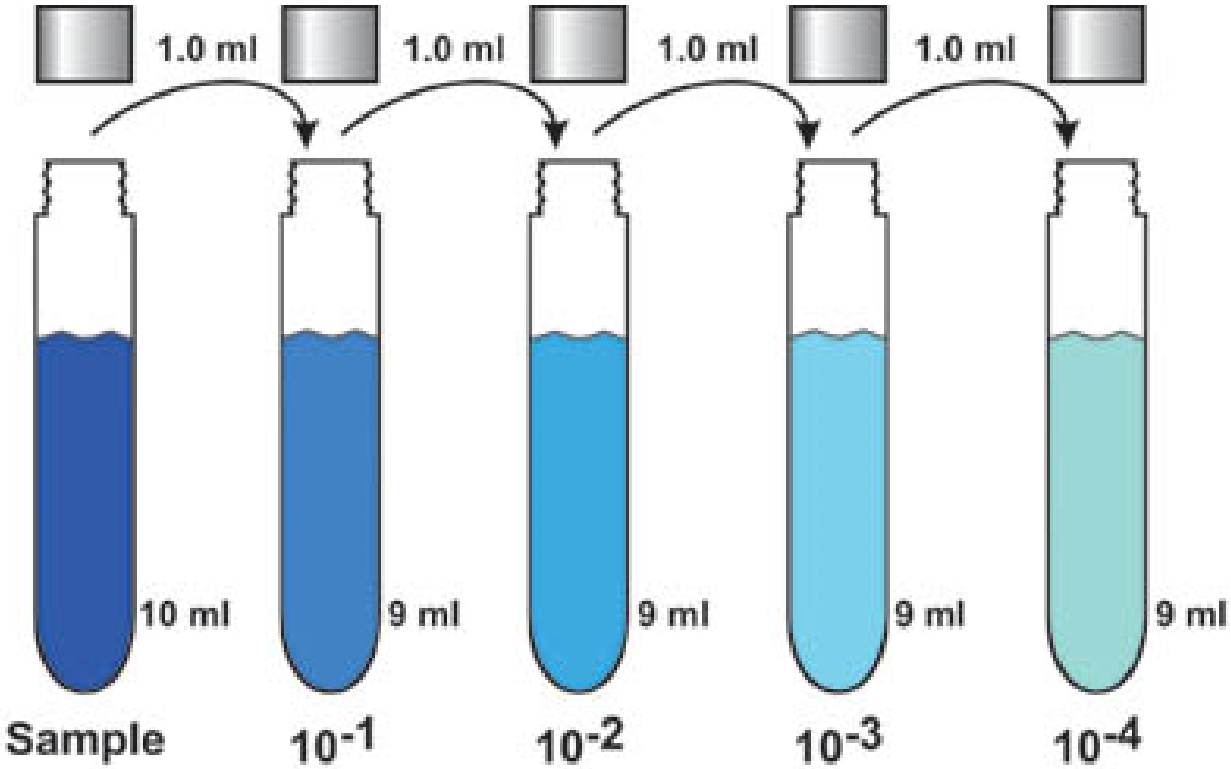
9c Concentration, dilution and saturation.

A solution becomes more **concentrated** as more solute is dissolved into the solvent. When a solvent can dissolve no more solute – and extra solute added remains as a solid – the solution is said to be **saturated.**
To **dilute** a solution more solvent is added – so there becomes fewer particles of solute dissolved into the solvent as a solution becomes more diluted.



9d Dilution series

A solution can be made into a **dilution series** by adding a set quantity to a volume of solvent (usually water) then continuing the process by taking the same set quantity from the new diluted solution and adding it to more solvent.
To obtain a dilution factor of 10 then 1ml of the sample solution needs to be added to 9ml of water. This can be repeated for each step. After 4 dilution steps that solution will be 10,000 **less concentrated** than the original sample.



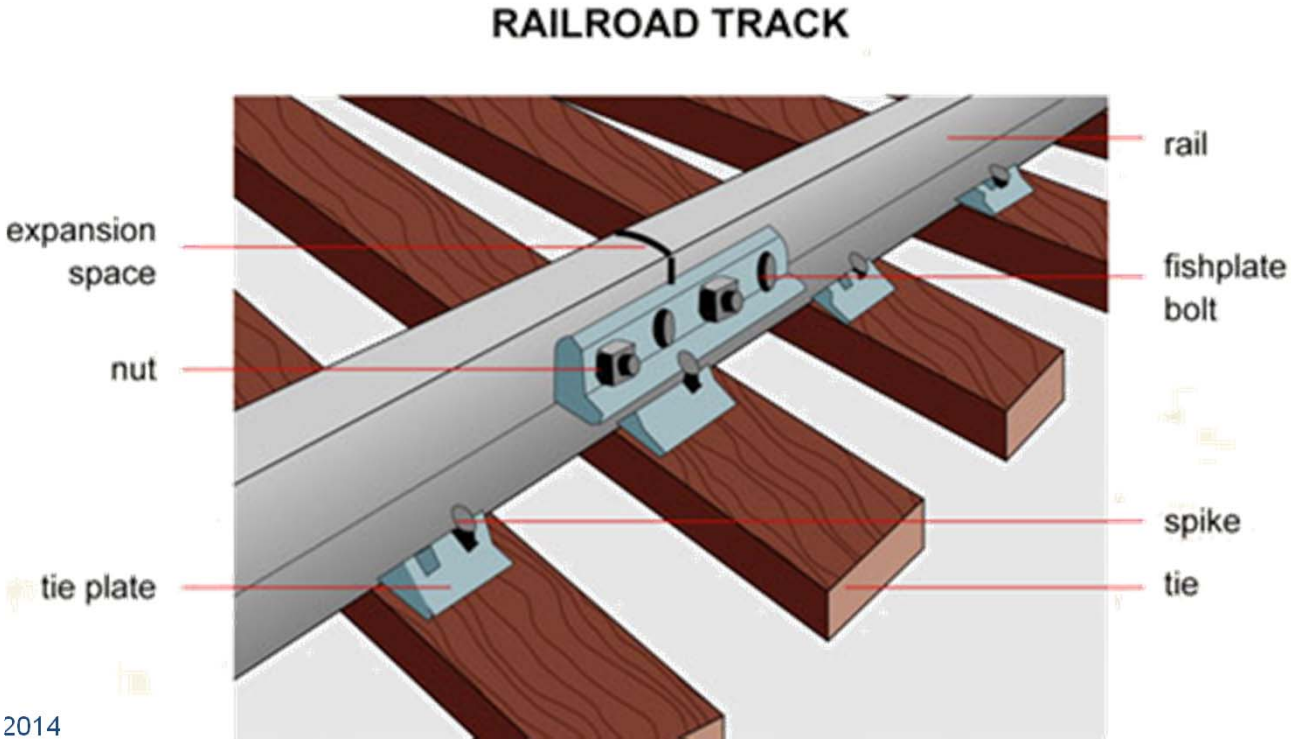
extension

10a Expansion and Contraction of matter

Matter **expands** or gets bigger when it is heated up. It **contracts** or gets smaller when it is cooled down.

Some types of matter, such as metals, conduct heat very well and therefore the effects of expansion and contraction are more obvious.

