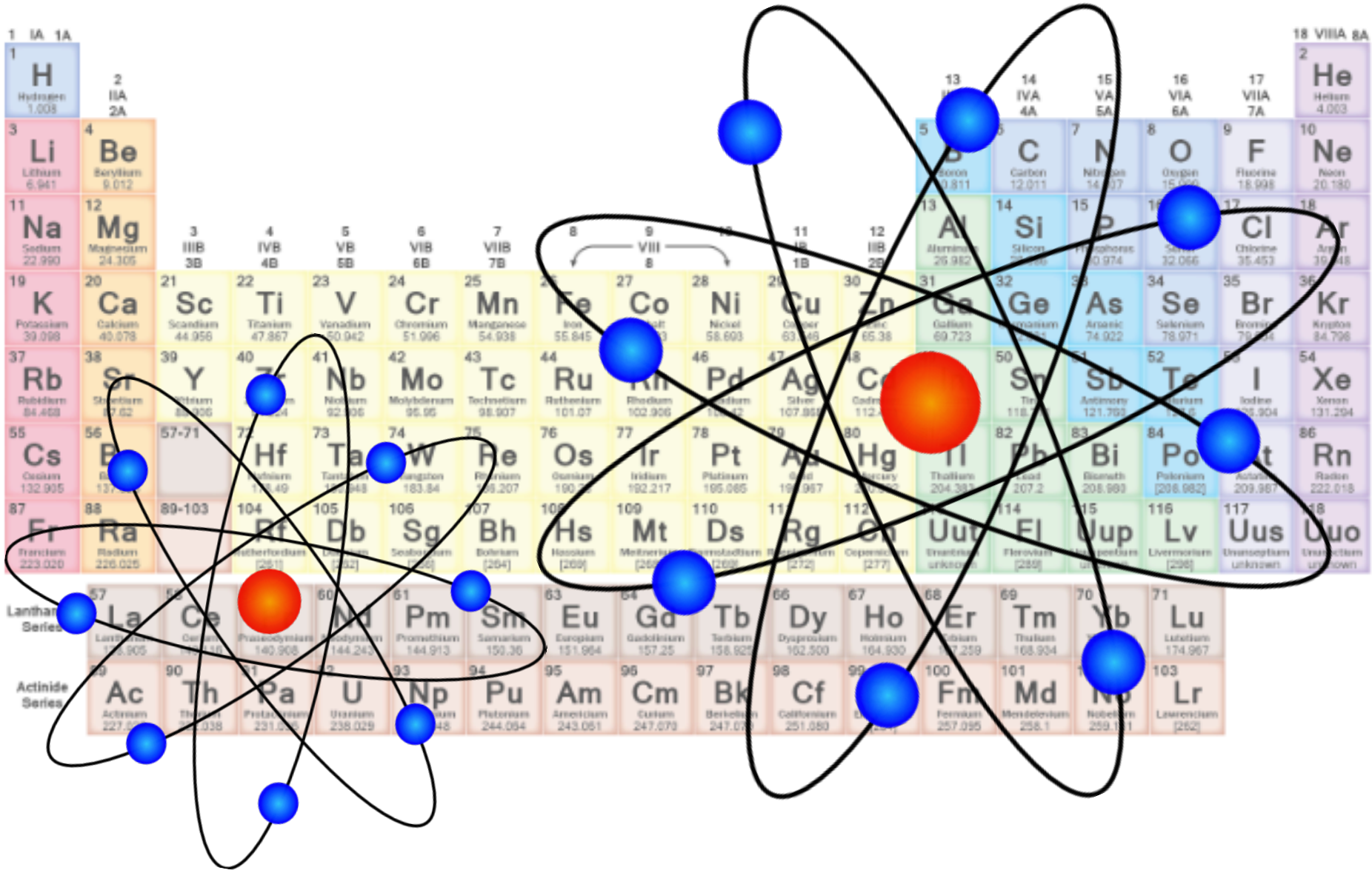
Topic: Atoms and the Periodic Table



Atoms

- the basic building blocks of all substances
- 92 different naturally-occurring types of atom
- the smallest amount of any **element** we can have

Fun Facts:

