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GCSE Chemistry

AQA Topic – Atomic structure and the periodic table

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Overview

Atomic structure and the periodic table

Atoms, elements, compounds and mixtures

- Atoms, elements and compounds
- Word and symbol equations
- Separation techniques

Atomic model

- History of the atomic model
- Size and mass of atoms
- Atomic structure

Periodic table

- History of the periodic table
- Group 0, group 1 and group 7
- *Transition metals (chemistry only)*

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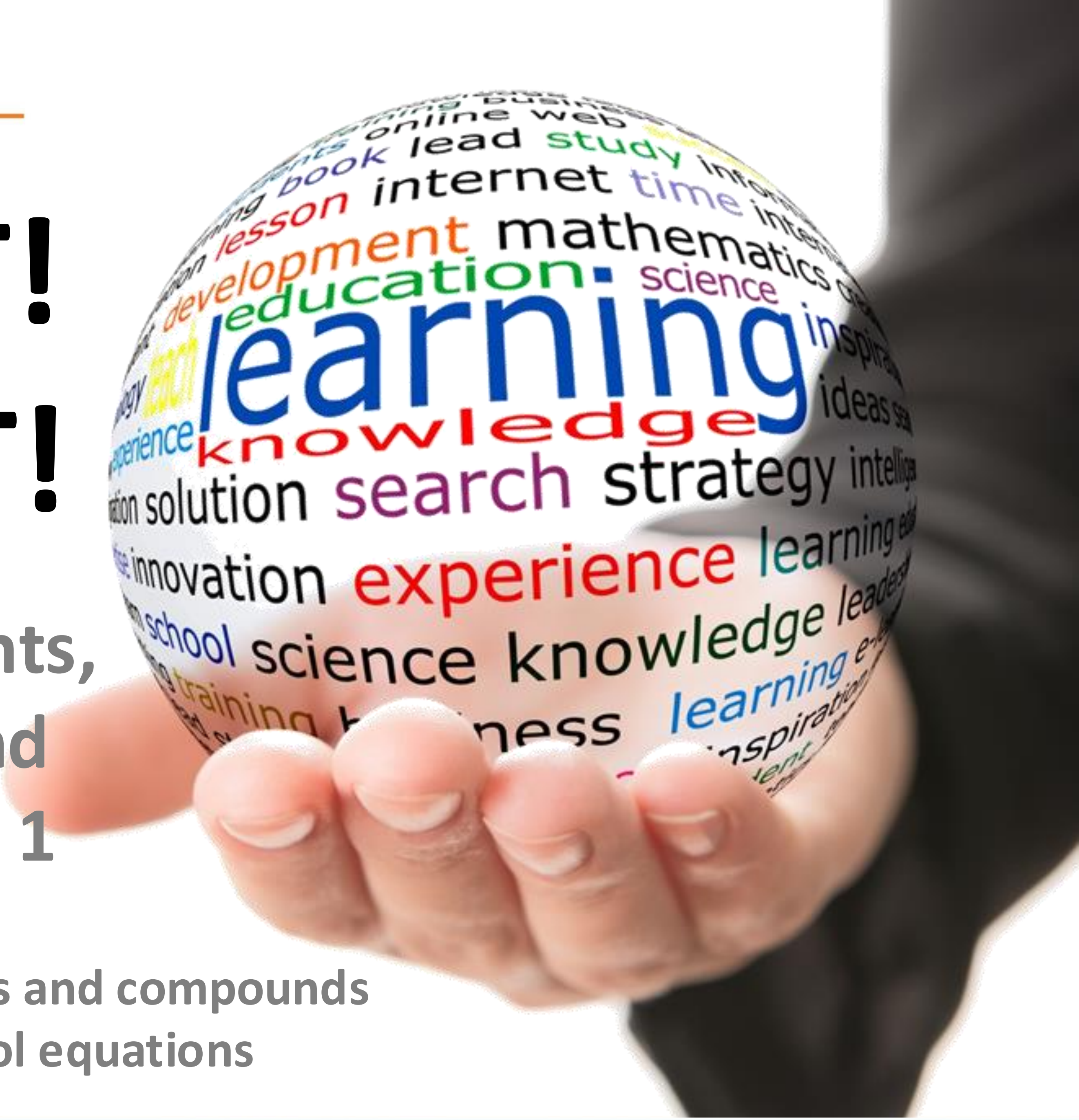
Atoms, elements, compounds and mixtures PART 1



- Atoms, elements and compounds
- Word and symbol equations

Atoms, elements, compounds and mixtures - PART 1

All substances are made of **atoms** that cannot be chemically broken down. It is the smallest part of an **element**.

Elements are made of only one type of atom. Each element has its own **symbol.**
e.g. Na is sodium.

There are about 100 different elements

Key
relative atomic mass
atomic symbol
name
atomic (proton) number

1	2											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
85 **Rb** rubidium 37	88 **Sr** strontium 38	89 **Y** yttrium 39	91 **Zr** zirconium 40	93 **Nb** niobium 41	96 **Mo** molybdenum 42	[98] **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	178 **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	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac*** actinium 89	[261] **Rf** rutherfordium 104	[262] **Db** dubnium 105	[266] **Sg** seaborgium 106	[264] **Bh** bohrium 107	[277] **Hs** hassium 108	[268] **Mt** meitnerium 109	[271] **Ds** darmstadtium 110	[272] **Rg** roentgenium 111	Elements with atomic numbers 112-116 have been reported but not fully authenticated						

Compounds contain more than one type of atom. They are formed from elements by **chemical reactions**, which always involve the formation of one or more new substance, often involving an **energy change**.

The components of a compound **cannot** be **separated** by **physical** means. They can be separated only by **chemical** means.

You need to:

- **Know the names and symbols for the first 20 elements and all of group 1, 7 and 0**
- **Name compounds when given the formulae or symbol equations**

magnesium ← $MgCl_2$ → chlorine

Magnesium chloride

Atoms, elements, compounds and mixtures - PART 1

Compounds contain **two or more** elements **chemically** combined in **fixed proportions** and can be represented by formulae using the symbols of atoms from which they formed.

Naming a compound with **two elements** (usually a metal and a non metal) apply these rules:

- The metal name does not change
- The non-metal's name ends in **ide**

For example:

Na_2S = sodium sulf**ide**

K_2O = potassium ox**ide**

When a compound contains a transition metal, the names become a bit more complicated. To distinguish them, Roman numerals indicate the charge on the metal ion
e.g. iron(II) chloride.

Naming a compound with a metal that reacts with ions that consist of **two or more** non-metal atoms covalently bonded together apply these rules:

- The metal name does not change
- The non-metal's name ends in **ate** if oxygen is present

For example: Na_2CO_3 = sodium carbon**ate**

KNO_3 = potassium nitr**ate**

Atoms, elements, compounds and mixtures - PART 1

Chemical equations: Show the **reactants** (what we start with) and the **products** (what we end with).
No **atoms** are **lost** or **made**. The **mass** of the **products** equals the **mass** of the **reactants**.

You need to:

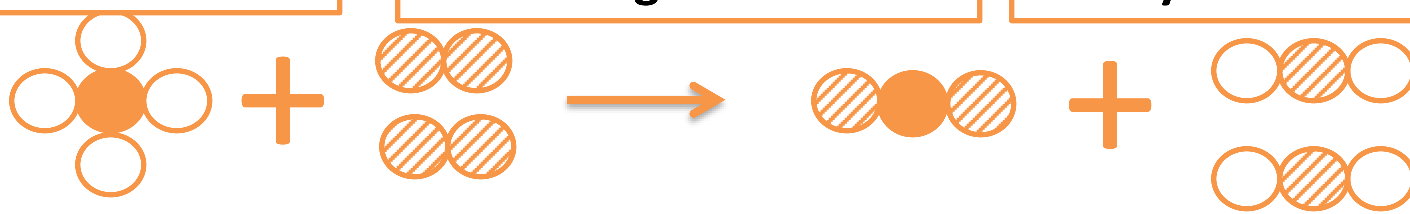
- **Write word equations**
- **Balanced symbol equations**

Word equation:	**methane + oxygen → carbon dioxide + water**	
Symbol equation:	$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$	

There are 4 hydrogens here, bonded together.

There are 2 molecules of oxygen not bonded together.

There are 4 hydrogens here. You multiply the big number by the little number.



Equations MUST balance

- **We can ONLY add BIG numbers to the front of a substance**
- **We can tell elements within a compound by BIG letters**
- **We can check an equation is balanced by counting the number of each type of atom on either side**

Atoms, elements, compounds and mixtures - PART 1

We can add **state symbols** to a symbol equation to show whether the reactants and products in a chemical reaction are solids, gases, liquids or dissolved in water.

Solid = s
Liquid = l
Gas = g
Aqueous (dissolved in water) = aq

Word equation: **sodium + water → sodium hydroxide + hydrogen**

Symbol equation: $2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$

The reaction between copper sulfate and sodium hydroxide is:

copper sulfate + sodium hydroxide → sodium sulfate + copper hydroxide

$$CuSO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + Cu(OH)_2(s)$$

You can tell that the copper hydroxide forms a solid (the precipitate) because its state symbol is (s) for solid, rather than (aq) for aqueous (dissolved in water).