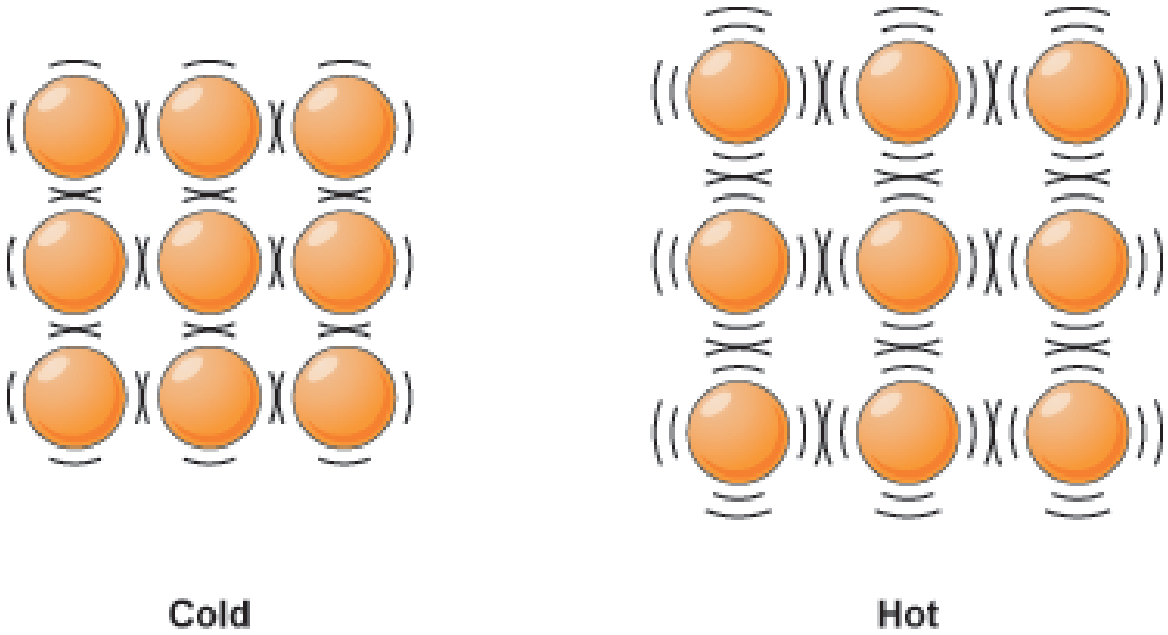
Structures such as bridges and railway tracks that are made out of metal have to be built with **gaps** so they don't warp out of shape when exposed to higher temperatures during summer.



10a

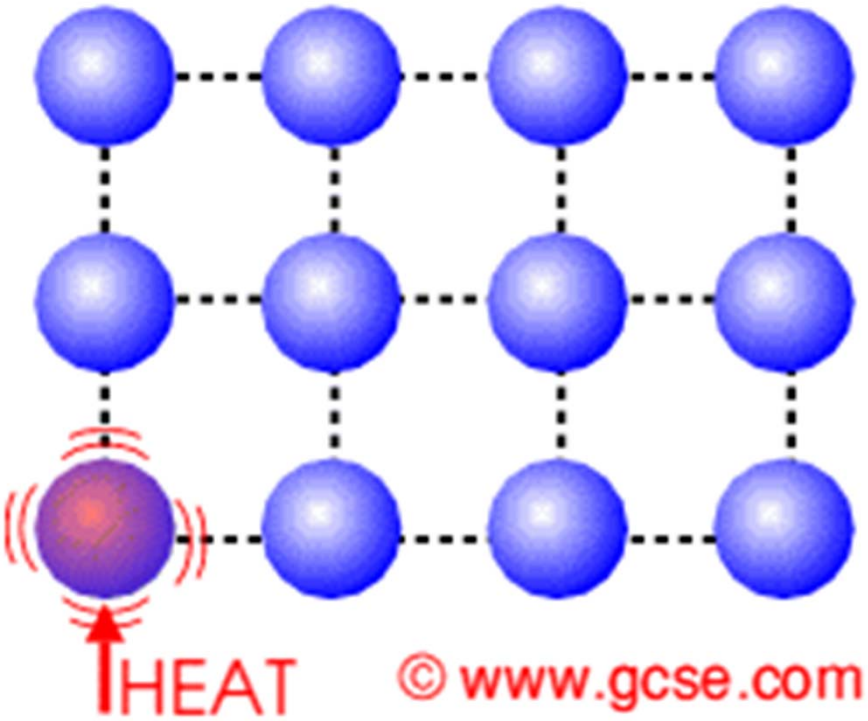
Expansion and Contraction of matter

When matter expands or contracts only the **space between** the particles changes: not the size of the particles.
The particles in a **solid** vibrate more when it is heated, and take up more space.
The particles in a **liquid** move around each other more when it is heated, and take up more space.
The particles in a **gas** move more quickly in all directions when it is heated, and take up more space.

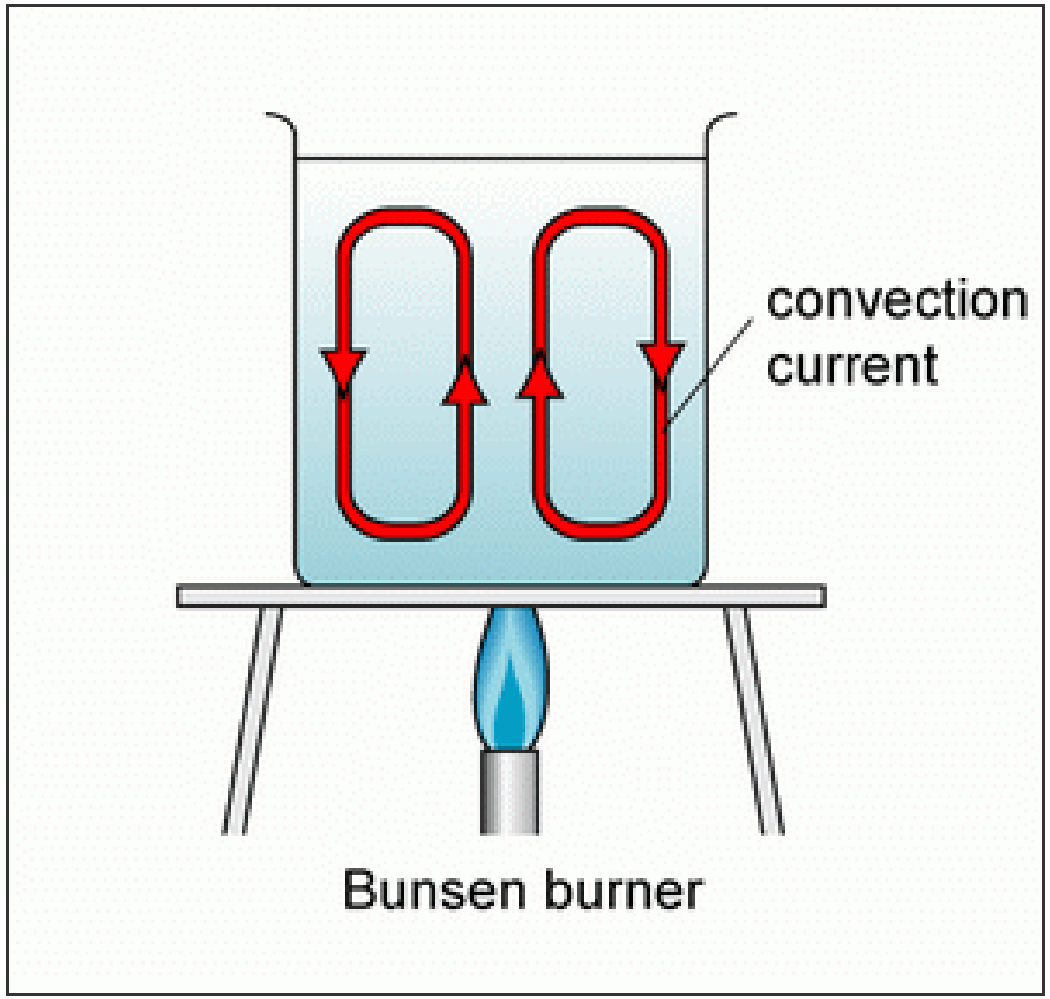


10b Solids transfer heat energy by Conduction

When heat is transferred by conduction – the atoms remain in fixed solid position – and the heat energy is transferred from one atom to another by being carried by moving electrons surrounding the atoms. The more heat energy an electron has the faster it moves. Some materials conduct better than others. They are called **conductors** and include metals which have electrons that are free to move. Those materials that cannot conduct heat are known as **insulators**. They have no free electrons to carry the heat energy.