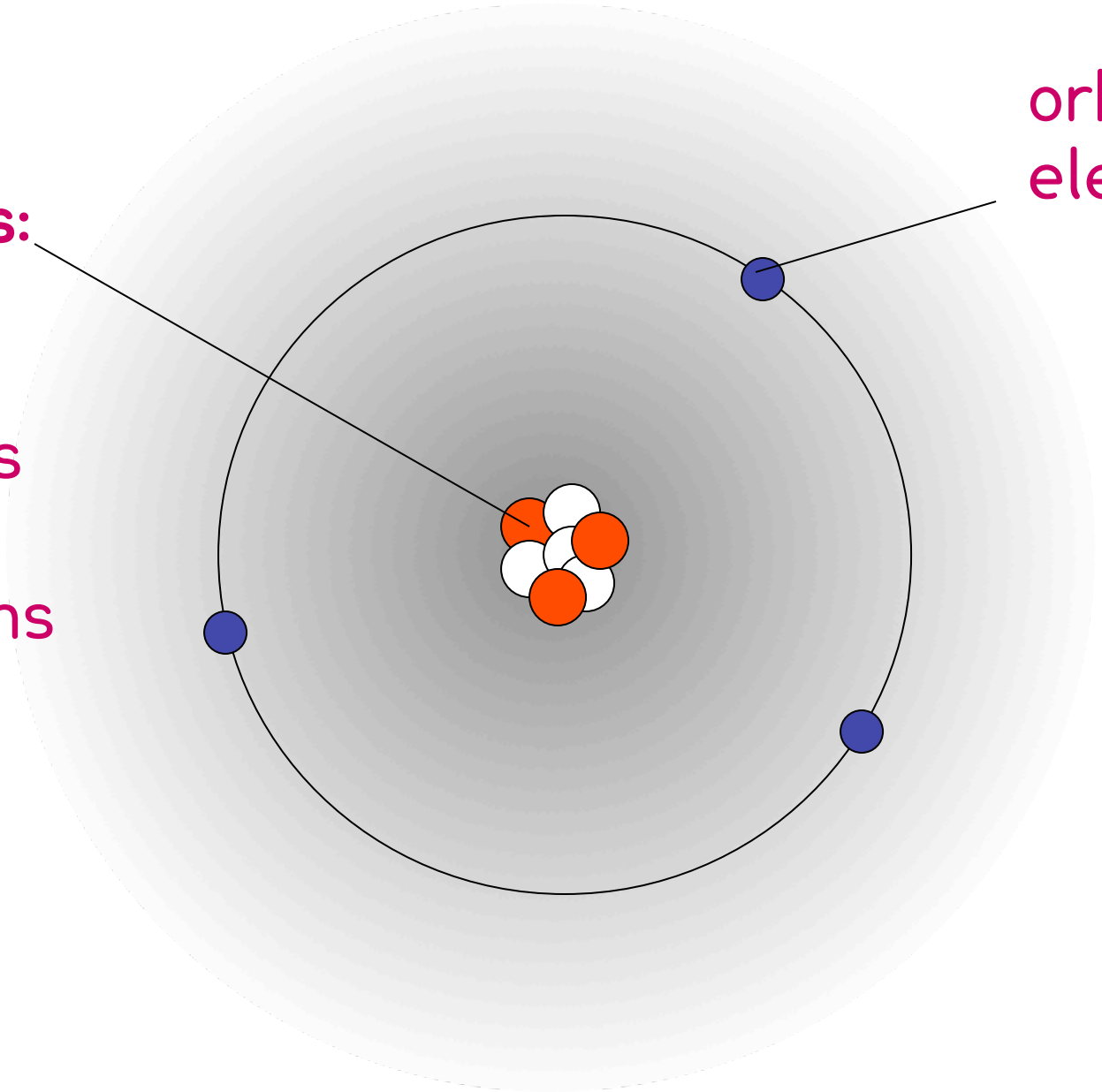
One cubic centimetre of air contains around 90 million million atoms.

Half a million (500,000) atoms lined up shoulder to shoulder could hide behind a human hair.

If you wanted to see the atoms in a drop of water you'd have to enlarge it until it was 24km across

If Julius Caesar's dying breath was evenly distributed through the atmosphere, each time you breathe in you'd take in 100 molecules of it.

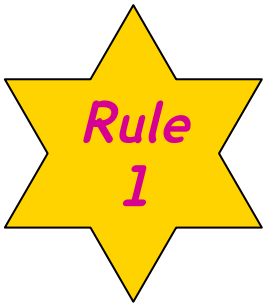
Structure of an atom



Protons, neutrons and electrons are **sub-atomic particles** with different properties:

Sub-atomic particle	Charge	Mass
Proton	**+ 1**	**1**
Neutron	**0**	**1**
Electron	**- 1**	**0.0005**

An **atom** has **no overall charge** because...

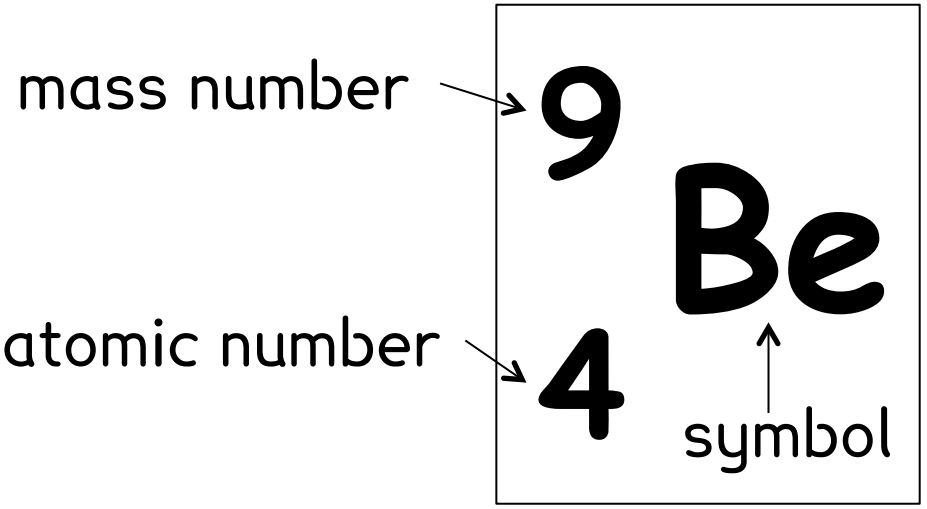


number of protons = number of electrons

An atom is mostly empty space ! If an atom were expanded to the size of a stadium, the nucleus would be the size of a pea at the centre of the pitch.