HT only – write balanced half equations and ionic equations

The reaction can also be shown by an **ionic equation**:

$$Cu^{2+}(aq) + 2OH^{-}(aq) \rightarrow Cu(OH)_2(s)$$

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QuestionIT!

Atoms, elements, compounds and mixtures PART 1

- Atoms, elements and compounds
- Word and symbol equations

Atoms, elements, compounds and mixtures PART 1 – QuestionIT

1. Around how many different types of element are there in the periodic table?

2. What does it mean if a compound ends in –ide?

3. What does it mean if a compound ends in –ate?

4. What does a chemical reaction involve?

5. Name the following substances:
   - $NaCl$
   - $NaSO_4$

6. Why is it useful to have symbols for atoms of different elements?

7. What is the difference between an element and a compound?

8. Explain why it is difficult to separate a compound, compared to an element.

9. Solid sodium reacts with water to form a sodium hydroxide ($NaOH$) solution and hydrogen gas.

    a) Write a word equation to represent this reaction.

    b) Give the balance symbol equation for the reaction.

HT only:

10. When magnesium reacts with sulfuric acid, the hydrogen ions in the acid will be displaced from the solution by magnesium.

    Balance the following ionic equation.

$$Mg(s) \quad + \quad H^{+}(aq) \quad \rightarrow \quad Mg^{2+}(aq) \quad + \quad H_2(g)$$

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AnswerIT!

Atoms, elements, compounds and mixtures
PART 1

- Atoms, elements and compounds
- Word and symbol equations

Atoms, elements, compounds and mixtures PART 1 – QuestionIT

1. Around how many different types of elements are there in the periodic table?
   1000
2. What does it mean if a compound ends in –ide?
   Contains 2 elements; usually metal and non-metal.
3. What does it mean if a compound ends in –ate?
   Contains 3 or more elements, 1 of which is always oxygen.
4. What does a chemical reaction involve?
   The formation of one or more new substances; usually with an energy change.
5. Name the following substances:
   - $NaCl$ **Sodium chloride.**
   - $NaSO_4$ **Sodium sulfate.**

6. Why is it useful to have symbols for atoms of different elements?

When elements join together to form a compound, it tells you how many atoms there are.

7. What is the difference between an element and a compound?

Elements contain one type of atom and compounds contain more than one type.

8. Why is it difficult to separate a compound?

A compounds elements are chemically joined together.

9. Solid sodium reacts with water to form a sodium hydroxide solution and hydrogen gas.

   a) Write a word equation to represent this reaction.

   Sodium + water → sodium hydroxide + hydrogen

   b) Give the balance symbol equation for the reaction.

   $2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$

HT only:

10. When magnesium reacts with sulfuric acid, the hydrogen ions in the acid will be displaced from the solution by magnesium. Balance the following ionic equation.

$$Mg(s) \quad + \quad 2H^{+}(aq) \quad \rightarrow \quad Mg^{2+}(aq) \quad + \quad H_2(g)$$

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Atoms, elements, compounds and mixtures PART 2

- Mixtures

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Atoms, elements, compounds and mixtures - PART 2

A mixture consists of **two or more** elements or compounds **not** chemically combined together. The chemical properties of each substance in the mixture are **unchanged**.

Solvent	the liquid in which a solute dissolves
Solute	the substance that dissolves in a liquid to form a solution
Solution	is the mixture formed when a solute has dissolved in a solvent
Soluble	describes a substance that will dissolve
Insoluble	describes a substance that will not dissolve

<u>FILTRATION</u>: This technique separates substances that are insoluble in a solvent from those that are soluble

Mixtures can be separated by **physical processes** including:

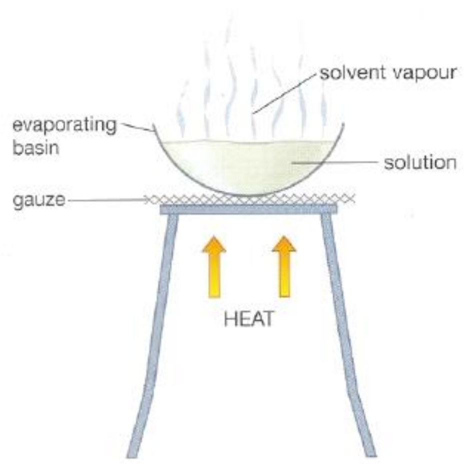
1. Filtration
2. Crystallisation
3. Simple distillation
4. Fractional distillation
5. Chromatography

These physical processes do not involve chemical reactions and no new substances are made.

Atoms, elements, compounds and mixtures - PART 2

Crystallisation

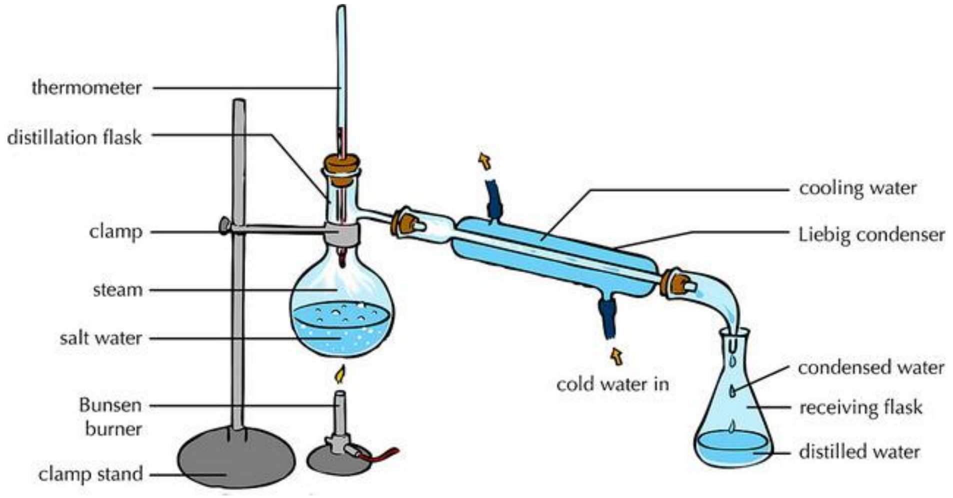
This technique separates a soluble substance from a solvent by evaporation



Example - crystallisation of sodium chloride from salt solution

Simple distillation

This technique separates a liquid from a mixture by evaporation follow by condensation

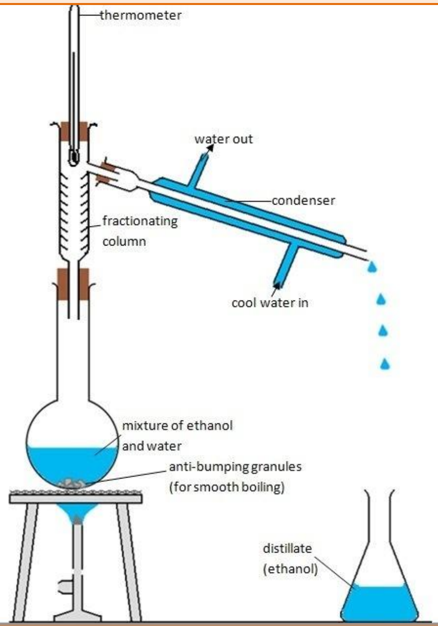


Example - obtaining water from sea water

Atoms, elements, compounds and mixtures - PART 2

Fractional distillation

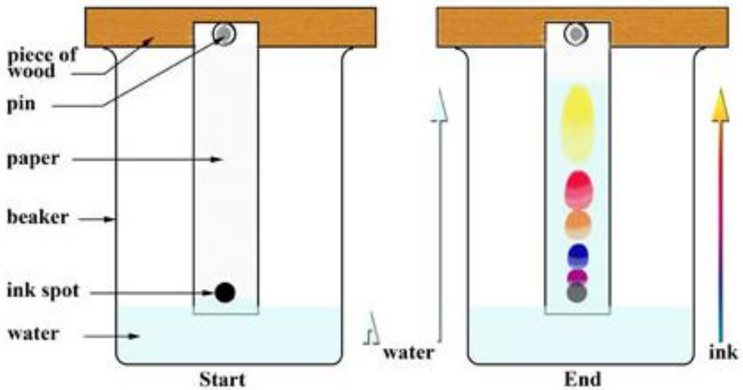
This technique separates a mixture into a number of different parts, called **fractions**. Substances with **high** boiling points **condense at the bottom** and substances with **low** boiling points **condense at the top**.
Fractional distillation works because the different substances in the mixture have different boiling points.



Example - obtaining ethanol from a mixture of ethanol and water

Chromatography

This technique separates small amounts of dissolved substances by running a solvent along absorbent paper



Example - separating the different colours in ink partners in excellence

QuestionIT!

