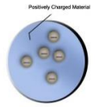
Chemistry Knowledge organiser – Unit 1 Atomic Structure

J.J Thomson Plum Pudding Model

As the atom is so small, people found it hard to understand the way it was structured.

The first person who discovered electrons, **Sir J.J Thomson,** put forth his 'Plum Pudding' Model of an atom**. He believed that the atom was a sphere with a positive charge and had electrons stuck inside it.**



Rutherford's Atomic Model

Ernst Rutherford was studying radioactive substances. Through his experiment of hitting gold foil with alpha particles he found that most of the alpha particles passed through the gold foil – he suggested that the atom was mostly made up of empty space.

Next he observed that some alpha particles were deflected through small and large angles. This proved that there was a 'centre of positive charge' in an atom.
Rutherford proved that the nucleus was **positively charged**. The nucleus is very small, dense and hard when compared to the whole atom.

Bohr's Model of the Atom

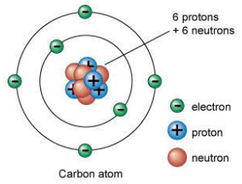
In 1913, Neil Bohr explained that the electrons were not in a cloud, but on energy levels orbiting the nucleus at different distances (a bit like the solar system model we have).

Bohr's Idea - The negative electrons are in orbit around the nucleus in shells and are kept in orbit by the pull of the protons.

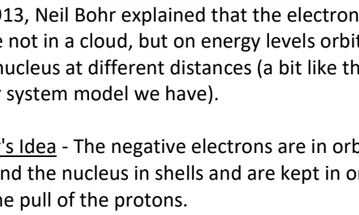
James Chadwick and Discovery of Neutrons

With the discovery of protons, neutrons and electrons, physicists could put forth a diagram of an atom. They could explain that an atom is made up of electrons, neutrons and protons.

The centre of an atom is the nucleus that contains protons and neutrons. This makes the nucleus positively charged. The electrons are present on different shells or orbits that revolve around the nucleus.



Helium has the lowest boiling point of group 0. The trend shows that the boiling point increase down the group.



The Development of the Periodic Table

In the past, masses were used by scientists trying to organise the elements. This was mainly because the idea of atoms being made up of smaller sub-atomic particles had not been developed.

Johan Dobereiner

In 1829, Johann Döbereiner recognised triads (threes) of elements with chemically similar properties, such as lithium, sodium and potassium, and showed that the properties of the middle element could be predicted from the properties of the other two.

John Newlands

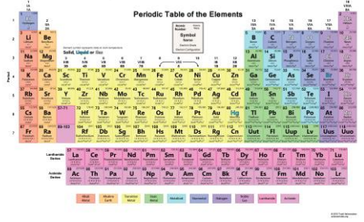
Newlands noticed that there were similarities between elements with atomic weights of + or - 7. He called this The Law of Octaves. Newlands did not leave any gaps for undiscovered elements in his table, and sometimes had to cram two elements into one box in order to keep the pattern.

Dmitri Mendeleev

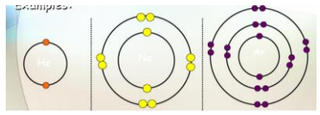
Mendeleev discovered the periodic table while attempting to organise the elements in February of 1869. He did it by writing the properties of the elements on pieces of card and arranging and rearranging them until he realised that, by putting them in order of increasing atomic weight, certain properties of elements regularly occurred.

Not only did Mendeleev arrange the elements in the correct way, but if an element appeared to be in the wrong place due to its atomic weight, he moved it to where it fitted with the pattern he had discovered.

The real genius of Mendeleev's achievement was to leave gaps for undiscovered elements in groups where he predicted they would have similar properties to the other elements in that group.
Within 15 years, three of these elements were discovered and Mendeleev's predictions were shown to be incredibly accurate.



Electronic configurations for the first THREE noble gases are:



They all have full outer shells and as a result are INERT (unreactive with other elements). They exist as single atoms.

The Group 0 – Noble Gases

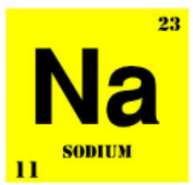
Group 0 are all gases.

He, Ne, Ar, Kr, Xe, Rn

Uses of the noble gases

Use in welding to prevent the metal reacting with oxygen in the air.

Relative Atomic Masses



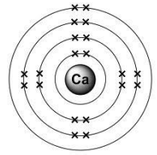
23 is the atomic mass of sodium. This is called the **relative atomic mass**.
Relative is because the protons and neutrons are too small to weigh individually.
It is also an average of all the **isotopes** of sodium.

Isotope – This is an element with the **same** number of protons – **but a different number of neutrons in its nucleus**.
If you look at chlorine on the periodic table its RAM is **35.5** this is because it exists as the two isotopes of: $^{35}_{17}Cl$ $^{37}_{17}Cl$

Electronic Configuration

By looking at the periodic table we know how many protons, neutrons and electrons each element has.
In Chemistry, we need to know where we find the electrons.
Electronic configuration – are the diagrams we draw to show where the electrons are. These are important in helping us to understand how the atoms bond together to make compounds.

Surrounding the positive nucleus are the **negative electrons**.
However, they are not randomly placed, but have specific places they can occupy.
These are called electron shells, levels or orbitals – they all mean the same thing – the place where electrons are found.
The electron levels can only hold a set number of electrons.
The first – closest to the nucleus – fills first and can hold up to **2**.
The second – fills next and can hold up to **8**.
The third – fills next and can hold up to **8**.
The fourth – fills next and can hold up to **18**.
(Luckily for us we only have to ever put on 2!)



