2.1.1 Atomic Structure

Details of the three Sub-atomic (fundamental) Particles

Particle	Position	Relative Mass	Relative Charge
Proton	Nucleus	1	+1
Neutron	Nucleus	1	0
Electron	Orbitals	1/1800	-1

There are various models for atomic structure

An atom of Lithium (Li) can be represented as follows:

Mass Number → 7 Li ← Atomic Symbol

Atomic Number → 3

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

The **atomic number**, Z, is the number of protons in the nucleus.
The **mass number** ,A, is the total number of protons and neutrons in the atom.

Number of neutrons = A - Z

Isotopes

Isotopes are atoms of same element with the same number of protons, but different numbers of neutrons.

Isotopes have similar chemical properties because they have the same electronic structure. They may have slightly varying physical properties because they have different masses.

DEFINITION: **Relative Isotopic mass** is the **mass** of one isotope compared to one twelfth of the mass of one atom of carbon-12

DEFINITION: **Relative atomic mass** is the weighted mean **mass** of one atom compared to one twelfth of the mass of one atom of carbon-12

DEFINITION: **Relative molecular mass** is the **average mass** of a molecule compared to one twelfth of the mass of one atom of carbon-12

Calculating the Relative Atomic Mass of an Element

The relative atomic mass quoted on the periodic table is a weighted mean mass of all the isotopes- taking into account the relative abundances of all the isotopes.

$$\text{R.A.M} = \frac{\Sigma\,(\text{isotopic mass x \% abundance})}{100}$$

Percentage Abundance	78.7	10.13	11.17
Relative Isotopic mass	24.00	25.00	26.00
Isotope	Mg^{24}	Mg^{25}	Mg^{26}

For above example of Mg
R.A.M = [(78.7 x 24) + (10.13 x 25) + (11.17 x 26)] /100 = 24.3

$$\text{R.A.M} = \frac{\Sigma\,(\text{isotopic mass x relative abundance})}{\text{total relative abundance}}$$

If relative abundance is used instead of percentage abundance use this equation

Example: Calculate the relative atomic mass of tellurium from the following abundance data:
124-Te relative abundance 2; 126-Te relative abundance 4; 128-Te relative abundance 7;
130-Te relative abundance 6

$$\text{R.A.M} = \frac{[(124\text{x}2) + (126\text{x}4) + (128\text{x}7) + (130\text{x}6)]}{19}$$

$$= 127.8$$

Example: Copper has two isotopes 63-Cu and 65-Cu. The relative atomic mass of copper is 63.5. Calculate the percentage abundances of these two isotopes.

$63.55 = yx63 + (1-y)x65$

$63.55 = 63y + 65 - 65y$

$63.55 = 65 - 2y$

$2y = 1.45$

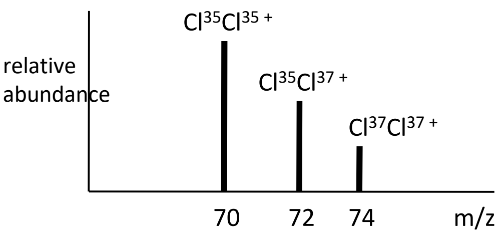
$y = 0.725$

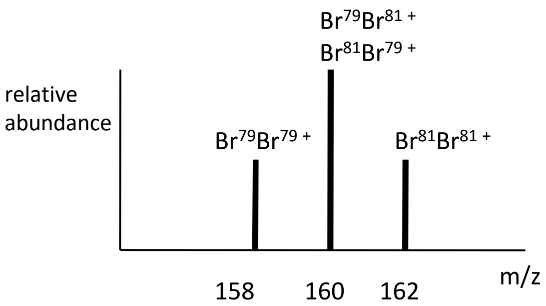
%abundance 63-Cu =72.5% %abundance 65-Cu = 27.5%

Mass spectra for Cl_2 and Br_2

Cl has two isotopes Cl^{35} (75%) and Cl^{37}(25%) Br has two isotopes Br^{79} (50%) and Br^{81}(50%)

These lead to the following spectra caused by the diatomic molecules





The 160 peak has double the abundance of the other two peaks because there is double the probability of 160 Br^{79}-$Br^{81\,+}$ as can be Br79-Br81 and Br81-79

2.1.2 Compounds, formulae and equations

Summary of most important ions to know

+1	+2	+3	-3	-2	-1
Group 1 Hydrogen Silver Gold **Ammonium (NH_4^+)**	Group 2 Zinc Copper (II) Iron (II) Tin Lead	Group 3 Iron (III)	Group 5 Phosphate (PO_4^{3-})	Group 6 **Carbonate (CO_3^{2-})** **Sulfate (SO_4^{2-})**	Group 7 **Nitrate (NO_3^-)** **Hydroxide (OH^-)**

How to work out the formula from the ionic charge

What is the formula of lithium sulfate?

1. Identify the ionic charges of the two ions

   Lithium is in group 1 so has a +1 charge, Li^+

   sulfates have a -2 charge, SO_4^{2-}

2. Combine the ions together to get a neutral compound. i.e. combine so that the total +ve charge cancels out the total –ve charge

Li^+ **Li^+** **SO_4^{2-}**

We need two lithium ions to cancel out the -2 charge on the sulfate

The formula is therefore **Li_2SO_4**

What is the formula of calcium phosphate?

1. Identify the ionic charges of the two ions

   Calcium is in group 2 so has a +2 charge, Ca^{2+}

   Phosphates have a -3 charge, PO_4^{3-}

2. Combine the ions together to get a neutral compound. i.e. combine so that the total +ve charge cancels out the total –ve charge

We need to multiply up to get the same charge. Three calcium ions would produce +6 charge to cancel out the -6 charge on two phosphate ions

The formula is therefore Ca_3**$(PO_4)_2$**

Only use brackets when there is more than one of the compound ion in the formula.

e.g. Copper nitrate is $Cu(NO_3)_2$

Calcium hydroxide is $Ca(OH)_2$

Ammonium sulfate is $(NH_4)_2SO_4$

Writing ionic equations

We usually write ionic equations to show the key changes in a reaction. Ionic equations only show the ions that are reacting and leave out spectator ions.

Spectator ions are ions that are not
- Not changing state
- Not changing oxidation number

Take full equation

$$Pb(NO_3)_2\ (aq) + 2NaCl\ (aq) \rightarrow PbCl_2\ (s) + 2\ NaNO_3\ (aq)$$

Separate (aq) solutions into ions

$$Pb^{2+}_{(aq)} + 2NO_3^-{}_{(aq)} + 2Na^+{}_{(aq)} + 2Cl^-{}_{(aq)} \rightarrow PbCl_{2\ (s)} + 2\ Na^+{}_{(aq)} + 2NO_3^-{}_{(aq)}$$

Cancel out spectator ions leaving ionic equation

$$Pb^{2+}_{(aq)} + 2Cl^-{}_{(aq)} \rightarrow PbCl_{2\ (s)}$$