Atoms, elements, compounds and mixtures PART 2

- Mixtures

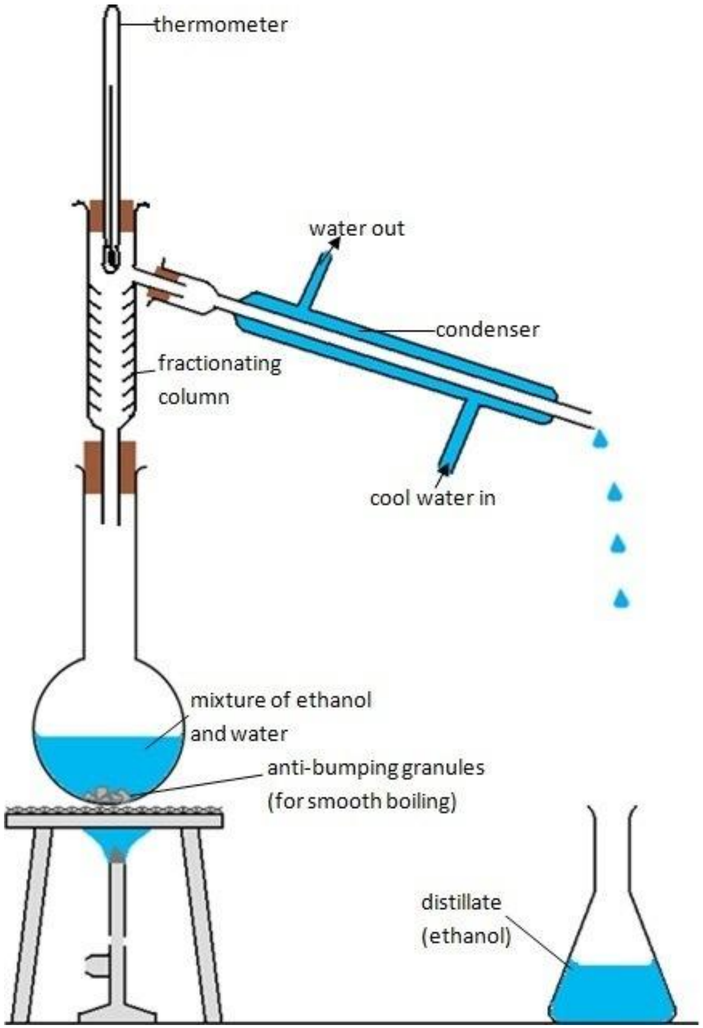
Atoms, elements, compounds and mixtures PART 2 – QuestionIT

1. What is the difference between a compound and a mixture?

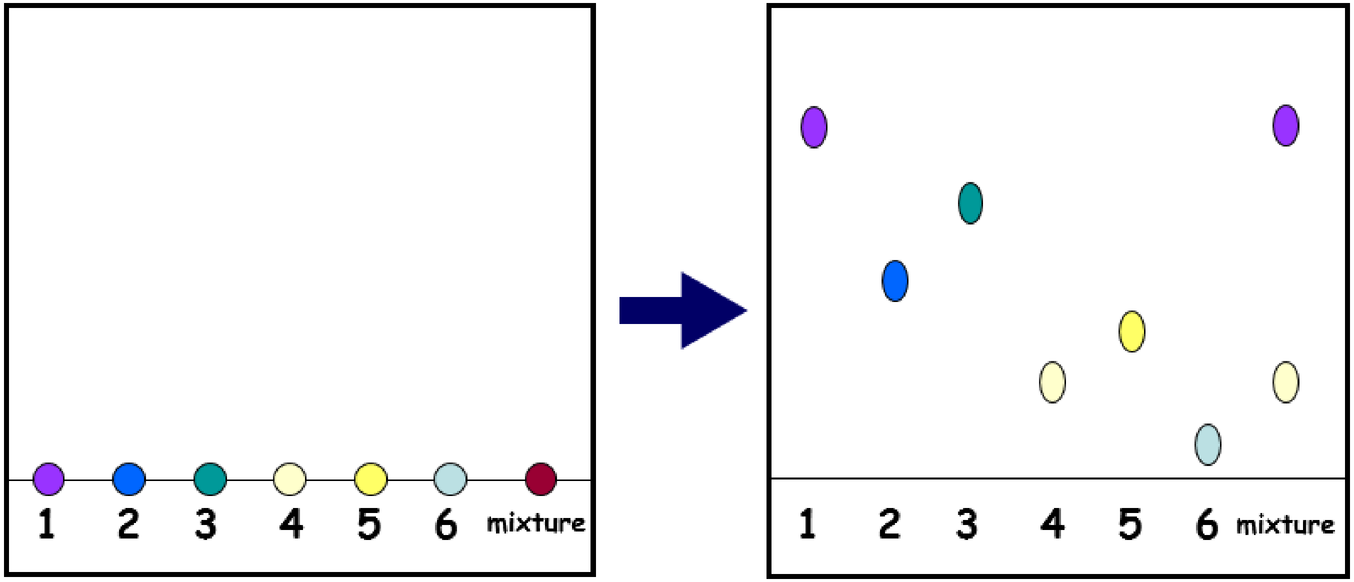
2. Describe the method used to collect the salt from a mixture of sand and salt.

3. What process is used to purify seawater to obtain usable water?

4. Describe how the following equipment is used to separate water and ethanol.



5. A mixture and six colours are tested using chromatography. The following chromatogram was produced.



a) What can you conclude about the mixture?

b) Why do the inks separate?

AnswerIT!

Atoms, elements, compounds and mixtures
PART 2

- Mixtures

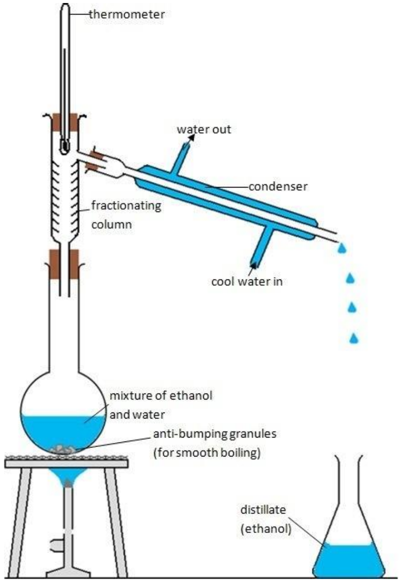
Atoms, elements, compounds and mixtures PART 2 – QuestionIT

1. What is the difference between a compound and a mixture?
   The substances in a mixture are not chemically bonded together, but they are in a compound.

2. Describe the method used to collect the salt from a mixture of sand and salt.
   Add water and stir to dissolve the salt. Use filtration to remove the sand. Heat the water (gently) to allow the salt to crystallise (to avoid dryness).

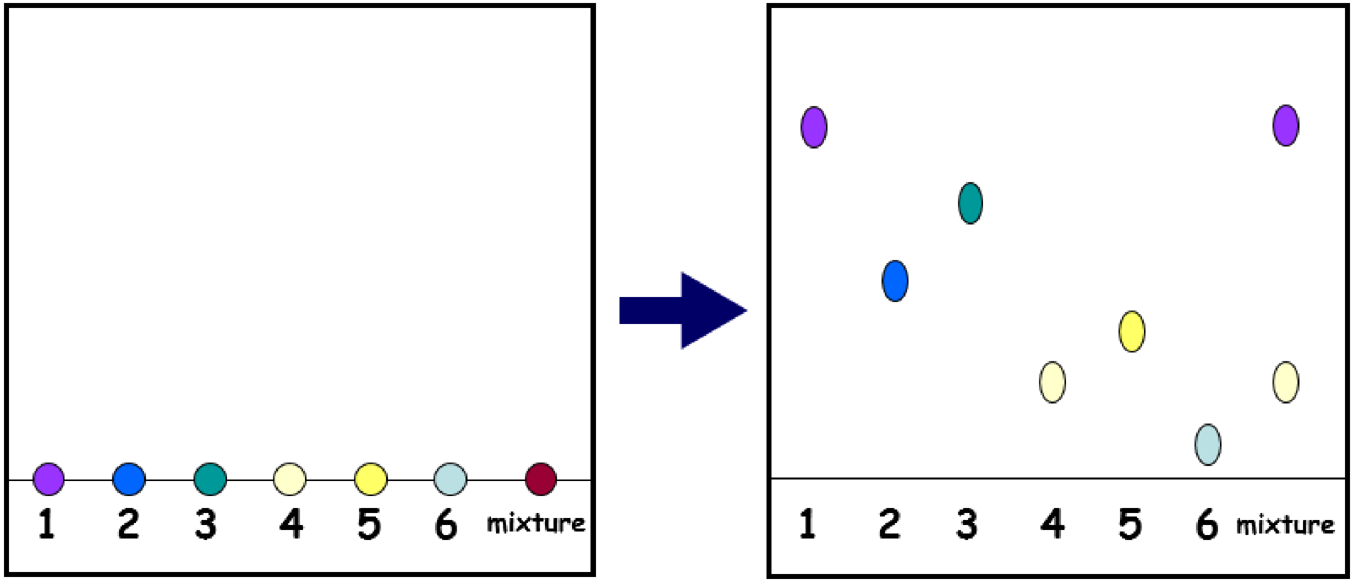
3. What process is used to purify seawater to obtain usable water?
   Simple distillation.

