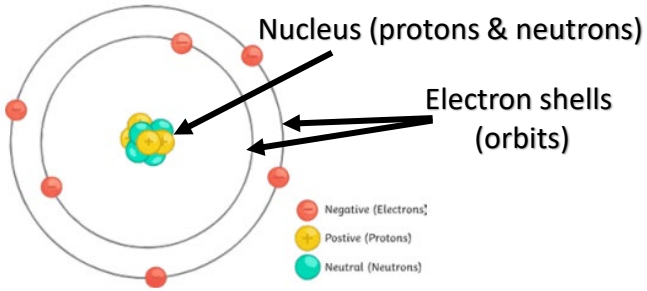
C1 – Atomic Structure and The Periodic Table

Atoms

- Made up of **protons, electrons** and **neutrons**.



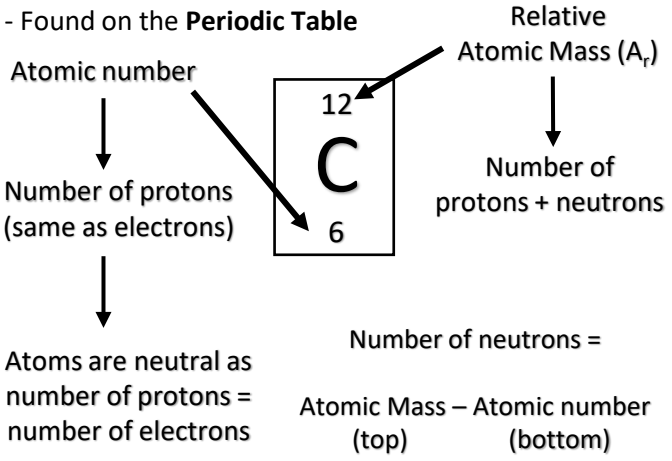
Subatomic particle	Relative Mass	Charge
Proton	1	Positive
Neutron	1	Neutral
Electron	Very small	Negative

Atoms have a radius of about 0.1nm ($1x10^{-10}$ m)

Radius of nucleus = about $1x10^{-14}$ m

Elements

- Only have **one type** of atom
- Found on the **Periodic Table**

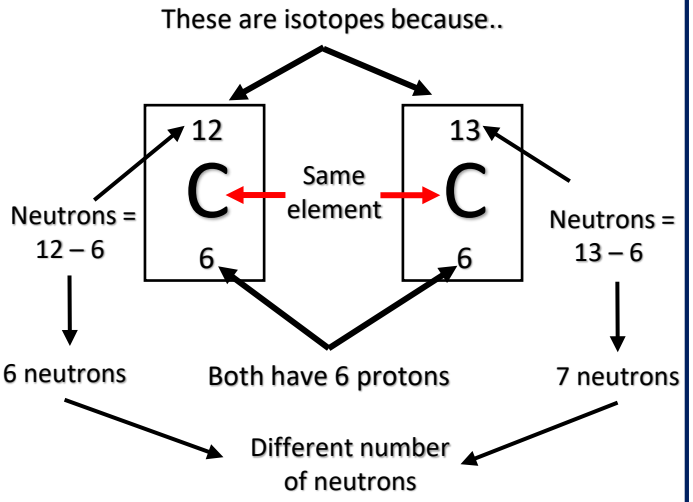


Compounds

- Two or more elements **chemically combined**.
- Formed by chemical reactions
- For example: CO_2 H_2O CH_4 HCl NaCl

Isotopes

Isotope = atoms of the **same element** which have the **same number of protons**, but **a different number of neutrons**.



Chemical Equations

- Shown by using a **word equation**.

e.g. magnesium + oxygen → magnesium oxide

Left of the arrow = **reactants**
Right of the arrow = **products.**

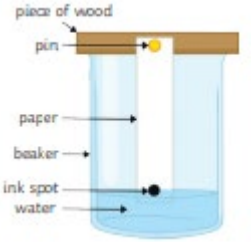
- Also can be shown by a **symbol equation**

e.g. $2Mg + O_2 \rightarrow 2MgO$

Mixtures and Separation

Mixtures – two or more elements or compounds **not** chemically joined.
This means the different components of the mixture can be separated by physical methods (below)
E.g. air is a mixture mainly made of nitrogen, oxygen and carbon dioxide.