Every atom has:

- A symbol
- An atomic number
- A mass number



Rule 2

The **atomic number** is the **number of protons** in the nucleus.

This is what gives an atom its identity.

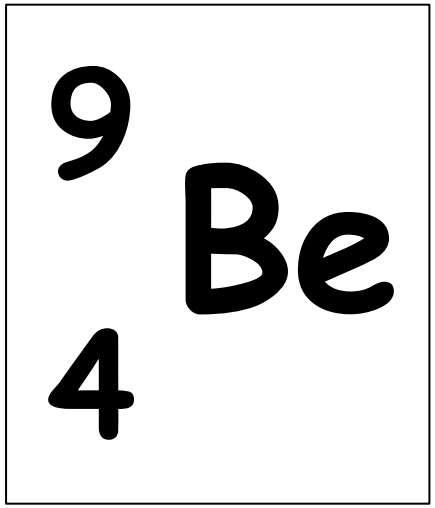
A phosphorus atom is a phosphorus atom and not a sulphur atom because it contains 15 protons, not 16.

Rule 3

The **mass number** is the total number of **protons + neutrons** in the nucleus

These are what give an atom its mass.

So how can we work out the number of neutrons ?



Neutrons = mass number – atomic number

Complete this table:

Atom	Protons	Neutrons	Electrons
$^{7}_{3}Li$	3	?	?
$^{?}_{?}?$	6	6	?
$^{39}_{?}?$	?	?	19
$^{?}_{?}F$	?	10	?
$^{?}_{?}?$	47	61	?

Check your answers:

Atom	Protons	Neutrons	Electrons
$^{7}_{3}Li$	3	4	3
$^{12}_{6}C$	6	6	6
$^{39}_{19}K$	19	20	19
$^{19}_{9}F$	9	10	9
$^{108}_{47}Ag$	47	61	47

Isotopes

$^{1}_{1}H$ hydrogen

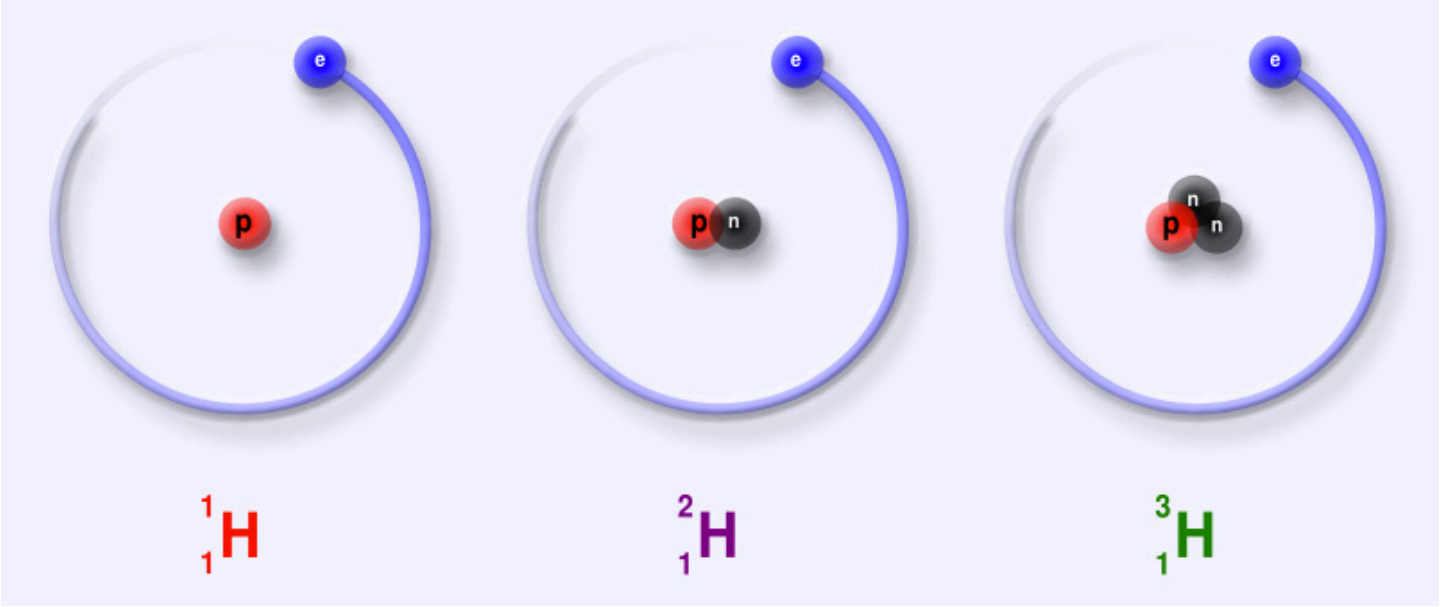
$^{2}_{1}H$ deuterium

$^{3}_{1}H$ tritium

Atoms of the same element with

- **same** number of **protons** (same atomic number)
- **different** numbers of **neutrons** (different mass number)