If you look there are:
2 on the first
8 on the second
8 on the third
2 on the fourth
We can write this as
2, 8, 8, 2
It tells us the information above, without the need for a diagram.

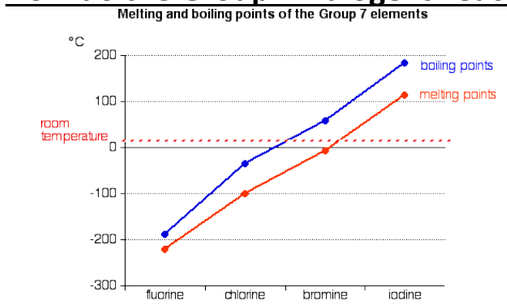
H 1							He 2
Li 2,1	Be 2,2	B 2,3	C 2,4	N 2,5	O 2,6	F 2,7	Ne 2,8
Na 2,8,1	Mg 2,8,2	Al 2,8,3	Si 2,8,4	P 2,8,5	S 2,8,6	Cl 2,8,7	Ar 2,8,8
K 2,8,8,1	Ca 2,8,8,2						

The electronic configurations shows us:

The **Group** number = number of **outer** electrons

The **Period** number = number of electron shells.

How do the Group 7 Halogens react?



The trend show an increase in the melting and boiling points of the halogens as the size of the atom increase.

Halogen	Formula	State	Colour
Fluorine	F_2	Gas	Pale yellow
Chlorine	Cl_2	Gas	Green
Bromine	Br_2	Liquid	Red
Iodine	I_2	Solid	Purple
Astatine	At_2	Solid	Grey

Halogens will dissolve in water to produce acidic solutions
eg hydrochloric acid

Halogens will react with silver nitrate to produce coloured **precipitates.**

	Colour of precipitate when silver nitrate is added	Equation
Potassium chloride	white	$AgNO_3 + KCl \rightarrow AgCl_{(s)} + KNO_3$
Potassium bromide	cream	$AgNO_3 + KBr \rightarrow AgBr_{(s)} + KNO_3$
Potassium iodide	yellow	$AgNO_3 + KI \rightarrow AgI_{(s)} + KNO_3$

Halogens will displace a less reactive halogen from a solution.

		Salt			
		sodium fluoride	sodium chloride	sodium bromide	sodium iodide
Halogen	fluorine		reaction	reaction	reaction
	chlorine	no reaction		reaction	reaction
	bromine	no reaction	no reaction		reaction
	iodine	no reaction	no reaction	no reaction	

Equations

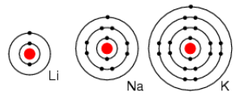
Chlorine + potassium bromide → Potassium + Bromine Chloride

Cl_2 + 2KBr → 2KCl + Br_2

How do the Group 1 metals react with chlorine, oxygen and water?

Reaction	Lithium	Sodium	potassium
With oxygen	Burns red flame White ash of lithium oxide	Burns more vigorously with yellow flame White ash of sodium oxide	Burns violently with lilac flame White ash of potassium oxide
With water	Floats, fizzes producing hydrogen gas, produces colourless lithium hydroxide solution (alkali)	Floats and melts , fizzes producing hydrogen gas, produces colourless sodium hydroxide solution	Floats, hydrogen gas sets on fire with lilac flame, produces colourless potassium hydroxide solution

What do all Group 1 elements have in common?
They all have one outer electron.



The reactivity INCREASES down the group:
More shielding of the nucleus
Outer electron is easier to remove releasing more energy as heat.

Equations:

Lithium + oxygen → Lithium oxide

$4Li + O_2 \rightarrow 2Li_2O$

Lithium + chlorine → lithium chloride

$2Li + Cl_2 \rightarrow 2LiCl$

Lithium + water → lithium hydroxide + hydrogen

$2Li + H_2O \rightarrow 2LiOH + H_2$

This is the reaction pattern for all group 1 – just change the name and symbol ☺

1. **Describe the position, charge and mass of a proton.**
2. **Describe the position, charge and mass of a neutron.**
3. **Describe the position, charge and mass of an electron.**
4. **How many elements are in $CaCO_3$?**
5. **How many atoms are in $CaCO_3$?**
6. **What is a mixture?**
7. **Why can't compounds be separated by physical processes?**
8. **What does distillation separate?**
9. **What can crystallisation separate?**
10. **What can Filtration separate?**
11. **Who came up with the plum pudding theory?**
12. **Who came up with the idea of electron shells?**
13. **Who discovered protons in the nucleus?**
14. **What did Rutherford discover?**
15. **How did he discover it?**
16. **Why are atoms neutral?**
17. **What is an ion?**
18. **Why do ions form?**
19. **What are isotopes?**
20. **How many neutrons are in Carbon-14?**
21. **Where can you find the number of protons in an atom?**
22. **What is the number of electrons equal to?**
23. **What is the max number of electrons in each shell?**
24. **Draw the electron structure of phosphorus?**
25. **What does the group number tell you about an atom's electron structure?**
26. **What do all group 0 elements have in common?**
27. **Why are group 1 elements so reactive?**
28. **Why are group 7 elements so reactive?**
29. **What is the general equation for a group 1 metal reacting with water?**
30. **What do all of the formulas of group 7 elements have in common.**
31. **Describe the trend in reactivity as you go down group 1.**
32. **Why does this trend exist?**
33. **Describe the reactivity trend as you go down group7**
34. **Why does this trend exist?**
35. **What will a more reactive halogen do to a less reactive one?**