Chromatography
to separate out mixtures (usually liquids) (e.g. colours in ink)



Filtration
To separate insoluble solids from liquids (e.g. sand and water)

Evaporation
To quickly separate soluble solids from a solution.
(e.g. salt and water)

Crystallisation
To slowly separate a soluble salt from a solution.
(e.g. copper sulfate crystals)

C1 – Atomic Structure and The Periodic Table

1. Name the three subatomic particles.
2. Which two subatomic particles are found in the nucleus of an atom?
3. What is the mass of a proton?
4. What is the radius of an atom?
5. What is the radius of the nucleus of an atom?

1. Where is the list of elements found?
2. What does the relative atomic mass of an element show?
3. What does the atomic number show?
4. How do you calculate the amount of neutrons?

1. Define the word compound.
2. Give three examples of compounds.

1. What is an isotope?

2. Why are the two elements below isotopes? (use the numbers of **subatomic particles**)

14
N
7

15
N
7

1. Where do you find the reactants in a chemical reaction?
2. Where do you find the products in a chemical reaction?

1. Is air an element, compound or mixture? Why?
2. What is chromatography used to separate?
3. What can be separated using filtration?
4. Give an example of a mixture that can be separated using filtration.
5. What is evaporation used to separate?
6. Give an example of a mixture that can be separated using evaporation.

C1 – Atomic Structure and The Periodic Table

1. Name the three subatomic particles. Protons, neutrons, electrons
2. Which two subatomic particles are found in the nucleus of an atom? Protons and neutrons
3. What is the mass of a proton? 1
4. What is the radius of an atom? 1×10^{-10} m
5. What is the radius of the nucleus of an atom? 1×10^{-14} m

1. Where is the list of elements found? Periodic table
2. What does the relative atomic mass of an element show? The number of protons + neutrons
3. What does the atomic number show? Number of protons
4. How do you calculate the amount of neutrons? Mass number – atomic number

1. Define the word compound. 2 or more elements chemically joined together
2. Give three examples of compounds. Water, sodium chloride, carbon dioxide

1. What is an isotope? An atom with the same number of protons, but different number of neutrons

2. Why are the two elements below isotopes? (use the numbers of **subatomic particles**)

14	15
N	N
7	7

They both have 7 protons, but one has 7 neutrons and one has 8

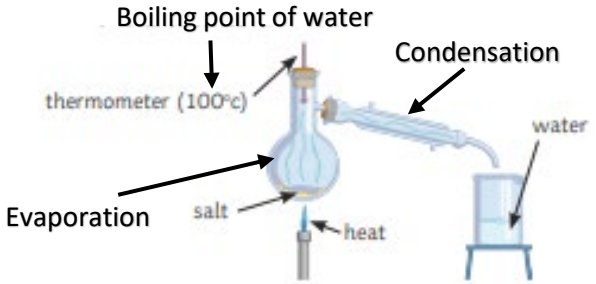
1. Where do you find the reactants in a chemical reaction? Left hand side of the arrow
2. Where do you find the products in a chemical reaction? Right hand side of the arrow

1. Is air an element, compound or mixture? Why? It is a mixture because it contains nitrogen, oxygen etc and they are not joined together
2. What is chromatography used to separate? Mixtures of dissolved substances
3. What can be separated using filtration? Liquids and insoluble solids
4. Give an example of a mixture that can be separated using filtration. Sand and water
5. What is evaporation used to separate? Soluble solids and liquids
6. Give an example of a mixture that can be separated using evaporation. Salt water

C1 – Atomic Structure and The Periodic Table

Distillation

Simple distillation – separating a liquid from a solution.