10C Liquids and Gases transfer heat energy by Convection

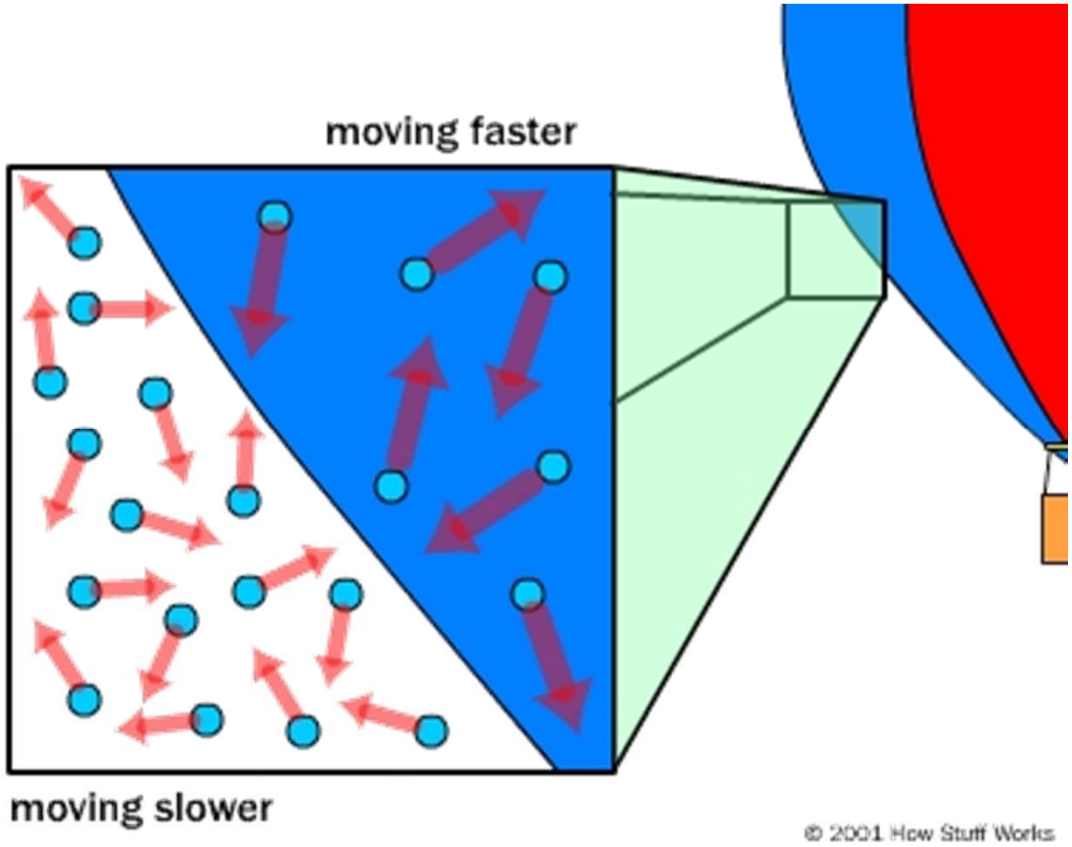


Convection occurs when free moving particles found in liquids and gases are heated. This causes an increase in kinetic energy of the particles and as they collide into each other they push apart more. The hotter area of liquid or gas becomes less dense or lighter and rises. As the particles lose energy they slow down and become closer to each other which makes them denser and they fall back down. This movement creates **convection currents** where the particles circulate.

10C

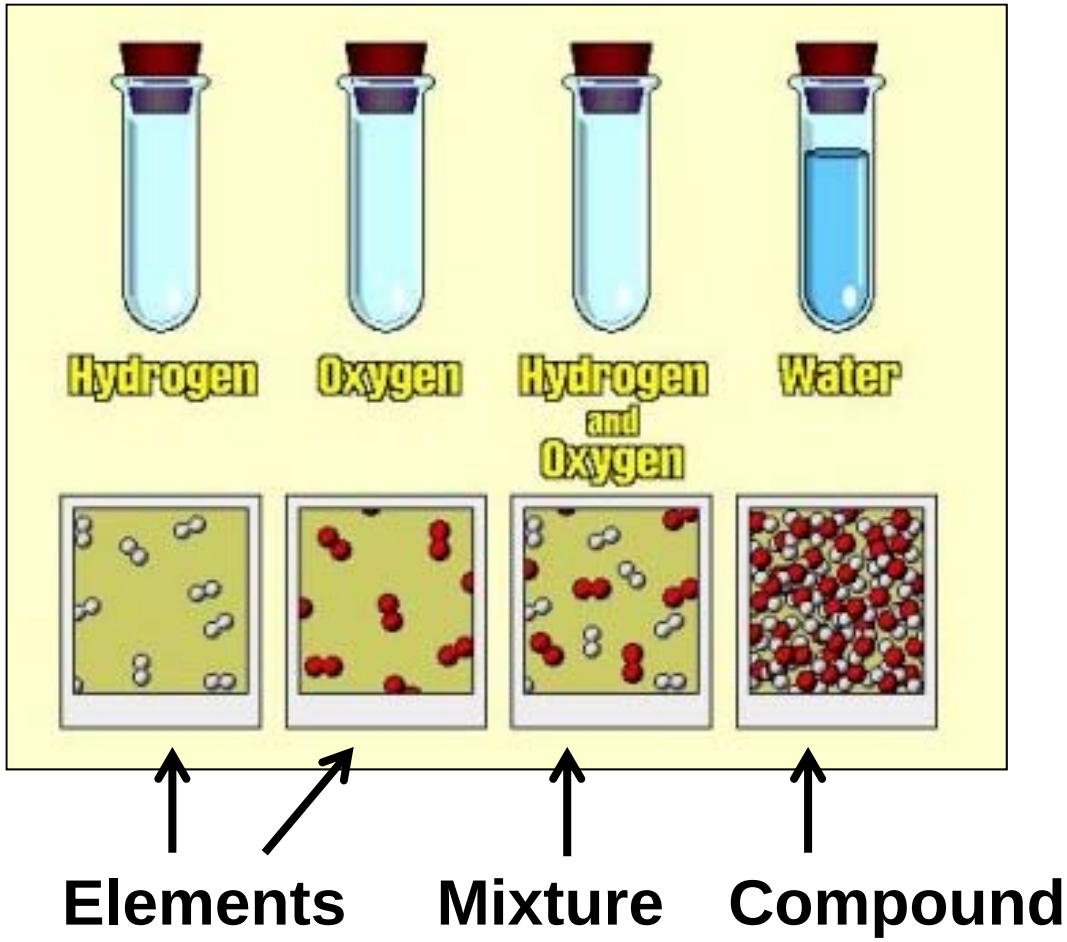
Hot air balloons rise due to Convection

When you heat the air in the balloon your increase the kinetic energy of the air particles. The air particles absorb the heat energy and move faster. This makes them move faster. Air particles are pushed out of the balloon, as they take up more space.
A hot air balloon rises because it is filled with hot, less dense air and is surrounded by colder, more dense air.



11a Elements are pure substances that combine to make mixtures & compounds

There are approximately 100 different elements but many millions of substances. Most matter around us is made up of combinations of elements.
If different elements have chemically reacted together and joined then they form a **compound**.
If different elements and/or compounds are just jumbled up and not joined (or bonded together) then they form a **mixture**.