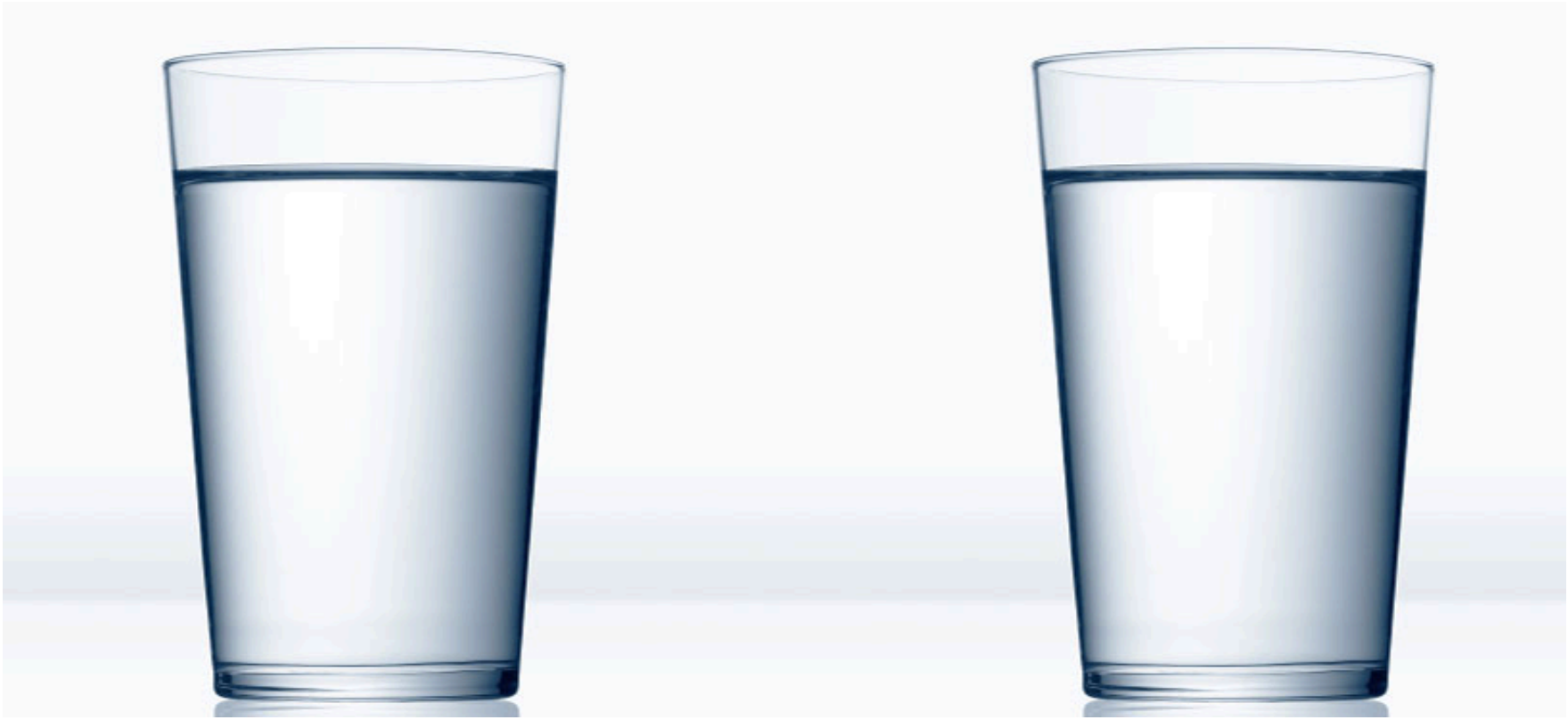
They have **exactly the same** chemical properties, but different mass.



One of these glasses contains water, H_2O.
The other contains deuterium oxide, ^2H_2O.

How can we tell them apart?

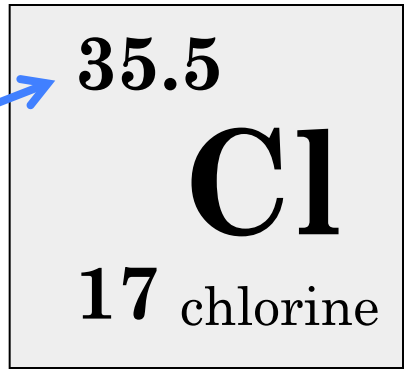
One of these glasses contains water, H_2O.
The other contains deuterium oxide, ^2H_2O.



Answer: They will weigh different masses. The one with deuterium oxide will be about 10% heavier

Relative Atomic Masses

Surely we can't have half a proton or neutron??



The periodic table does not show mass numbers, it shows relative atomic masses.

Because different isotopes have different masses, this is an **average** mass, taking into account the **how much** of each isotope exists naturally.

We use a scale where one atom of the **carbon-12 isotope** has a mass of 12 units exactly.

Working out Relative Atomic Mass (Symbol: A_r)

We need to know:

- how much of each isotope there is (its **% abundance**)
- the **mass number** of each isotope

e.g. ^{35}Cl atoms have an abundance of 75% and ^{37}Cl atoms have an abundance of 25%...

Mass number	Fractional Abundance (% ÷ 100)	MULTIPLY
35	75 ÷ 100 = 0.75	35 x 0.75 = 26.25
37	25 ÷ 100 = 0.25	37 x 0.25 = 9.25

Add: 26.25 + 9.25 = 35.5

Magnesium has three isotopes. Their abundances are ^{24}Mg 79%, ^{25}Mg 10%, ^{26}Mg 11%.

Calculate the relative atomic mass of magnesium.