- Liquid is heated to boiling point and evaporates
- Vapours travel up into the condenser
- Condenser has cold water around it.
- Vapours cool and condense (turn back into a liquid).

Electronic Structure

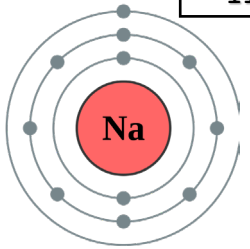
- Electrons are found on shells (orbits) orbiting the nucleus.
- There is a maximum number of electrons allowed on each shell:

First shell = 2 electrons
Second shell = 8 electrons
Third shell = 8 electrons.

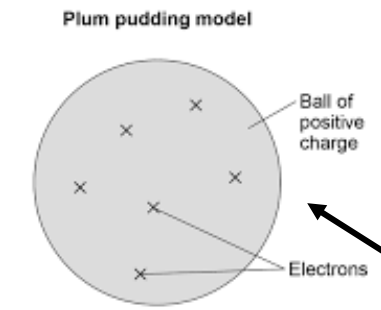
11 electrons

23
Na
11

1st shell = 2
2nd shell = 8
3rd shell = 1



Total = 11 electrons



History of the atom

Scientist	Time	Discovery
John Dalton	Start of the 19th century	Atoms were first described as solid spheres.
JJ Thomson	1897	Plum pudding model – atom is a ball of + charge with electrons scattered
Ernest Rutherford	1909	Alpha scattering experiment - mass concentrated at the centre, only the nucleus is + charged. Most of the atoms is empty space.
Niels Bohr	Around 1911	Electrons are in shells orbiting the nucleus
James Chadwick	Around 1940	Discovered that there are neutrons in the nucleus.

Differences to nuclear model

- Ball of positive charge (no protons)
- No nucleus
- No neutrons
- Evenly distributed mass

Rutherford tested the plum pudding model

What happened ?

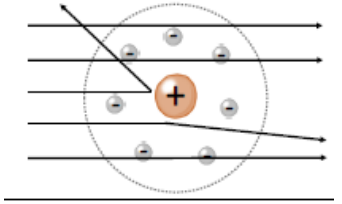
Rutherford's scattering experiment

alpha particles are positively charged

Fired at gold foil

some alpha particles are deflected/ repelled

most alpha particles passed straight through



Conclusions made

Observation	Conclusion
Most of the particles passed straight through	Most of the atom is empty space
Some were deflected to the sides	The particles had passed close by a positive charge
A very small number were repelled straight back	The alpha particles had approached the nucleus straight on. the tiny number told him that the positive charge is in a very small dense core

C1 – Atomic Structure and The Periodic Table

1. What two changes of state occur in distillation?
2. What temperature would the thermometer show when distilling salt and water?
3. Why does the water vapour condense in the condenser?

1. Who suggested the plum pudding model?
   JJ Thomson
2. State three differences between the nuclear model and the plum pudding model.
3. What did Niels Bohr discover?
4. What did James Chadwick discover?
5. Put the particles into order of discovery:
   proton electron neutron

1. Where are electrons found?
2. How many electrons can be placed in the first, second and third shells?
3. Which number on the element shows the number of electrons?

1. Who conducted the scattering experiment?
2. What was fired at gold leaf during the scattering experiment?
3.
4. Only a tiny number of the alpha particles were deflected, what did this show about the atom?
5. Some particles went straight through, what did this show about the atom?