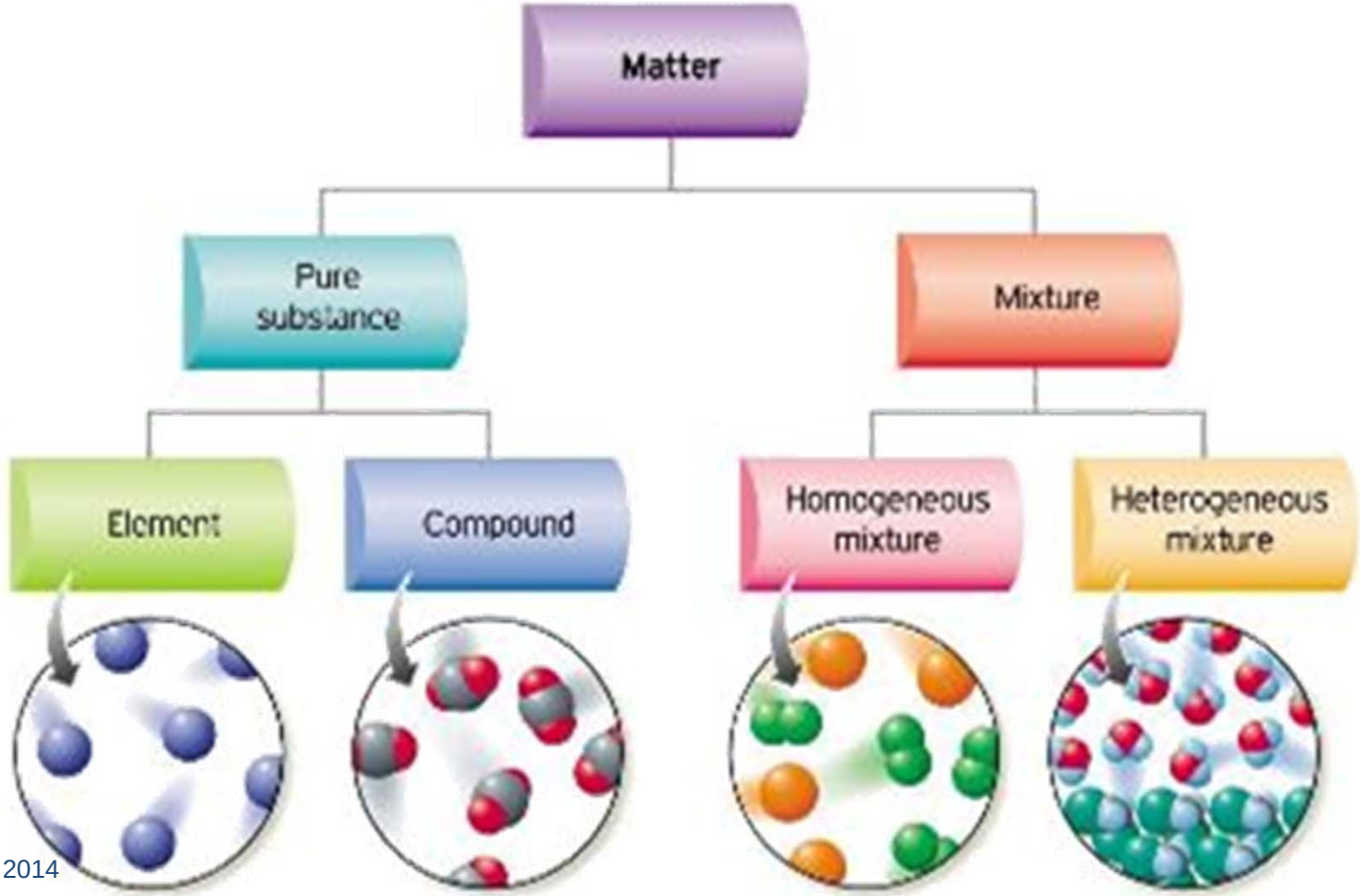


11a Everyday Elements, Compounds and Mixtures

All around us are examples of elements, compounds and mixtures. Few elements are found in their natural state because they react with chemicals around them so instead we have chemical processes to extract and purify them. Many of the everyday items we use are compounds that have been manufactured by chemical processes as well.

11b Elements are pure substances that combine to make mixtures & compounds

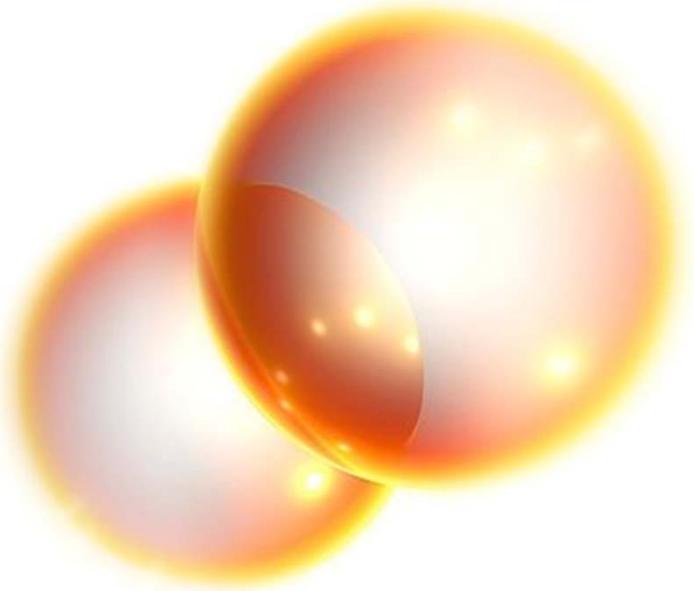
Matter can be divided into **pure substances** which include elements (atoms of the same type) and compounds (different atoms joined together) and **Mixtures** which can either be **homogeneous** (evenly mixed) or **heterogeneous** (unevenly mixed)



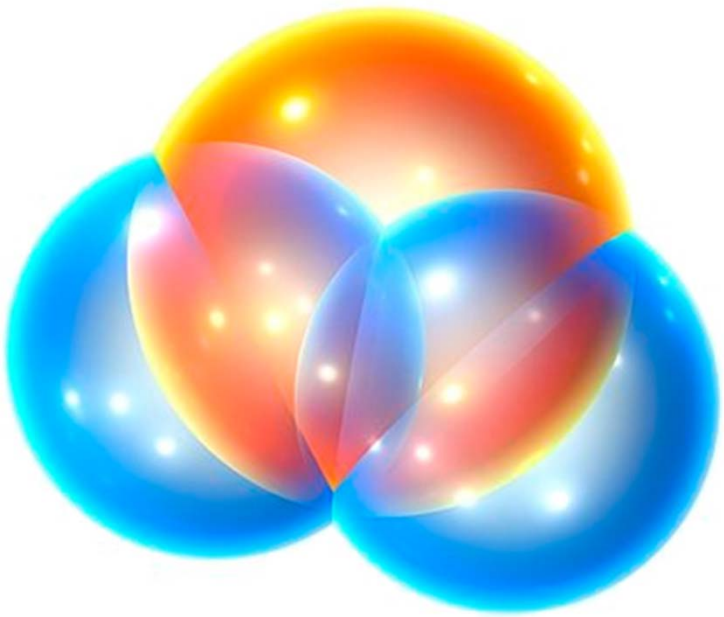
11b

Elements are pure substances that combine to make mixtures & compounds

A **molecule** forms when atoms join together – either the same type of atom to form a molecule of an element (such as oxygen gas – O2) or different types of atom to form a molecule of a compound (such as water - H2O).



Oxygen Molecule – O_2

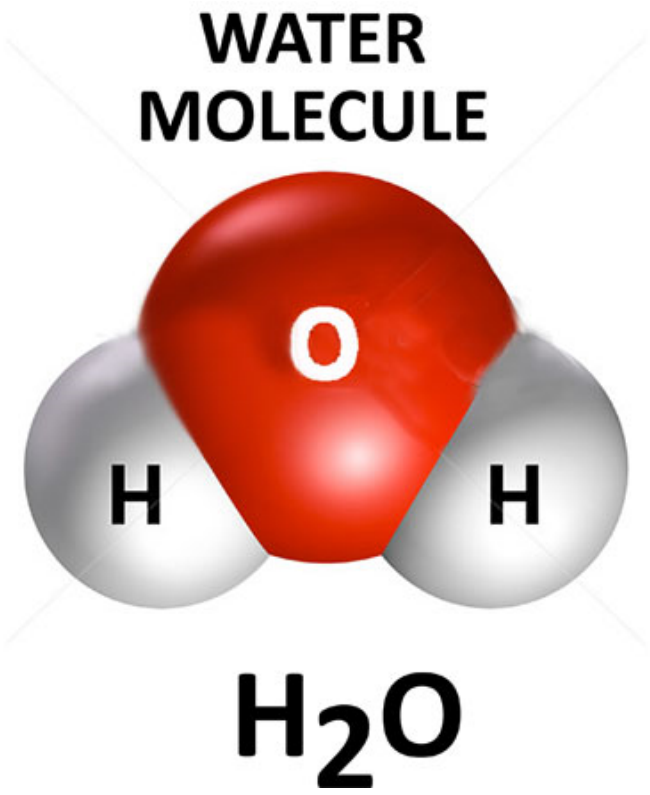


Water Molecule – H_2O

11b

Elements are pure substances that combine to make mixtures & compounds

Each compound has a chemical formula indicating the proportions of each combined element



Water has 2 hydrogen atoms (H) and 1 oxygen atom (O).
Normally the element found on the left of the periodic table is written first followed by the element found on the right of the periodic table.