Mass number	Fractional Abundance (% ÷ 100)	MULTIPLY
24	79 ÷ 100 = 0.79	24 x 0.79 = 18.96
25	10 ÷ 100 = 0.10	25 x 0.10 = 2.50
26	11 ÷ 100 = 0.11	26 x 0.11 = 2.86

18.96
+ 2.50
+ 2.86
= 24.32

The Periodic Table

- arranged in order of increasing **atomic number**
- the horizontal rows are called **periods**
- the vertical columns are called **groups**

e.g. magnesium is in Group 2 and Period 3

Period 1 has just Hydrogen and Helium in it – it is easy to miss these and start counting periods from lithium…

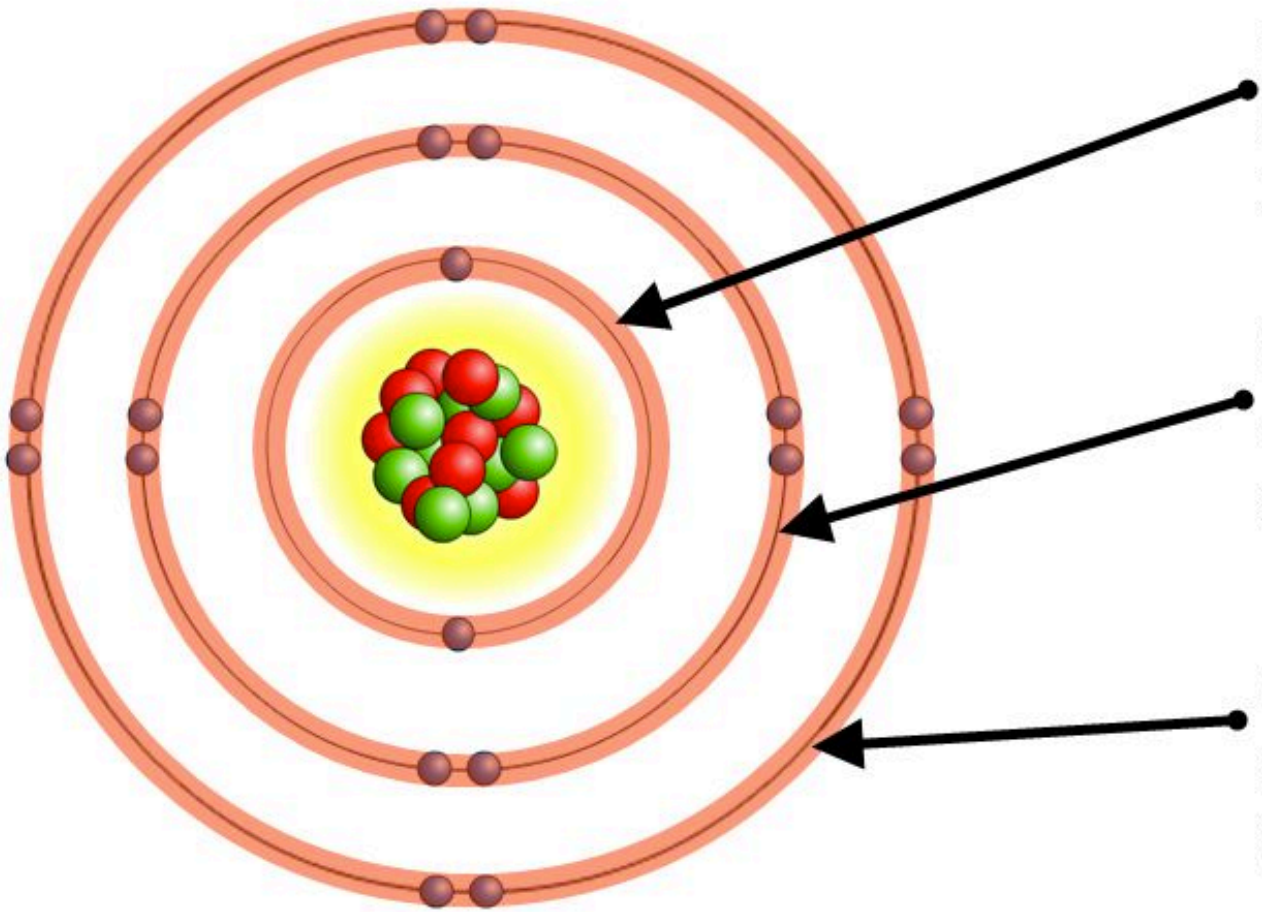
Electron Arrangement

Electrons are arranged around the nucleus in a series of **shells.** or **energy levels**.

Each shell has a **maximum number of electrons** that it can hold.

The negatively-charged electrons are attracted to the positively-charged nucleus, so they **fill the shells nearest to the nucleus first**.

Drawing atoms with electrons in shells



1st shell holds a maximum of 2 electrons

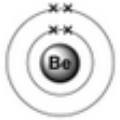
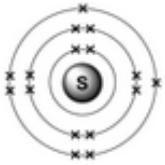
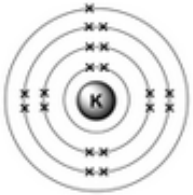
2nd shell holds a maximum of 8 electrons

3rd shell takes 8 electrons before the 4th shell starts to fill

This electron arrangement is written as 2,8,8.

Can you work out which element this atom is?