4. Describe how the following equipment is used to separate water and ethanol.



The ethanol and water mixture are heated. Ethanol has a boiling point of 78°C and will vaporise first. The gas passes over the fractionating column and into the condenser. Here it will condense, turning back into it's liquid state.

5. A mixture and six colours are tested using chromatography. The following chromatogram was produced:



a) What can you conclude about the mixture?

The mixture is made up from substance 1 and 4.

b) Why do the inks separate to produce a chromatogram?

The separation depends on how soluble the chemical is in the solvent and how strongly the chemical is attracted to the paper.

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Atomic model PART 1

- Development of the atomic model

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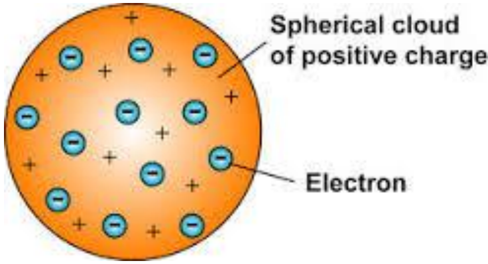
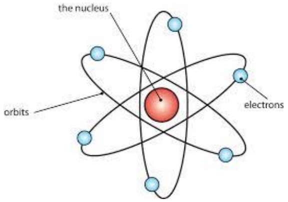
Atomic model - PART 1

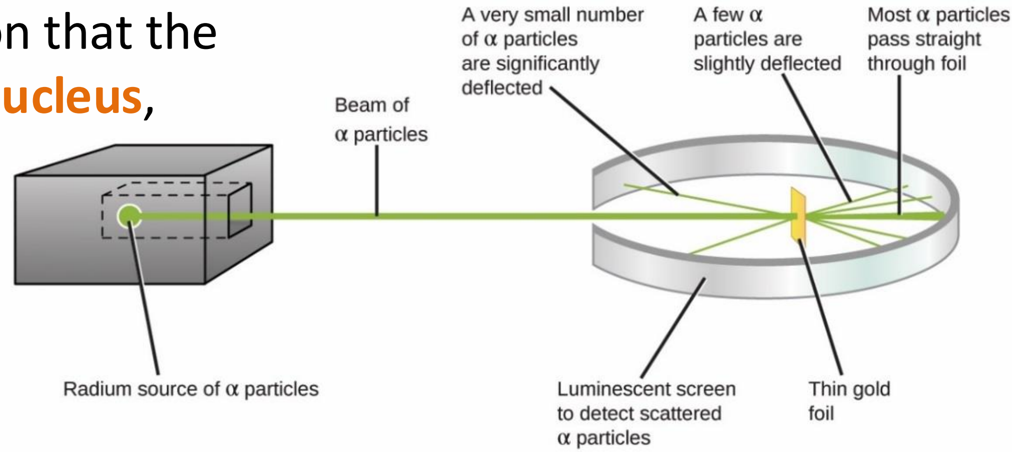
Early 1800s
Before the discovery of electrons, John Dalton's experiments led to the idea that atoms were **tiny spheres** that could **not** be **divided**.

End of 1800s
The electron was discovered by **JJ Thomson**. Scientists believed that atoms were **spheres** of **positive charge** with **negative charges spread** throughout - the **'plum-pudding' model**.



1908-1913
Ernst Rutherford designed an experiment carried out by **Geiger** and **Marsden.** **They** fired **alpha** particles at a piece of very thin **gold foil** (only a few atoms thick) which **scattered**, leading to the conclusion that the mass of an atom was concentrated in a **nucleus**, which was charged.
It proposed that **electrons orbited** around the nucleus.

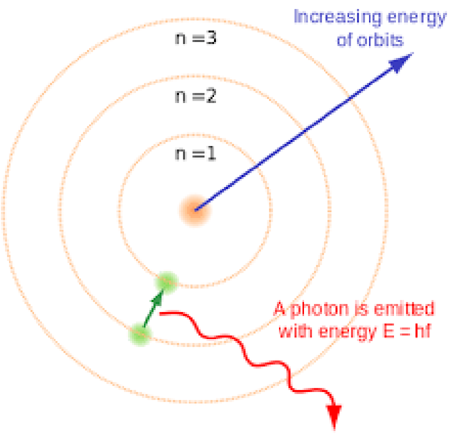




Atomic model - PART 1

1914

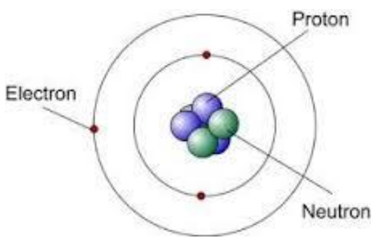
Niels Bohr noticed that the **light** given out when atoms were **heated** only had **specific** amounts of **energy** and he adapted the nuclear model by suggesting that electrons **orbit** the nucleus at **specific distances** in certain **fixed energy levels** (or shells). The energy must be given out when excited electrons **fall** from a **high** to **low** energy level.



Later experiments led to the idea that the **positive charge** of the nucleus could be **subdivided** into a **whole number** of **smaller particles**, each particle having the **same** amount of **positive** charge. The name **proton** was given to these particles.

1932

James Chadwick bombarded **beryllium** atoms with **alpha** particles. An unknown radiation was produced. Chadwick interpreted this radiation as being composed of particles with a **neutral electrical charge** and the approximate **mass of a proton**. This particle became known as the **neutron**.



Atomic model - PART 1

1800s

- John Dalton – **tiny spheres that could not be divided**.

1890s

- JJ Thomson – **electron** discovered. **Plum pudding model** - spheres of positive charge with negative charges spread evenly though.

1908 -1913

- E. Rutherford, Geiger and Marsden - **alpha particle scattering experiment**. Nuclear model - mass of atom concentrated in a **charged nucleus,** with **orbiting electrons**.

1914

- **Niels Bohr** – **electrons orbit nucleus at specific distances in fixed energy levels** (shells). Energy given out when electrons change level.

Later…

- Positive charge of nucleus could be subdivided into particles of positive charge – **protons**.

1932

- **James Chadwick** – provided evidence for the existence of **neutrons** within the nucleus.

QuestionIT!

Atomic model
PART 1

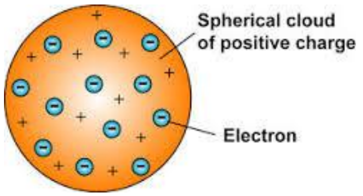
- **Development of the atomic model**

Atomic model PART 1 – QuestionIT

1. What was the earliest model of the atom?

2. Which subatomic particle did JJ. Thomson discover?

3. Which early atomic model does the following diagram show?



4. Name Rutherford's experiment.

5. State two ways in which Rutherford's experiment changed Thomson's model of the atom.

6. How did Bohr adapt the nuclear model?

7. Explain why Bohr revised Rutherford's model of the atom.

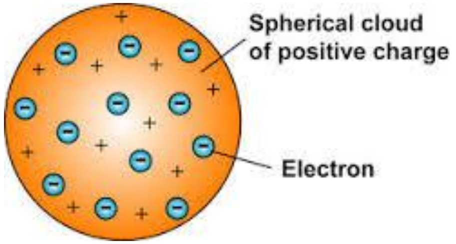
AnswerIT!

Atomic model
PART 1

- Development of the atomic model

1. What was the earliest model of the atom?
   Tiny spheres that could not be divided.
2. Which subatomic particle did JJ. Thomson discover?
   The electron

3. Which early atomic model does the following diagram show?
   The plum pudding model.



4. Name Rutherford's experiment.
   Alpha particle scattering.
5. State two ways in which Rutherford's experiment changed Thomson's model of the atom.
   He said the positive charge was concentrated into very small volume at centre of atom (nucleus) and the electrons orbit nucleus.

6. Explain why Bohr revised Rutherford’s model of the atom.
   Suggesting electrons orbit the nucleus at different distances.

7. Explain why Bohr revised Rutherford’s model of the atom.
   Energy emitted from electron transitions can only have certain fixed energies, so he refined the ‘orbiting electrons’ in Rutherford’s nuclear model to ‘orbiting electrons in energy levels (or shells) at fixed distances from the nucleus’.