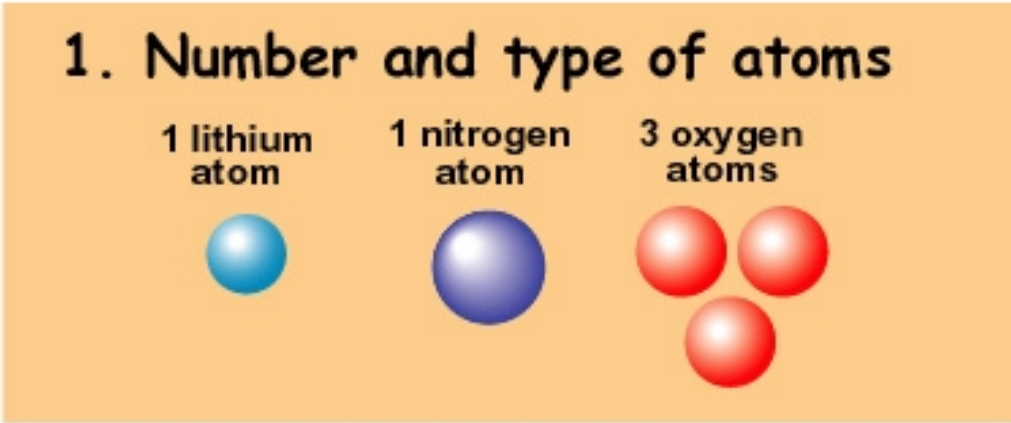
11C

Counting atoms in a compound

A formula tells you the type of atoms that are in a compound and the number of each atom.

lithium nitrate

$LiNO_3$



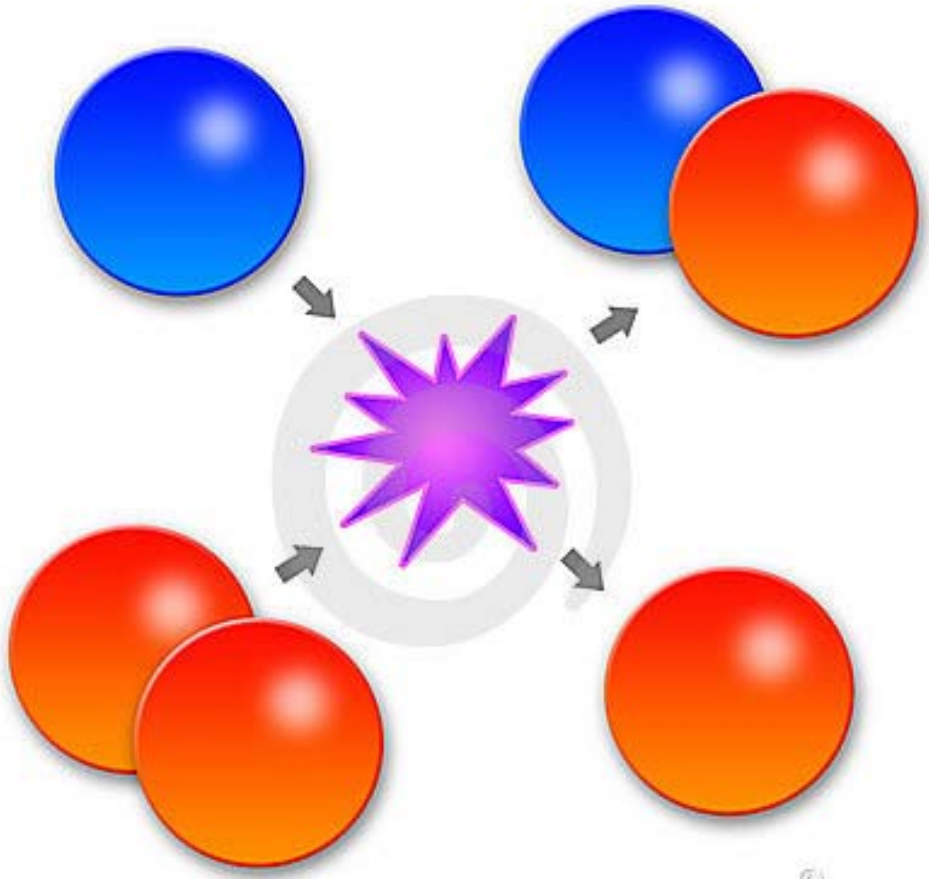
A number in front of the compound tells you how many molecules there are. **A number after** an atom tells you how many atoms of that type are in the molecule. **A number after brackets** tells you how many times to multiply every atom inside the brackets.

11d

Chemical and Physical change

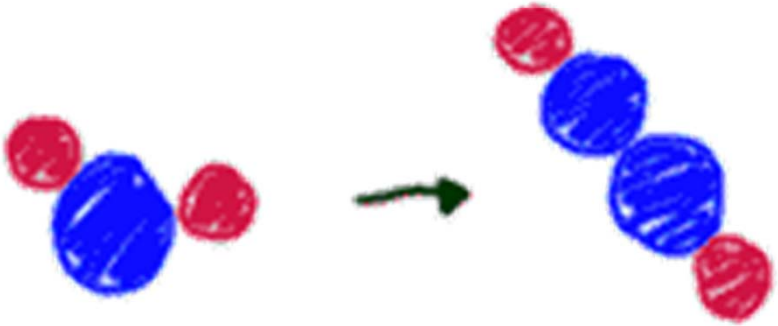
A **chemical reaction** is a process that produces a chemical change to one or more substances.
A chemical reaction will produce a **new substance.** Other observations may include a temperature change, a colour change or production of gas.
Chemicals that are used in a chemical reaction are known as **reactants**. Those that are formed are known as **products**.

Reactants → Products



11d Chemical and Physical change

PHYSICAL CHANGE OF WATER INTO ICE



CHEMICAL CHANGE OF WATER INTO HYDROGEN PEROXIDE

Physical changes are concerned with energy and states of matter. A physical change does not produce a new substance. Changes in state (melting, freezing, vaporization, condensation, sublimation) are physical changes. Examples of physical changes include bending a piece of wire, melting icebergs, and breaking a bottle

A **chemical change** makes a substance that wasn't there before.

The starting and ending materials of a physical change are the same, even though they may look different.

11d

Chemical and Physical change

Examples of Chemical Changes

burning wood
dissolving salt in water
mixing acid and base
digesting food

Examples of Physical Changes

crumpling a sheet of paper
melting an ice cube
casting silver in a mould
breaking a bottle

12a Mixtures can be easily separated physically

Mixtures of substances are not chemically bonded to each other so they can be separated by physical techniques.

The state of the various substances in the mixture such as a liquid and solid or the physical properties of the substances such as different boiling points will determine which method of separation will be used.

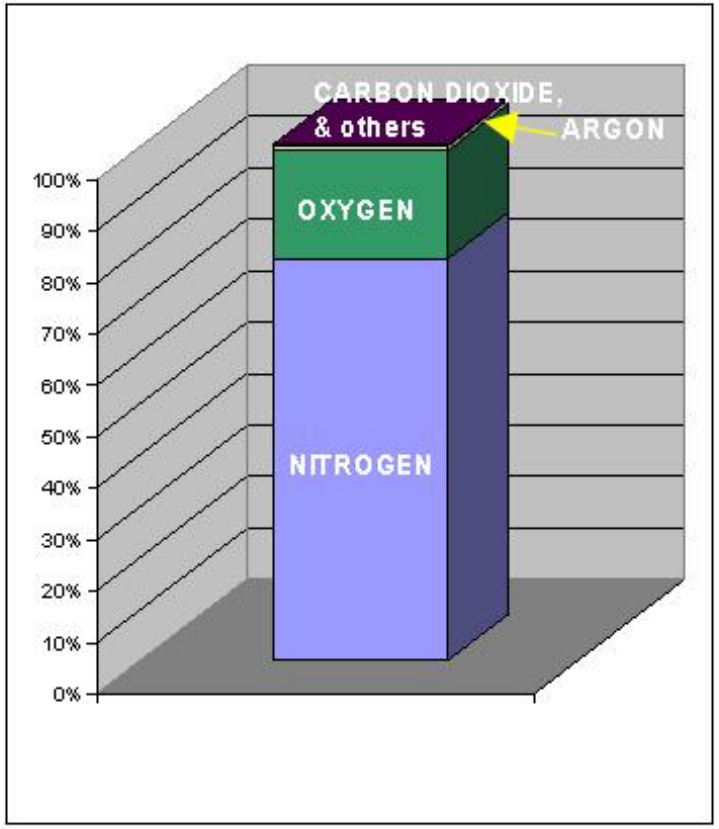
12a Mixtures are made up of different components

Mixtures can be physically separated into different components.
A common household example of a mixture could be a cup of white coffee. This mixture is made up of three major components: Milk, coffee and water. Milk itself is a mixture that can be further broken down into other components such as fat, protein, sugar and water

Mixtures that are made up of a set ratio of other elements and/or compounds that are evenly spread are known as **homogeneous** mixtures. These types of mixtures have uniform composition and similar properties throughout. Air is an example of a homogeneous mixture. There is a fixed ratio of nitrogen gas to oxygen and carbon dioxide gases.