GROUP

PERIOD	1	2	3	4	5	6	7	8/0
1	 hydrogen 1							 helium 2
2	 lithium 2.1	 beryllium 2.2	 boron 2.3	 carbon 2.4	 nitrogen 2.5	 oxygen 2.6	 fluorine 2.7	 neon 2.8
3	 sodium 2.8.1	 magnesium 2.8.2	 aluminium 2.8.3	 silicon 2.8.4	 phosphorus 2.8.5	 sulfur 2.8.6	 chlorine 2.8.7	 argon 2.8.8
4	 potassium 2.8.8.1	 calcium 2.8.8.2						

What patterns are there?

For any atom we can predict the **number of shells** and the **number of outer shell electrons:**

Periods - each row corresponds to a new electron shell
- **number of shells = period number**

Groups - every element in a Group has the same number of electrons in its outer shell
- **number of outer shell electrons = Group number**

After Period 2, the shells can contain MORE than 8 electrons, but this is beyond the scope of IGCSE. Use the rules above, rather than assuming a shell is full with 8.

Which of the following is the electron arrangement for Tellurium?

A: 2, 8, 8, 8, 6

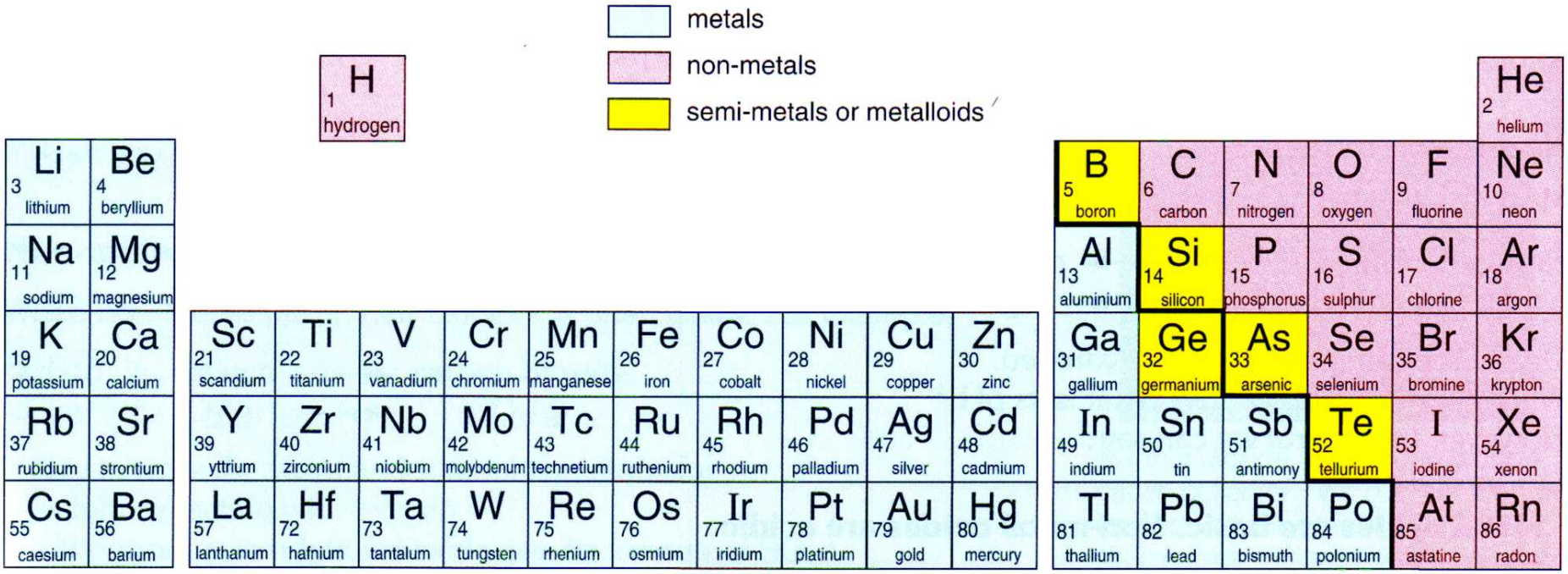
B: 2, 8, 8, 8, 8, 8, 8, 2

C: 2, 8, 18, 18, 6

D: 2, 8, 8, 14, 14

It is in period 5, so has 5 shells
It is in group 6, so has 6 outer shell electrons
Only answer that fits: **2, 8, 18, 18, 6**