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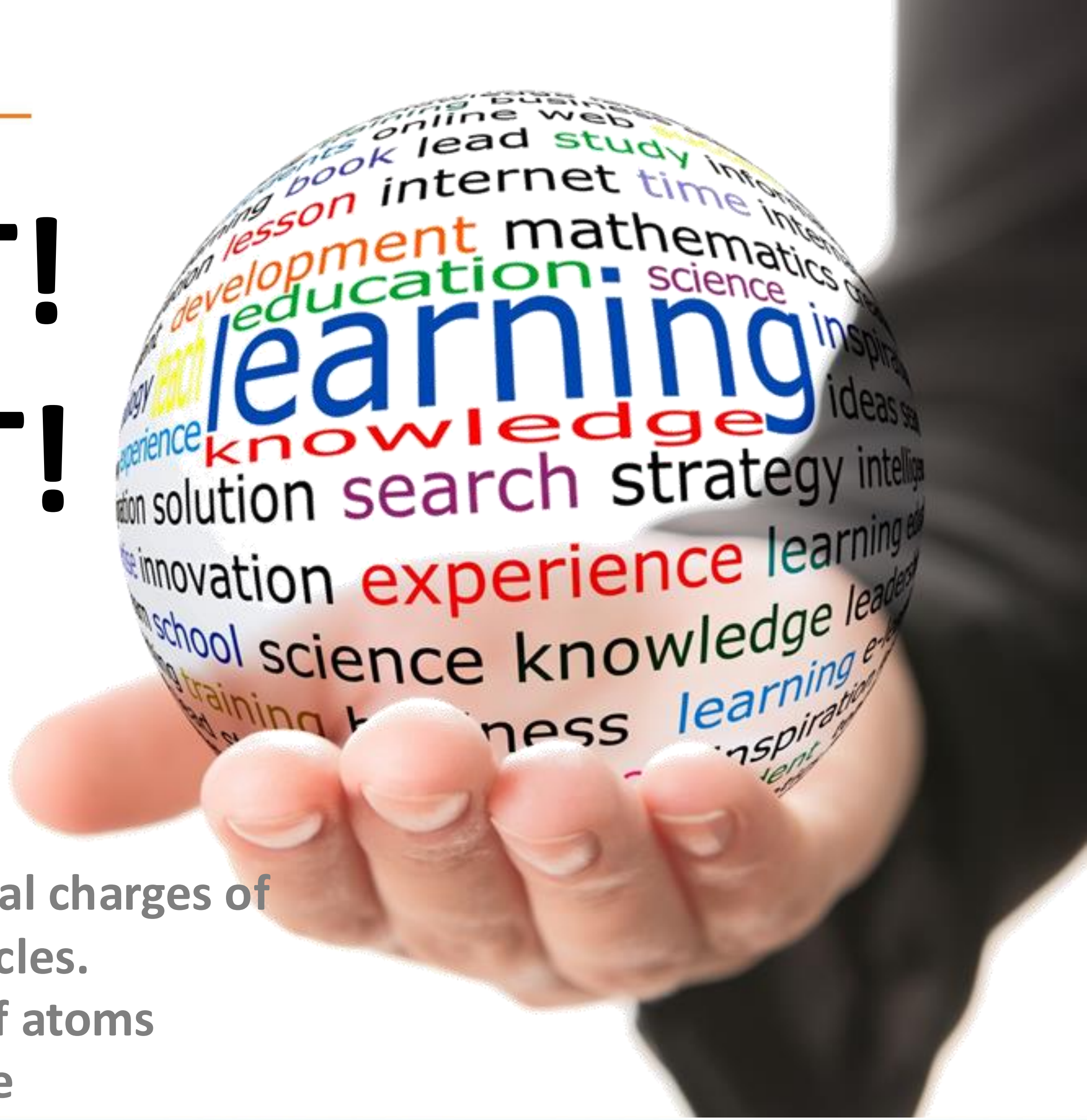
Atomic model PART 2



- Relative electrical charges of subatomic particles.
- Size and mass of atoms
- Atomic structure

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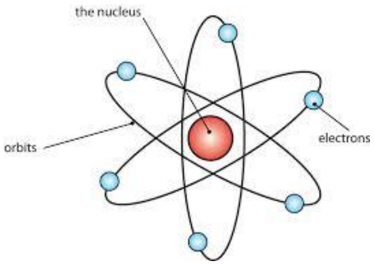
Atomic model - PART 2

Subatomic particles



	Mass	Charge	Location
Proton	1	+	nucleus
Neutron	1	0	nucleus
Electron	Very small	-	shells

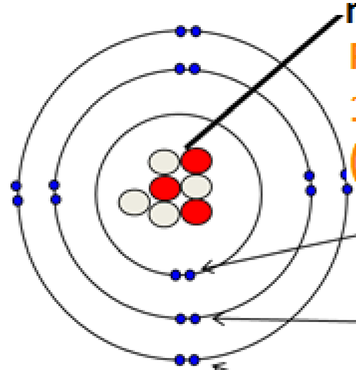
- An atom contains **equal** numbers of **protons** and **electrons**.
- Atoms have **no** overall electrical charge because the number of positive protons equals the number of negative electrons.

Number of protons = atomic number.

- All atoms of an element have the **same** number of **protons**.
- Atoms of **different** elements have **different numbers** of **protons**.

Atomic model - PART 2

Atoms are very small, having a radius of about **0.1nm** (1×10^{-10}m).
Protons and Neutrons are found in the **nucleus**. Electrons orbit the nucleus in **shells**.



Nucleus - almost all of the mass of an atom is here

Radius of a nucleus is less than 1/10 000 of that of an atom (about 1×10^{-14}m)

The first shell (energy level) can hold 2 electrons

The second can hold 8 electrons

The third can hold 8 electrons

Mass number = Number of **protons** and **neutrons**

Atomic number = Number of protons

$^{7}_{3}\mathrm{Li}$

Protons = 3
Electrons = 3
Neutrons = 4

To calculate the number of neutrons = Mass Number – Atomic Number

Atomic model - PART 2

Atoms sometimes **lose or gain** electrons (e.g. when a metal reacts with a none metal). When they do this they become a charge atom or an **ion**.

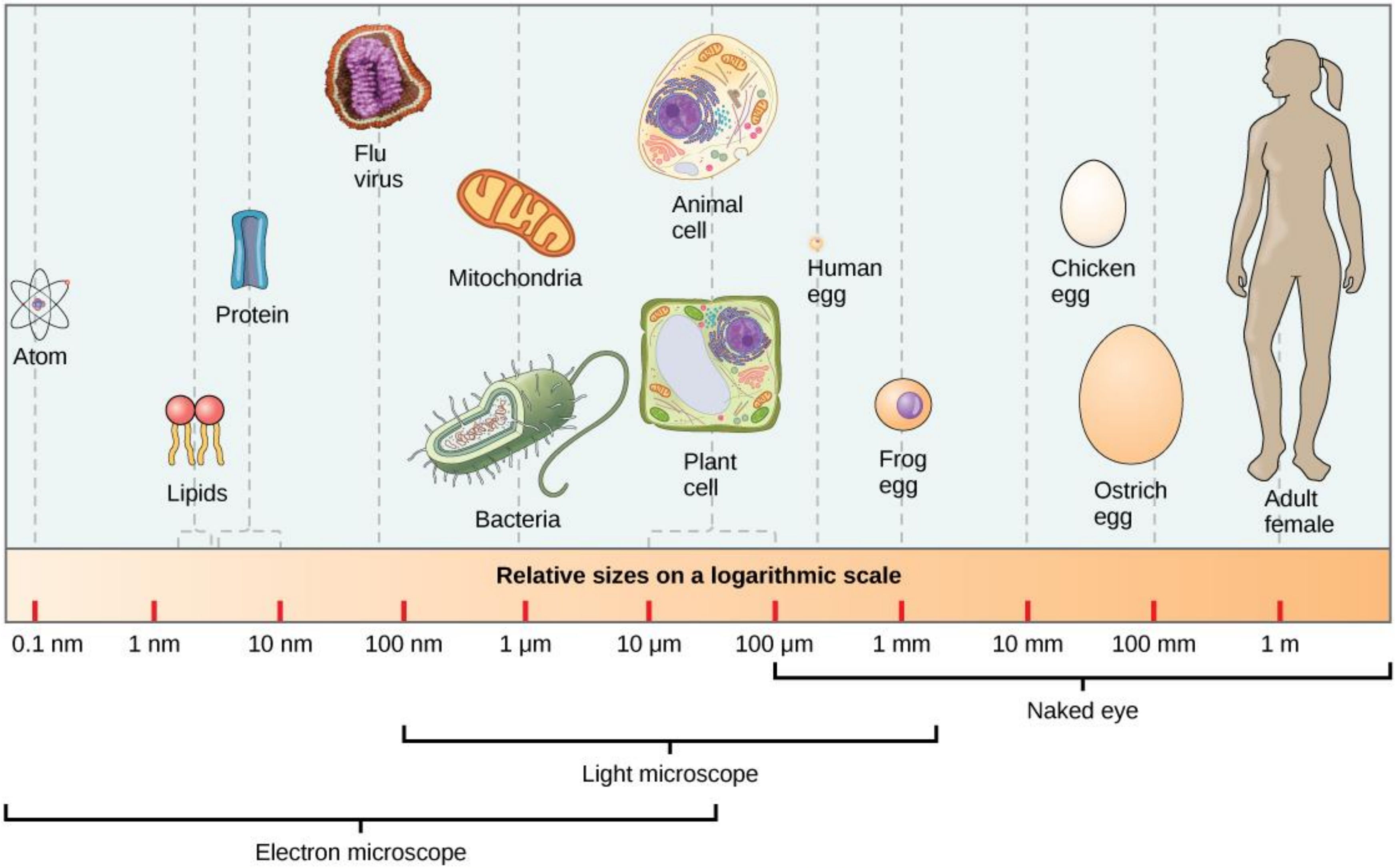
If an atom loses one or more electrons, it gains a **positive** charge because it has less electrons than protons.

e.g. If sodium atom loses one electron, it forms a **Na^{+} ion**.
It has 11 protons, 12 neutrons and 10 electrons.