Note: this just applies to air samples taken from the same set altitude as oxygen levels decrease with higher altitudes

Components of air mixture



12b Mixtures can be easily separated physically using methods such as: Decanting

Decanting is simply pouring off a liquid without loosing any of the more dense substance (usually an insoluble solid) in the bottom of the container. Decanting separates a **heavier substance from a lighter one**. Chemists are most often after the substance at the BOTTOM of the container.

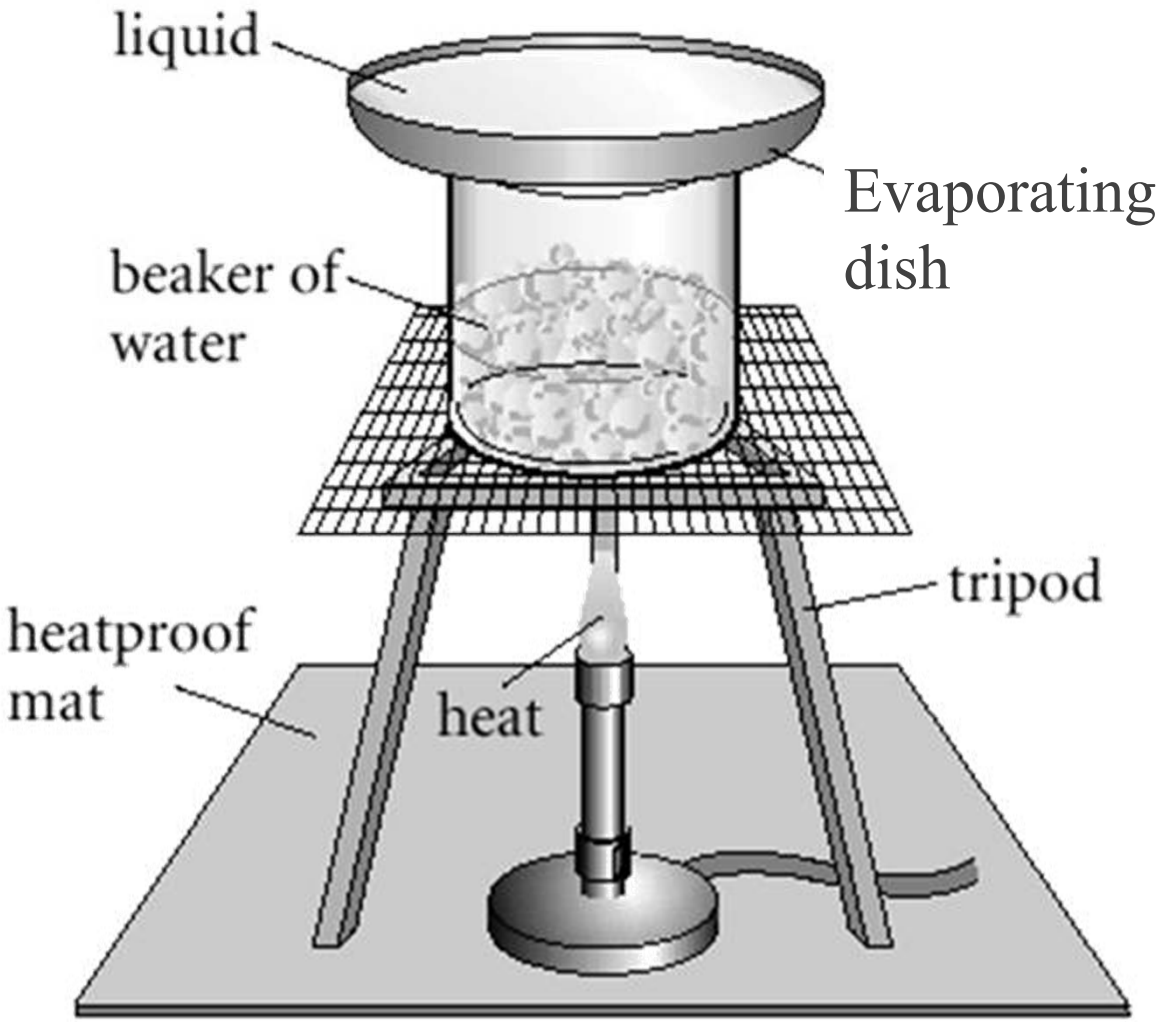
Original mixture of a solid and liquid

Heavier solid is allowed to settle to the bottom

The liquid is poured off the top while the solid remains

12b

Mixtures can be easily separated physically using methods such as: Evaporating



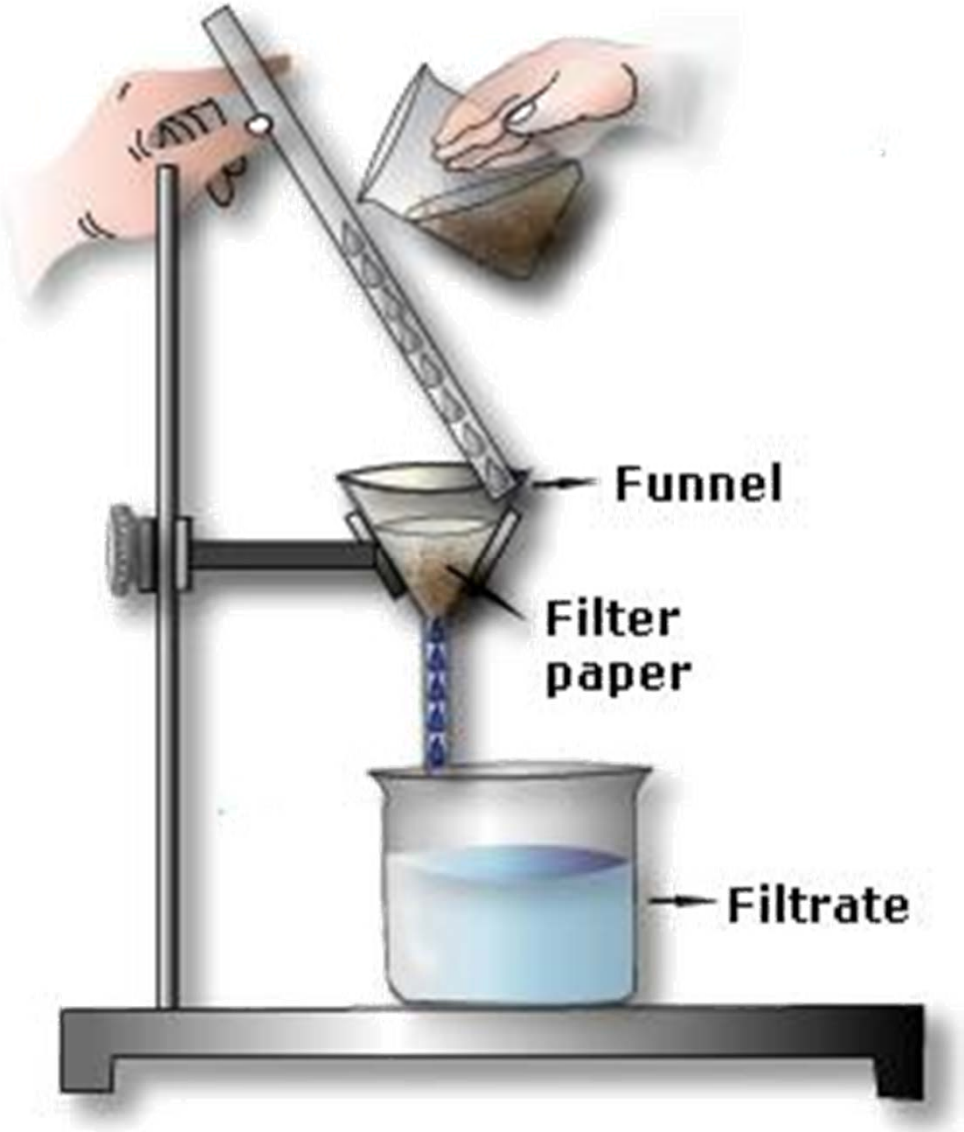
Evaporating separates a dissolved **solid from a liquid**. The solvent (liquid) is lost into the surroundings.

The liquid will evaporate but evaporation becomes faster at higher temperatures.

The solid remains because it has a higher (often very much higher) boiling point than the liquid.