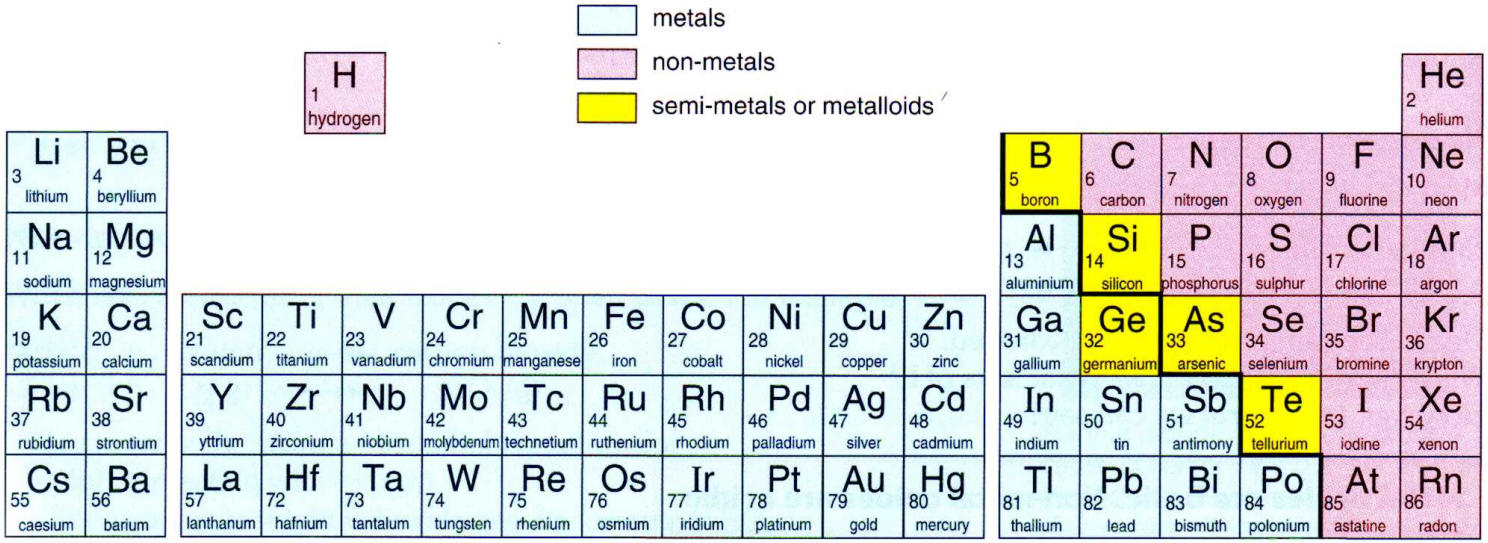
Metals and Non-metals



Lightly shade the Periodic Table in the back of your exercise book to show metals, semi-metals and non-metals

Metallic elements occupy the **left side and middle** of the periodic table.

Non-metals are found on the **right** side of the periodic table.

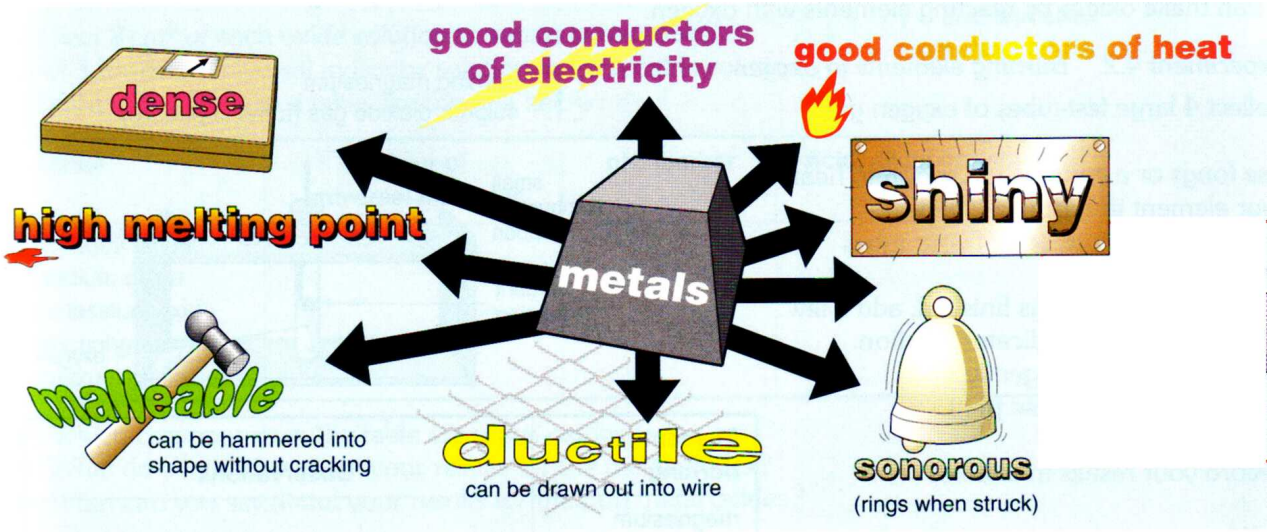


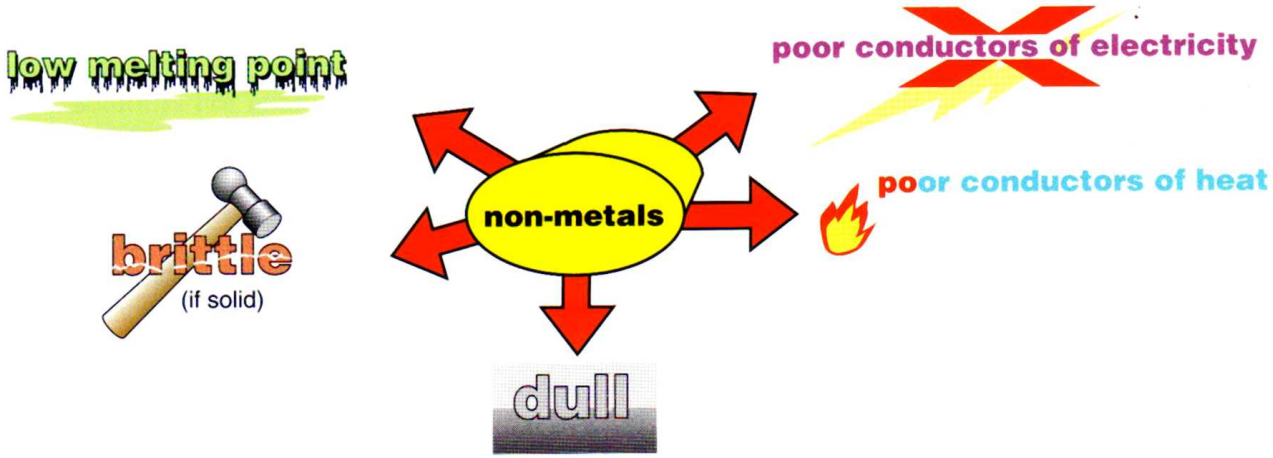
Metals and non-metals can be told apart by their different **physical properties** and by their different **chemical properties**.