If an atom gains one or more electrons, it gains a **negative** charge because it has more electrons than protons.

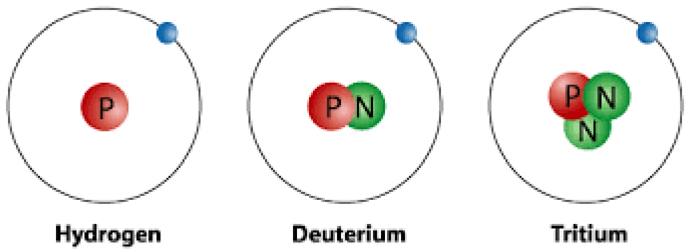
e.g. If an oxygen atom gains two electrons, it forms a **O^{2-} ion**.
It has 8 protons, 8 neutrons and 10 electrons.

Atoms are tiny - the radius of a typical atom is **one tenth** of a billionth of a meter.



Atomic model - PART 2

Atoms of the **same element** can have **different numbers** of **neutrons** – an **isotope**.



Isotopes of Hydrogen

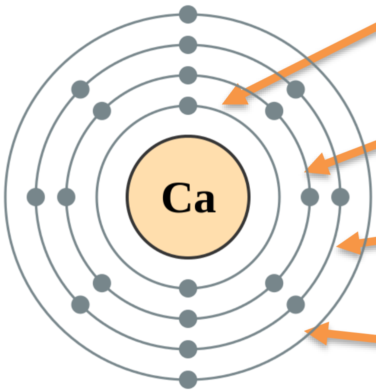
The **relative atomic mass** of an element is an **average** value that takes account of the **abundance** of the isotopes of the element. Samples of **different** isotopes of an element have different **physical properties** (e.g. different density), however, they always have the **same chemical properties**. It is calculated by working out the relative **abundance** of each isotope.

The relative atomic mass is therefore calculated using the equation:
(% of isotope 1 × mass of isotope 1) + (% of isotope 2 × mass of isotope 2) ÷ 100

Chlorine's relative atomic mass of 35.5 is an average of the masses of the different isotopes of chlorine.
For example, in any sample of Chlorine 25% will be ^{37}Cl and 75% ^{35}Cl.
(25 x 37) + (75 x 35) ÷ 100 = 35.5

Atomic model - PART 2

The electrons in an atom occupy the lowest available **energy levels** (innermost available shells). The electronic structure of an atom can be represented by numbers or by a diagram e.g.



Calcium has 2 electrons on its lowest energy level,

8 on the second energy level,

8 on the third energy level

and 2 on the fourth (the highest) energy level.

So the electron configuration for Calcium = 2,8,8,2

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QuestionIT!

Atomic model
PART 2

- Relative electrical charges of subatomic particles.
- Size and mass of atoms
- Atomic structure

Atomic model PART 2 – QuestionIT

1. Name three subatomic particles and their charges.

2. Complete the sentence ‘All atoms of one type of element have the same number of…’

3. What does the atomic number tell us about an atom?

4. What does the mass number tell us about an atom?

5. How is an isotope different to an atom?

6. What is the electron configuration for sodium?

7. Why is the overall charge of an atom zero?

8. Draw the electron configuration for a chlorine atom.

9. Write the electron configuration for potassium.

10. How many electrons does potassium have on its highest energy level?

11. Calculate how many protons, electrons and neutrons there are in

a) A silver atom with atomic number 47 and mass number 108

b) $^{39}_{19}K^{+}$

12. The atomic radius of a bromine atom is 9×10^{-11}m

a) Give its atomic radius in nanometres

b) Calculate the radius of the nucleus (in nm), given that it will be about 1/10,000 the radius of the atom. Give your answer in standard form.

AnswerIT!

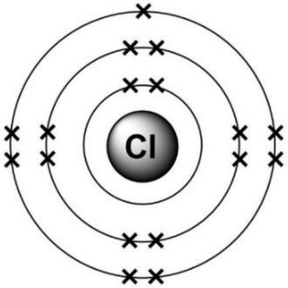
Atomic model
PART 2

- Relative electrical charges
  subatomic particles.
- Size and mass of atoms
- Atomic structure

Atomic model PART 2 – QuestionIT

1. Name three subatomic particles and their charges.
   Proton – positive; neutron – no charge; electron – negative.
2. Complete the sentence 'All atoms of one type of element have the same number of…'
   Protons.
3. What does the atomic number tell us about an atom?
   Number of protons.
4. What does the mass number tell us about an atom?
   Number of protons + number of neutrons.
5. How is an isotope different to an atom?
   Different number of neutrons.
6. What is the electron configuration for sodium?
   2,8,1

7. Why is the overall charge of an atom zero?
   Number of protons (positive) = number electrons (negative).
8. Draw the electron configuration for a chlorine atom.



9. Write the electron configuration for potassium.
   2,8,8,1
10. How many electrons does potassium have on its highest energy level?

    1

11. Calculate how many protons, electrons and neutrons there are in:

a) A silver atom with atomic number 47 and mass number 108

Protons = 47 Electrons = 47 Neutrons = 61

b) $^{39}_{19}K^{+}$

Protons = 19 Electrons = 18 Neutrons = 20

12. The atomic radius of a bromine atom is 9 x 10 $^{-11}$m

a) Give its atomic radius in nanometres.

0.09 nm

b) Calculate the radius of the nucleus (in nm), given that it will be about 1/10,000 the radius of the atom. Give your answer in standard form.

9×10^{-6}nm

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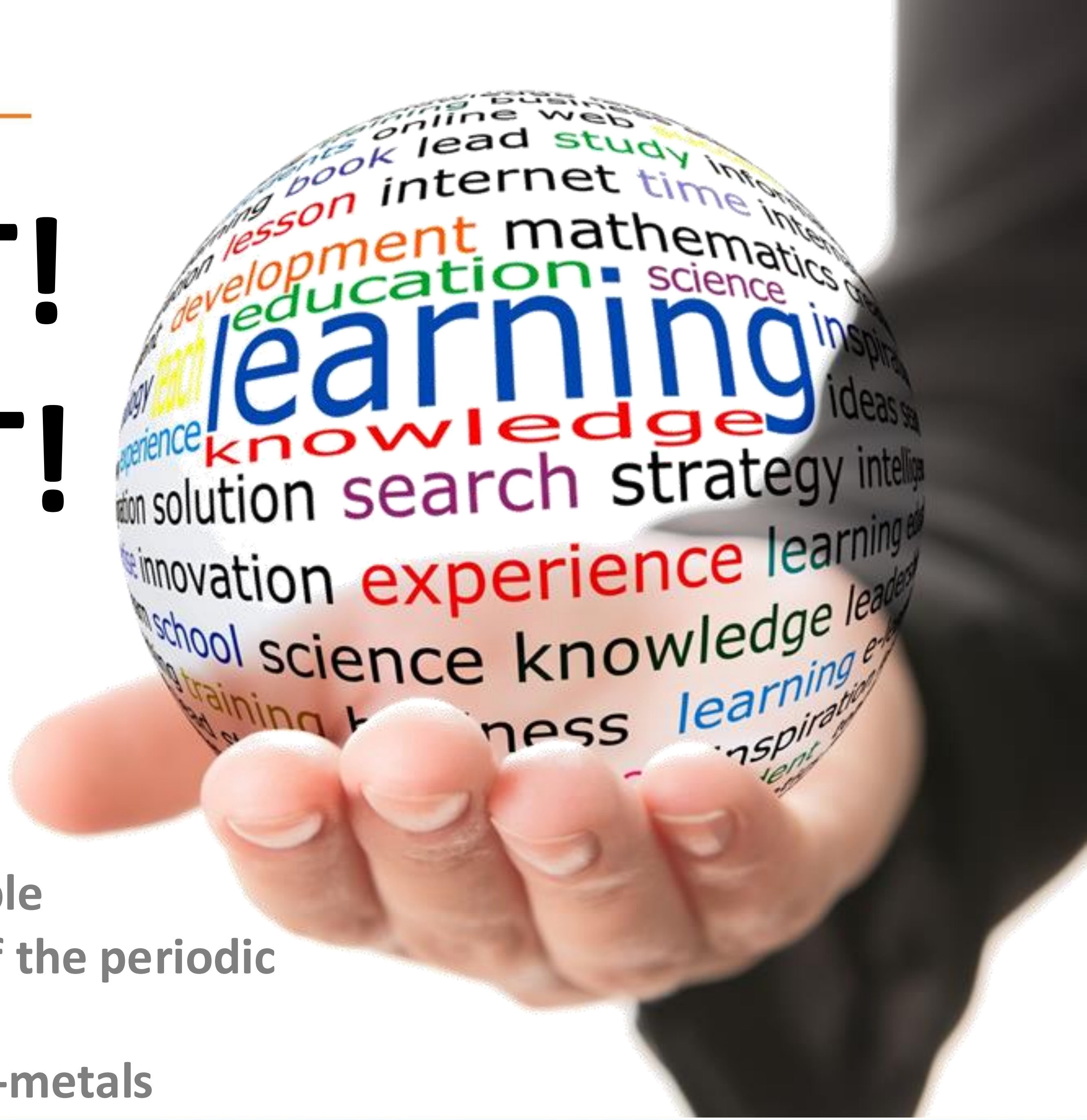
Periodic table
PART 1

- The periodic table
- Development of the periodic table
- Metals and non-metals



Periodic table - PART 1

The elements are arranged in order of increasing atomic number.