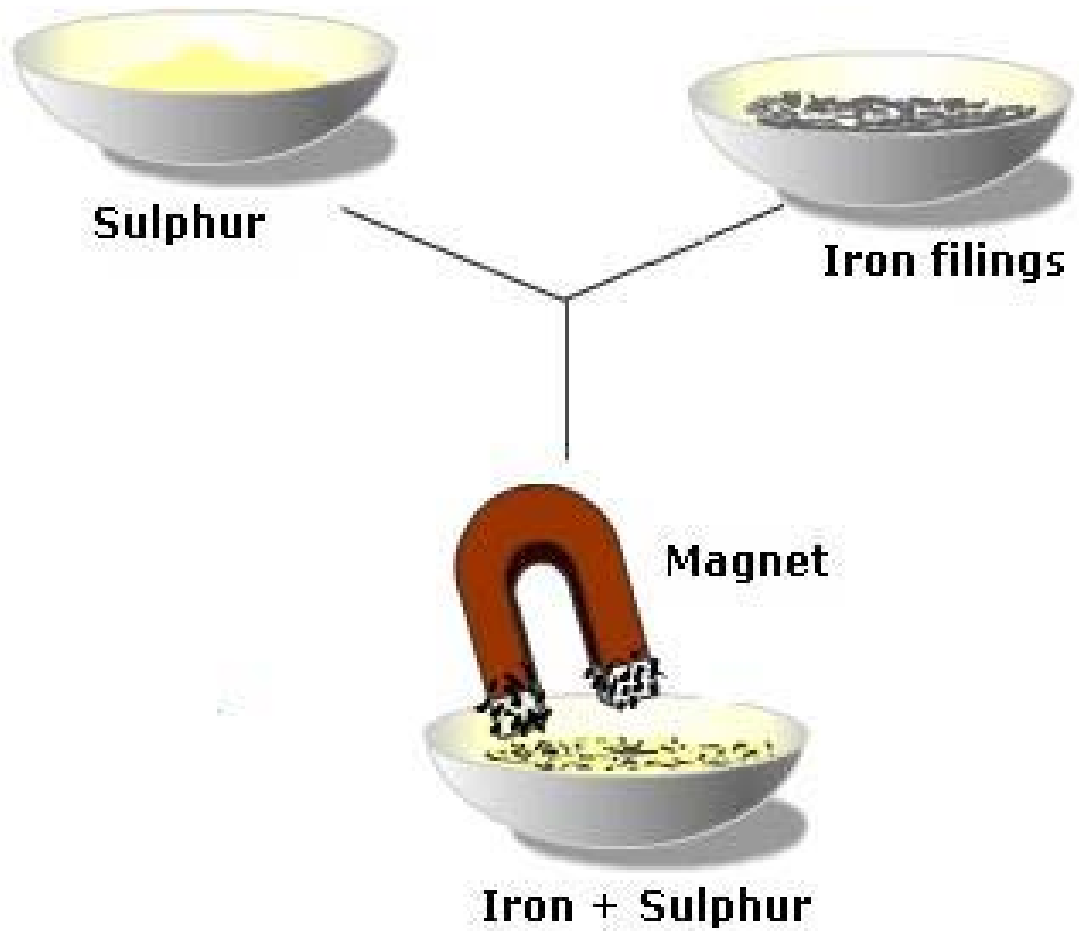
12b

Mixtures can be easily separated physically using methods such as: Filtering



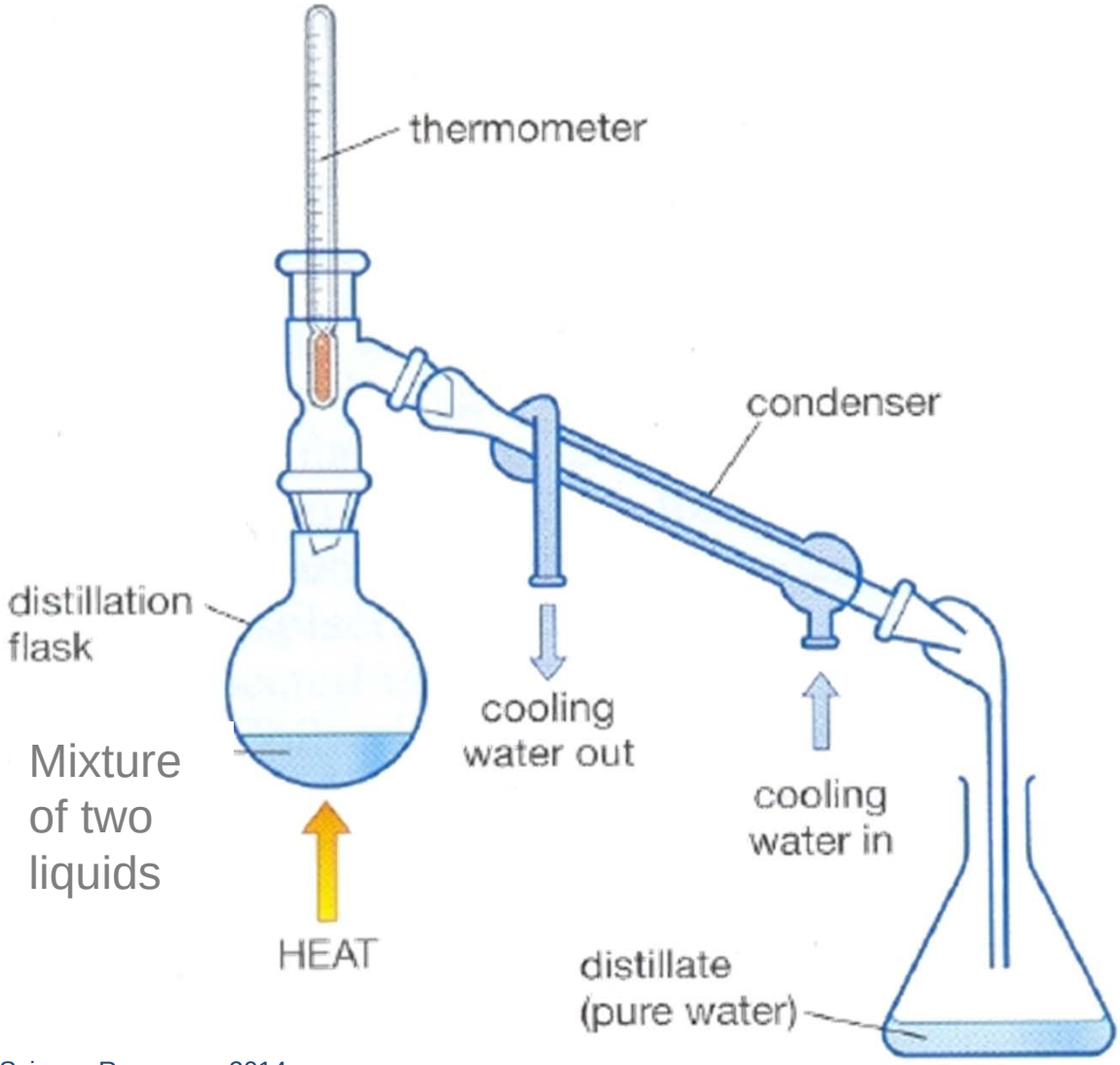
Filtering separates an insoluble solid in a mixture from the liquid completely.
The solvent molecules (liquid) and any dissolved molecules present in the solution can pass through the filter paper, which has small holes, while the solid particles cannot because they are to large and stay in the filter paper.
The solvent or solution containing dissolved substances passes through the filter paper, is called **filtrate**. The solid particles that remain on the filter paper is called the **residue**.

12b Mixtures can be easily separated physically using methods such as: Magnetism



Magnetism can be used to separate a magnetic substance (such as iron) from a mixture containing non- magnetic substances.
The magnetic substance of the mixture is separated with the help of the magnetic attraction.
A magnet is moved over the mixture containing the magnetic substance e.g., iron filings. These get attracted to the magnet. The process is repeated until the magnetic material is completely separated from the mixture. The non-magnetic substance is left behind.