C1 – Atomic Structure and The Periodic Table

1. What two changes of state occur in distillation? Evaporation and condensation
2. What temperature would the thermometer show when distilling salt and water? 100 °C
3. Why does the water vapour condense in the condenser? It cools down

1. Who suggested the plum pudding model?
   JJ Thomson
2. State three differences between the nuclear model and the plum pudding model. In the plum pudding model the positive charge was all over the atom, the electrons were randomly scatted and there was no nucleus. In the nuclear model, there is a nucleus where all the mass and the positive charge is, the electrons are in shells
3. What did Niels Bohr discover? That electrons orbit in shells
4. What did James Chadwick discover? neutrons
5. Put the particles into order of discovery:
   proton electron neutron
   electrons protons neutrons

1. Where are electrons found? In shells / energy levels
2. How many electrons can be placed in the first, second and third shells? 2 in the first, 8 in the second, 8 in the third
3. Which number on the element shows the number of electrons? The atomic number (as atoms have the same number of protons as electrons)

1. Who conducted the scattering experiment? Rutherford
2. What was fired at gold leaf during the scattering experiment? Alpha particles
3. Only a tiny number of the alpha particles were deflected, what did this show about the atom? That the nucleus is tiny and contains all of the positive charge
4. Some particles went straight through, what did this show about the atom? That most of it is empty space

C1 – Atomic Structure and The Periodic Table

Development of the Periodic Table

John Newlands – Law of Octaves

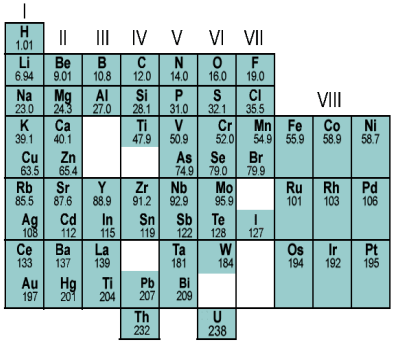
- Elements ordered by **atomic weight**.
- Noticed a pattern with every eighth element.
- Some elements placed inappropriately – metals and non-metals grouped together.
- Rejected by other scientists – had to put 2 elements in some boxes to make the pattern work

H	Li	Be	B	C	N	O
F	Na	Mg	Al	Si	P	S
Cl	K	Ca	Cr	Ti	Mn	Fe
Co, Ni	Cu	Zn	Y	In	As	Se
Br	Rb	Sr	Ce, La	Zr	Di, Mo	Ro, Ru

John Newlands' Law of Octaves

Dimitri Mendeleev

- Still ordered by atomic weight
- Left gaps for **undiscovered elements**
- Could predict properties of undiscovered elements.
- Some elements didn't fit pattern – switched them to keep pattern of **similar properties**.



Dimitri Mendeleev left gaps for undiscovered elements

Eventually, knowledge of isotopes explained why elements could not be ordered by atomic weight.

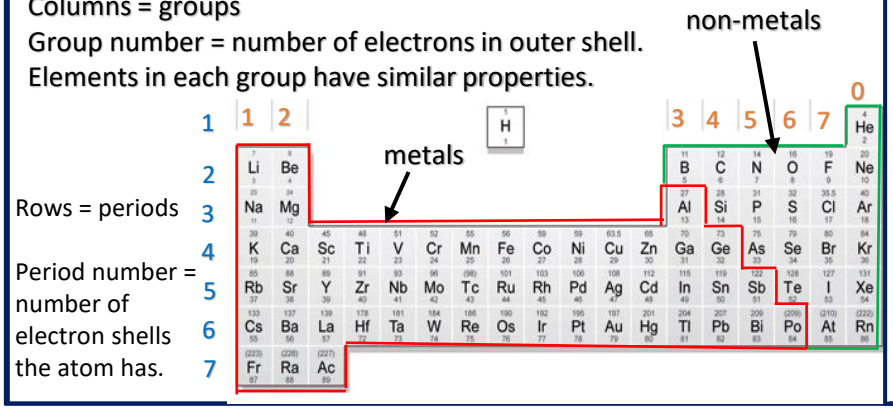
The Modern Periodic Table

- Ordered by **atomic (proton) number**.

Columns = groups

Group number = number of electrons in outer shell.

Elements in each group have similar properties.



Group 0 (Noble Gases)

- Full outer shell – unreactive as they don't need to lose or gain any electrons

He
Ne
Ar
Kr
Xe
Rn

As you go down…
- Boiling point increases
- More electron shells
- Bigger atoms
- More intermolecular forces
- More energy needed to break forces.