1	2											3	4	5	6	7	0
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	?	?	?						

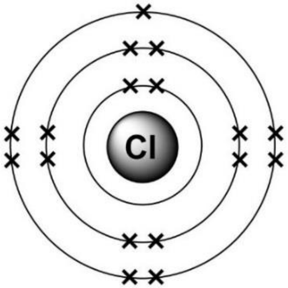
Elements with similar properties are in columns, known as groups.

Elements in the same group have the same number of electrons in their outer shell.

The rows in the table are called periods

It is called a periodic table because similar properties occur at regular intervals

Group = electrons in outer shell
Period = number of shells



Group = 7
Period = 3

Periodic table - PART 1

1808

John Dalton published a table of elements that were arranged in order of their atomic weights, which had been measured in various chemical reactions

1864

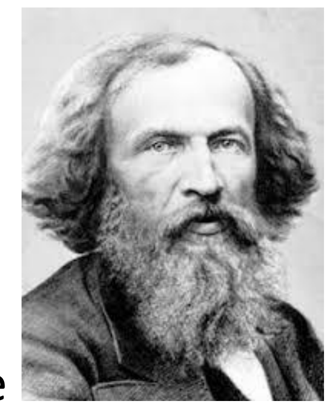
John Newlands published the law of octaves. However the **table was incomplete and elements were placed in inappropriate groups**

Newlands' Arranged Elements in Octaves:

H	F	Cl	Co/Ni	Br	Pd	I	Pt/Ir
Li	Na	K	Cu	Rb	Ag	Cs	Tl
G	Mg	Ca	Zn	Sr	Cd	Ba/V	Pb
Bo	Al	Cr	Y	Ce/La	U	Ta	Th
C	Si	Ti	In	Zn	Sn	W	Hg
N	P	Mn	As	Di/Mo	Sb	Nb	Bi
O	S	Fe	Se	Ro/Ru	Te	Au	Os

1869

Dmitri Mendeleev overcame Dalton's problem by **leaving gaps for the elements that he thought had not been discovered** and **in some places changed the order based on atomic weight** (e.g. Argon and Potassium). Elements with properties predicted by Mendeleev were eventually discovered.



Early20th Century - Scientists began to find out more about the atom and knowledge of **isotopes** explained why the order was not always correct.

Periodic table - PART 1

The elements can be divided into metals and non-metals.

1	2				H							3	4	5	6	7	0
																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	?	?	?						

Elements that do not form positive ions are non-metals

Elements that tend to form positive ions are metals

Non metals – found towards the right and towards the top of the periodic table

Most elements are metals – found towards the left and towards the bottom of the periodic table

Metals	Non-metals
Shiny	Dull
Mostly solid	Low density
Dense and strong	Weak
Malleable	Brittle
Good heat and electrical conductors	Poor heat and electrical conductors

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QuestionIT!

Periodic table
PART 1

- The periodic table
- Development of the periodic table
- Metals and non-metals

Periodic table PART 1 – QuestionIT

1. How are elements arranged in the periodic table?
2. What are the columns of the periodic table called?
3. What are the rows of a periodic table called?
4. What does the column an element is in tell you about the atoms?
5. What does the row an element is in tell you about the atoms?
6. Which side of the periodic table are the non-metals found?

Periodic table PART 1 – QuestionIT

7. How were elements classified before the discovery of subatomic particles?

8. What was the problem with early periodic tables?

9. How did Mendeleev overcome these problems?

10. Why is the order based on atomic masses not always correct?

11. What do we call elements that tend to form positive ions?

AnswerIT!

Periodic table
PART 1

- The periodic table
- Development of the perioc table
- Metals and non-metals

Periodic table PART 1 – QuestionIT

1. How are elements arranged in the modern periodic table?

   Increasing atomic number.

2. What are the columns of the periodic table called?

   Groups.

3. What are the rows of a periodic table called?

   Periods.

4. What does the column an element is in tell you about the atoms?

   Number of electrons in outer shell.

5. What does the row an element is in tell you about the atoms?

   Number of electron shells.

6. Which side of the periodic table are the non-metals found?

   Right and top.

7. How were elements classified before the discovery of subatomic particles?

   Arranging in order of their atomic weights.

8. What was the problem with early periodic tables?

   Incomplete; some elements placed in inappropriate groups.

9. How did Mendeleev overcome these problems?

   Left gaps for elements he thought had not yet been discovered; changed the order based on atomic weights for some elements if they did not fit the pattern.

10. Why is the order based on atomic masses not always correct?

    The presence of isotopes.

11. What do we call elements that tend to form positive ions?

    Metals.

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Periodic table
PART 2

- Group 0, Group 1 and Group 7

Periodic table - PART 2

THE NOBLE GASES

1	2											3	4	5	6	7	0
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	?	?	?						

Elements in **Group 0** of the periodic table are called the **noble gases**. They are unreactive because their atoms have **stable** arrangements of **electrons**. The atoms have **eight** electrons in their outermost shell, apart from helium, which has just **two**, but still has a complete outer shell.

The stable electronic structure explains why they exist as **single atoms**, they have no tendency to react to form **molecules**.

The **boiling points** of the noble gases get **higher** going **down** the group. For example helium boils at -269 °C and radon boils at -62°C.

Periodic table - PART 2

THE ALKALI METALS

1	2											3	4	5	6	7	0
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	?	?	?						

The alkali metals are very reactive. They need to be stored under **oil** to prevent them reacting with **oxygen** and **water** vapour in the **air**. The alkali metals have **low densities**. The metals are very **soft** and can be **cut** with a knife. They also have **low melting** and **boiling points**.
The properties are due to all the atoms having just **one** electron in their outermost shell. They only need to **lose** one electron to get the stable electronic structure of a noble gas.

Li
Na
K
Rb
Cs

Reactivity Increases

The atoms get **larger** as you go **down**, so the **single** electron in the outermost shell (highest energy level) is attracted **less** strongly to the positive nucleus. The **electrostatic attraction** with the nucleus gets **weaker** because the **distance** between the outer electron and the nucleus **increases**. Also the outer electron experiences a **shielding effect** from the inner electrons, **reducing** the attraction between the oppositely charged outer electron and the nucleus.

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Periodic table - PART 2

The alkali metals have a **silvery**, **shiny** surface when they are first cut. However, this goes **dull** very quickly as the metals reacts with the oxygen in the air.

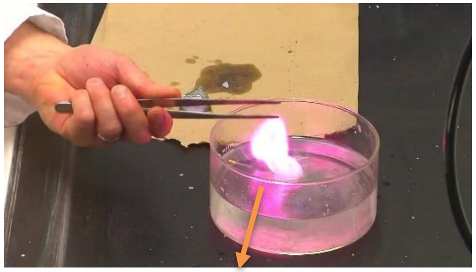
e.g. sodium + oxygen → sodium oxide

$4Na(s) + O_2(g) \rightarrow 2Na_2O(s)$

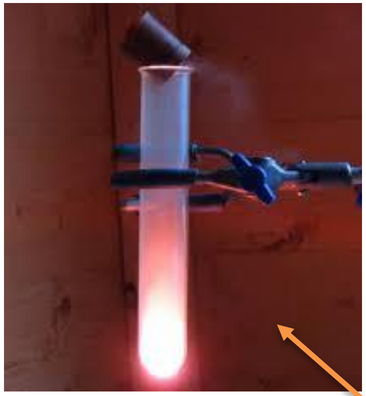
Lithium, sodium and potassium all react **vigorously** with water. When you add them to water, the metal **floats**, **moves** around and **fizzes**.

e.g. potassium + water → potassium hydroxide + hydrogen

$2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g)$



Potassium ignites with a lilac flame



They also react vigorously with non metals, such as group seven. They form **1+** ions in the reactions to make **ionic compounds**. These are generally **white** and **dissolve** in water, **giving colourless solutions**.

e.g. sodium + chlorine → sodium chloride

$2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$

Periodic table - PART 2

1	2											3	4	5	6	7	0
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	?	?	?						

THE HALOGENS

The halogens are a group of **toxic** non-metals that have **coloured** vapours. They have **low melting** and **boiling** points, which **increase** down the group. They are **poor conductors** of **heat** and **electricity**.

As elements, the halogens exist as **molecules** made up of pairs of atoms. These are called **diatomic** molecules **F_2, Cl_2, Br_2, I_2 and At_2**. The halogens have **seven** electrons in their outermost shell and need to **gain** one electron to achieve the stable electronic structure of a noble gas. When they react with non metals, they are joined together by a **covalent** bond.