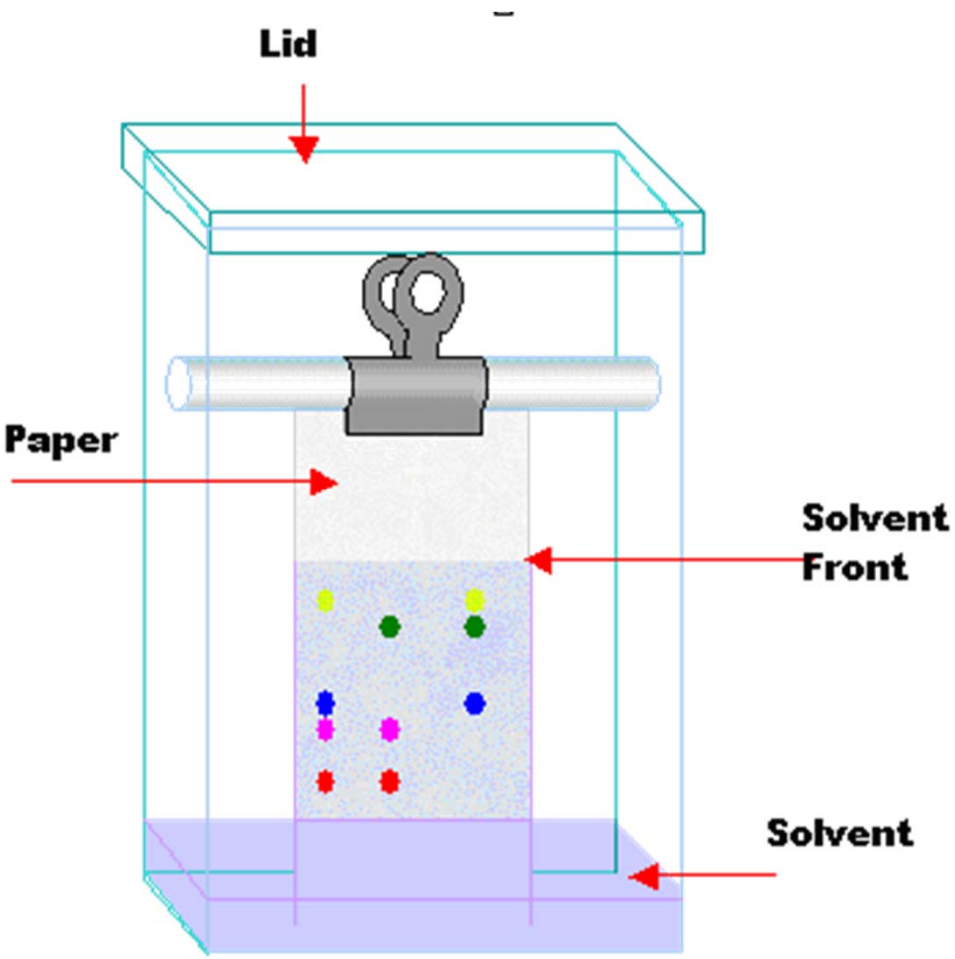
12b Mixtures can be easily separated physically using methods such as: Distillation



Distillation is a process of boiling a liquid and condensing and collecting the vapour. The liquid collected is the **distillate**. The Liebig condenser cools the vapour back into liquid. The purpose of distillation is separation of the of a mixture of two liquids. This is possible if the two substances have different boiling points and one substance turns to gas and collected while the other substance remains as a liquid.

12b Mixtures can be easily separated physically using methods such as: Chromatography

Chromatography is a technique used to separate the various substances in a complex **mixture of dye or ink**. Substances of the mixture will differ in how much they "stick" to things: to each other, and to other substances. Some of the substances of the ink will stick more tightly to the paper fibers. They will spend less time in the water as it moves along the paper fibers, and they will not travel very far. Other components of the ink will stick less tightly to the paper fibers. They will spend more time in the water as it moves along the paper fibers, and thus they will travel further through the paper.



12b

Mixtures can be easily separated physically

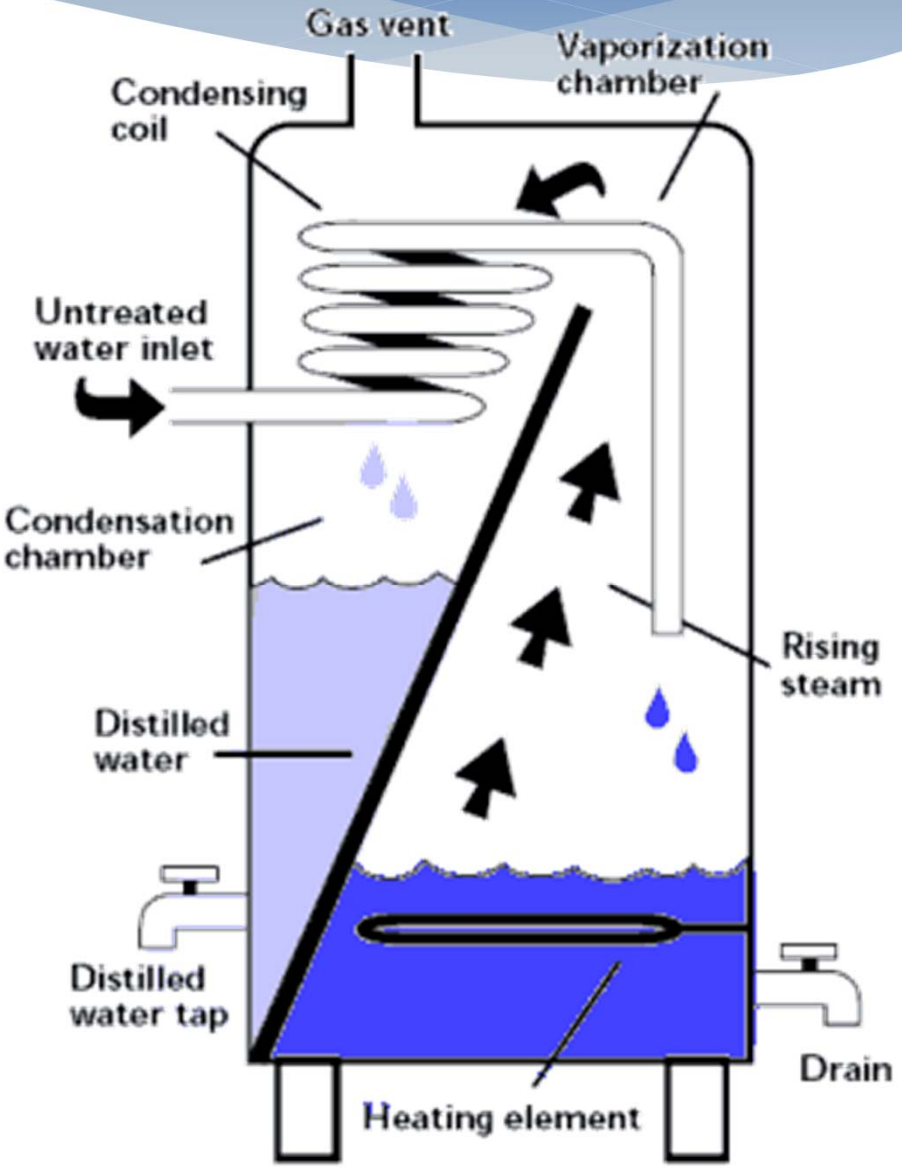
Separation technique	Property used for separation	example
Magnetic Attraction	magnestism	magnetic iron can be separated from non-magnetic sulfur using a magnet
Decanting	density or solubility	liquid water can be poured off (decanted) insoluble sand sediment less dense oil can be poured off (decanted) more dense water
Filtration	solubility	insoluble calcium carbonate can be separated from soluble sodium chloride in water by filtration
Evaporation	solubility and boiling point	soluble sodium chloride can be separated from water by evaporation
Crystallization	solubility	slightly soluble copper sulfate can be separated from water by crystallization
Distillation	boiling point	ethanol (ethyl alcohol) can be separated from water by distillation because ethanol has a lower boiling point than water

12C

Mixtures can be easily separated physically using methods such as: Crystallising

Crystallising is used to separate a solid compound in pure and crystal form. A nearly saturated solution of an impure substance is prepared in a hot solvent. The prepared solution is quickly filtered and the filtrate is then allowed to cool slowly in an evaporating dish. Once all the solvent (often water) is evaporated pure crystals will form.

12d Separation processes can create substances that are useful for us

In areas that have a limited amount of fresh water but access to salty sea water a purification machine (as shown to the right) can be used to separate out the salt and other substances from the pure water that can then be drunk.

If we require the salt instead of the water we use the same starting solution of salt water. This time we evaporate off the water in large holding ponds and collect the salt deposits that remain.