Group 1 (alkali metals)

- Similar properties as all have 1 electron in outer shell.
- All lose one electron in reactions to form 1+ ions
- Soft, grey, shiny metals
- Stored in oil as would react with oxygen in air.
- When placed in water they produce an alkali (hence alkali metals) and hydrogen gas

E.g Lithium + water → lithium hydroxide + hydrogen

Reactivity of Group 1

Li
Na
K
Rb
Cs
Fr

As you go down the group…
- Elements are more reactive because:
- More electron shells
- Outer electron = further from nucleus and more shielded by the other shells
- The electrostatic force of attraction between outer electron and nucleus is weaker
- Easier for outer electron to be lost

Group 7 (Halogens)

- 7 electrons in outer shell – all react similarly
- All gain one electron when they react to form 1- ions
  - Form molecules (e.g. Cl_2, F_2)
  - Non-metals.
  - A more reactive halogen can replace a less reactive halogen in a reaction **(displacement)**

Reactivity of Group 7

F
Cl
Br
I
At

As you go down the group…
- Elements **are less** reactive because:
- More electron shells
- Outer shell is further from nucleus and is **more shielded** by the other shells
- The electrostatic force of attraction between free electron and nucleus is **weaker**
- Harder to attract an electron into the outer shell.

C1 – Atomic Structure and The Periodic Table

1. Who created the 'Law of Octaves'?
2. What was the main problem with this version of the periodic table?
3. How were the elements ordered in old versions of the periodic table?
4. How did Dimitri Mendeleev order his elements?
5. Why did Mendeleev leave gaps in his periodic table?
6. The knowledge of what eventually explained why elements could not be ordered by atomic weight?

1. How are elements ordered in the modern periodic table?
2. Groups are rows or columns?
3. What does group number show?
4. What does period number show?

1. What are elements in group 0 known as?
2. Why are these elements unreactive?
3. What happens to boiling point as you go down group 0?

1. State 2 properties of Group 1 metals.
2. Why are they known as the alkali metals?
3. Are they reactive or unreactive?
4. As you go down the group, what happens to the reactivity of elements?
5. Explain your answer to Q4.

1. How many electrons do the halogens have in the outer shell?
2. What type of element are they?
3. State the trend in reactivity as you go down group 7.
4. Explain your answer to Q4.

C1 – Atomic Structure and The Periodic Table

1. Who created the 'Law of Octaves'? John Newlands
2. What was the main problem with this version of the periodic table? He had to put two elements in some boxes
3. How were the elements ordered in old versions of the periodic table? Atomic weight
4. How did Dimitri Mendeleev order his elements? Atomic weight
5. Why did Mendeleev leave gaps in his periodic table? For undiscovered elements
6. The knowledge of what eventually explained why elements could not be ordered by atomic weight? isotopes

1. How are elements ordered in the modern periodic table? Atomic number
2. Groups are rows or columns? columns
3. What does group number show? Number of electrons in the outer shell
4. What does period number show? Number of shells

1. What are elements in group 0 known as? Noble gases
2. Why are these elements unreactive? They have full outer shells so don't lose or gain any electrons
3. What happens to boiling point as you go down group 0? It increases

1. State 2 properties of Group 1 metals. They are soft, conduct electricity, they react with oxygen and water
2. Why are they known as the alkali metals? They form an alkali when they react with water
3. Are they reactive or unreactive? reactive
4. As you go down the group, what happens to the reactivity of elements? It increases
5. Explain your answer to Q4. Going down the group, the outer electron is further away from the nucleus and is more shielded, so it is more easily lost

1. How many electrons do the halogens have in the outer shell? 7
2. What type of element are they? Non metal
3. State the trend in reactivity as you go down group 7.Decreases
4. Explain your answer to Q4. Going down group 7, the outer shell is further from the nucleus and there is more shielding, so it become more difficult to attract an electron into the outer shell.