When Group 7 elements react, the atoms **gain** an electron in their outermost shell. Going down the group, the outermost shell's electrons get **further away** from the attractive force of the nucleus, so it is **harder** to **attract** and **gain** an extra electron. The outer shell will also be **shielded** by more inner shells of electrons, again **reducing** the **electrostatic attraction** of the nucleus for an incoming electron.

F
Cl
Br
I
At

Reactivity Decreases

Periodic table - PART 2

The halogens react with **hydrogen**. The reactions with hydrogen become **less** reactive as you go **down** the group.

e.g. **fluorine + hydrogen → hydrogen fluoride**

$$F_2(g) + H_2(g) \rightarrow 2HF(g)$$

The halogens also react with **metals**. The halogen atoms **gain** a single electron to give them a stable arrangement of electrons. They form **ionic compound**.

e.g. **sodium + chlorine → sodium chloride**

$$2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$$

A more reactive halogen will also **displace** a less reactive halogen from solutions of its **salts**.

e.g. **chlorine + potassium bromide → potassium chloride + bromine**

$$Cl_2(g) + 2KBr(aq) \rightarrow 2KCl(aq) + Br_2(aq)$$

The **colour** of the solution after mixing depends on the **less** reactive pair of halogens.

$Cl_2(aq)$ $Br_2(aq)$ $I_2(aq)$

QuestionIT!

Periodic table
PART 2

- Group 0, Group 1 and Group 7

1. What are the elements in Group 0 called?
2. What are the elements in Group 1 called?
3. What are the elements in Group 7 called?
4. What happens to the boiling point of elements in Group 0 as you go down the group?
5. Why are the elements in Group 0 so unreactive?
6. Why do all elements in Group 1 react in a similar way to each other?

7. What happens to the reactivity of the elements as you go down Group 1?

8. Write a word equation for the reaction between sodium and oxygen.

9. Why do all the elements in Group 7 react in a similar way to each other?

10. Halogens are diatomic. What does the word ‘diatomic’ mean?

11. What happens to the reactivity as you go down Group 7?

Periodic table PART 2 – QuestionIT

12. What happens to the melting point and boiling point as you go down Group 7?

13. Write a word equation for the reaction between lithium and chlorine.

14. Write a balanced chemical equation for the reaction between lithium and chlorine gas.

AnswerIT!

Periodic table
PART 2

- Group 0, Group 1 and Group 7

Periodic table PART 2 – QuestionIT

1. What are the elements in Group 0 called?
   Noble gases.
2. What are the elements in Group 1 called?
   Alkali metals.
3. What are the elements in Group 7 called?
   Halogens.
4. What happens to the boiling point of elements in Group 0 as you go down the group?
   Increase.
5. Why are the elements in Group 0 so unreactive?
   Full outer shell of electrons.
6. Why do all elements in Group 1 react in a similar way to each other?
   1 electron in outer shell.

7. What happens to the reactivity of the elements as you go down Group 1?

   Increases.

8. Write a word equation for the reaction between sodium and oxygen.

   sodium + oxygen → sodium oxide

9. Why do all the elements in Group 7 react in a similar way to each other?

   7 electrons in outer shell.

10. Halogens are diatomic. What does the word ‘diatomic’ mean?

    There molecules contain 2 atoms.

11. What happens to the reactivity as you go down Group 7?

    Decreases.

12. What happens to the melting point and boiling point as you go down Group 7?
    Increases.
13. Write a word equation for the reaction between lithium and chlorine.
    lithium + chlorine → lithium chloride
14. Write a balanced chemical equation for the reaction between lithium and chlorine gas.
    $2Li(s) + Cl_2(g) \rightarrow 2LiCl(s)$

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Periodic table
PART 3

- **Transition Metals (chemistry only)**

Periodic table - PART 3 Chemistry only

THE TRANSITION METALS

1	2											3	4	5	6	7	0
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	?	?	?						

The general trend is the reactivity **decreases across the period**, but there are exceptions, for example Zinc is very reactive.

Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn

Reactivity decreases

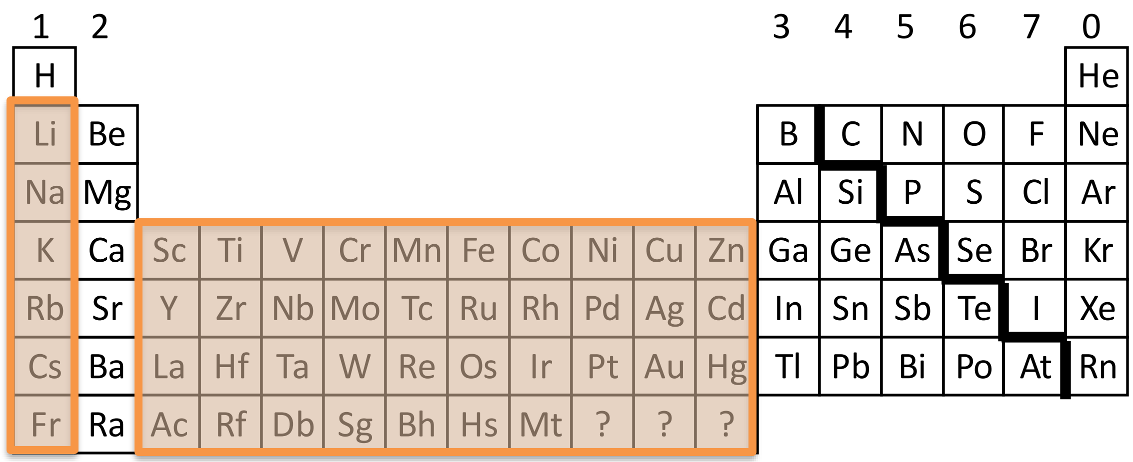
The transition metals are located **between group 2** and **group 3**.

The transition metals have:
High melting points
High boiling points
High densities

They are:
Shiny when polished
Malleable – can be hammered into a shape
Strong – don't break easily when a force is applied
Sonorous – makes a ringing sound when hit
Ductile – can be stretched into wires
Conductors of **electricity** and **heat**

Periodic table - PART 3
Chemistry only

Transition metals have **different properties** compared to the **alkali** metals (group 1).



	Alkali metals	**Transition metals**
Melting points	Low	High (except mercury, which is liquid at room temperature)
Reactivity	High (react vigorously with water or oxygen)	Low (do not react so vigorously with water or oxygen)
Strength	Soft or liquid so cannot withstand force	Strong and hard
Density	Low	High
Compounds formed	White or colourless	Coloured

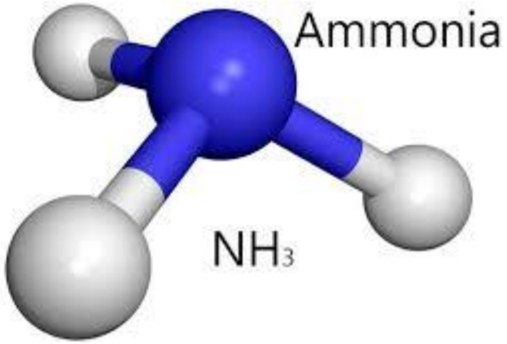
Periodic table - PART 3
Chemistry only

The transition metals have many different **uses** due to their **properties**. **Copper** has **properties** that make it useful for **electrical wiring** and **plumbing**. Not very reactive, **excellent conductor of electricity**, easily **bent** into shape for **water pipes** in plumbing.

They can also be useful as **catalysts**. A catalyst is a substance that **speeds up** a **chemical reaction** without being used up. Catalysts are hugely valuable in industry where they can **save time** and **energy**.

Nickel is the catalyst used in the hydrogenation of oil to produce **margarine**

Iron is the catalyst used in the Haber process to produce **ammonia**



QuestionIT!

Periodic table
PART 3

- **Transition Metals (chemistry only)**

Periodic table PART 3 – QuestionIT

1. Where are transition metals found on the periodic table?

2. How do the melting points of transition metals compare to Group 1 metals?

3. How do the densities of transition metals compare to Group 1 metals?

4. How does the strength of transition metals compare to Group 1 metals?

5. Describe the differences between the reactions of the alkali metals and the reactions of transition metals.

6. State two typical properties of transition metals.

7. State one use of transition metals.

8. Explain why copper is used for plumbing.

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AnswerIT!

Periodic table
PART 3

- **Transition Metals (chemistry only)**

1. Where are transition metals found on the periodic table?
   Between Group 2 and Group 3.
2. How do the melting points of transition metals compare to Group 1 metals?
   Transition metals have a higher melting point than alkali metals.
3. How do the densities of transition metals compare to Group 1 metals?
   Transition metals are more dense than alkali metals.
4. How does the strength of transition metals compare to Group 1 metals?
   Transition metals are stronger than alkali metals.

5. Describe the differences between the reactions of the alkali metals and the reactions of transition metals.

   Alkali metals react vigorously with water and with oxygen from the air. The transition elements react slowly with these reagents if at all.

6. State two typical properties of transition metals.

   Have ions with different charges; form coloured compounds.

7. State one use of transition metals.

   Transition metals can be used as catalysts.

8. Explain why copper is used for plumbing.

   It has a high melting point, it conducts heat and is strong and malleable. It also does not react with water.