Physical properties are characteristics of substances which don't involve reactions – for example melting or boiling points.

Key Difference:

- Metals conduct electricity
- Non-metals (except graphite) do not conduct electricity





Chemical properties include how reactive a substance is, and what reactions it can do.

Key Difference:

- oxides of **metals** form **alkaline** solutions in water

- oxides of **non-metals** form **acidic** solutions in water

Experiments to show that magnesium is a metal

electrical conductivity test:
conducts electricity

burning to form magnesium oxide, dissolving magnesium oxide in water, and testing pH:
alkaline solution

Experiments to show that sulphur is a non-metal

electrical conductivity test:
does not conduct electricity

burning to form sulphur dioxide, dissolving sulphur dioxide in water, and testing pH:
acidic solution

Chemical Families

Elements in the same Group have the same number of outer shell electrons.

Chemical properties are determined by the number of outer shell electrons.

This means elements in the **same Group** have **similar chemical properties** – so each Group is a chemical family.

Group 0 – The Noble Gases

Group 1 – The Alkali Metals

Group 7 – The Halogens

The noble gases

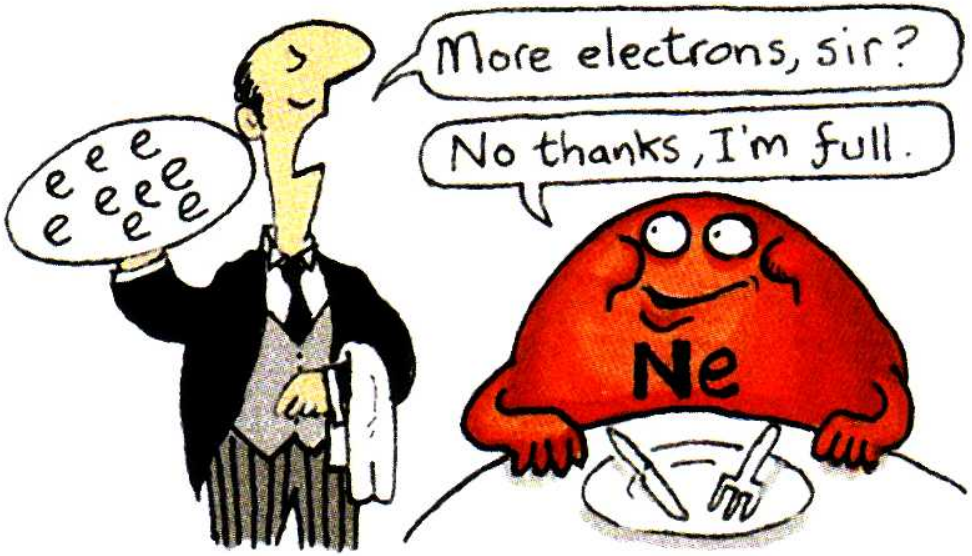
The noble gases prefer to be alone

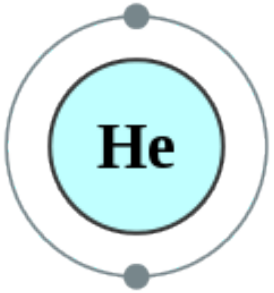
The noble gases are in Group 0 (or 8)

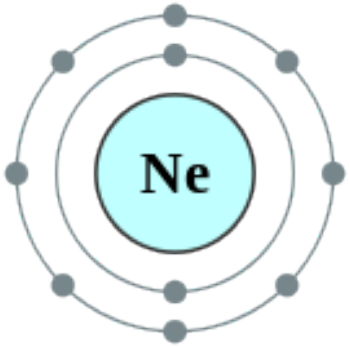
Appearance: They are colourless gases

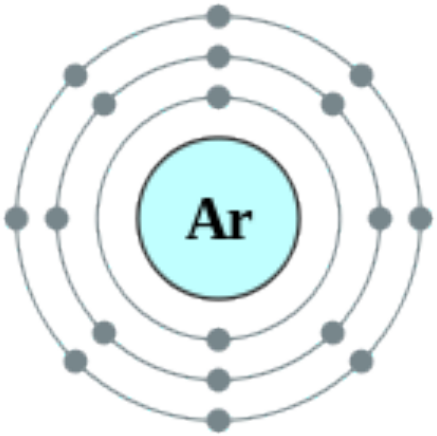
Reactivity: They are very unreactive

Electron arrangement: The have a full outer shell.









They do not readily react because they have a **full outer shell** and therefore **don't form stable ions**.

It takes a lot of energy to rearrange the **full outer shell** so that it could form bonds with other atoms, so this doesn't happen either.