Topic 1a – Atomic Structure
Revision Notes

1) Fundamental particles

- Atoms consist of protons, neutrons and electrons
- Protons and neutrons are found in the nucleus which contains most of the mass of the atom and all of the positive charge
- The neutrons help to reduce repulsion between the positively charged protons
- The electrons are arranged in energy levels (shells) around the nucleus
- The electron arrangement of an element determines its chemical properties i.e. what reactions it does

	Relative mass	Relative charge
Proton	1	+1
Neutron	1	0
Electron	1/2000	-1

2) Mass number and isotopes

- Atomic number = number of protons in the nucleus
- Mass number = number of protons and neutrons in the nucleus
- Number of neutrons = mass number – atomic number
- Number of electrons = number of protons (in a neutral atom)

$^{9}_{4}Be$ Mass number = 9 Atomic number = 4

4 protons, 5 neutrons, 4 electrons

3) Isotopes

- Isotopes have the same number of protons but different numbers of neutrons
- For example, chlorine has two isotopes ^{35}Cl and ^{37}Cl. Both have 17 protons but they have 18 and 20 neutrons, respectively
- Isotopes of an element have the same chemical properties because they have the same electron arrangement
- Isotopes of an element may have different physical properties, such as rate of diffusion, because they have different masses

4) Ions

- Ions are formed when atoms gain or lose electrons
- As an atom Cl has 17 electrons. A Cl^- ion has gained one electron so it now has 18
- As an atom Na has 11 electrons. An Na^+ ion has lost one electron so it now has 10
- Early models of atomic structure predicted that atoms and ions with noble gas electron arrangements should be stable e.g. Cl^- has the same electron arrangement as argon and Na^+ has the same electron arrangement as neon

Topic 1b – Formulae & Equations
Revision Notes

1) Formulae

a) Elements

- For most elements the formula is just the symbol e.g. Na for sodium, S for sulphur
- The exceptions are the seven diatomic elements – H_2, N_2, O_2, F_2, Cl_2, Br_2 and I_2

b) Ionic compounds

- Compounds of a metal and a non-metal are made of ions.
- Metal ions have a positive charge and non-metal ions have a negative charge.
- To work out the formula of an ionic compound
    - Write the formulae of the ions
    - Adjust the number of each ion so that there is no overall charge

Example 1 – magnesium bromide	Example 2 – aluminium nitrate
Ions are Mg^{2+} and Br^- Need 2 x Br^- to balance Mg^{2+} Formula is $MgBr_2$	Ions are Al^{3+} and NO_3^- Need 3 x NO_3^- to balance Al^{3+} Formula is $Al(NO_3)_3$

- The formulae for ions are given on the attached sheet. This sheet is <u>not</u> available in exams so the formulae will have to be learnt.

c) Covalent compounds

- Some formulae for covalent compounds can be worked out from the name.
- The prefix mono- means one, di- means two and tri- means three.
- Therefore, carbon monoxide is CO, silicon dioxide is SiO_2 and sulphur trioxide is SO_3
- Other formulae have to be learnt e.g. ammonia is NH_3 and methane is CH_4

2) Equations

- **There are no word equations at A-level. An equation means a balanced symbol equation.**
- To write a balanced symbol equation:
    - Identify the reactants and products
    - Write a word equation
    - Write down the formula for each substance
    - Balance the equation by putting numbers in front of formulae
    - Add state symbols (s), (l), (g) or (aq)

Example – marble chips and hydrochloric acid

Reactants are calcium carbonate and hydrochloric acid
Products are calcium chloride, carbon dioxide and water

Calcium carbonate + hydrochloric acid $\rightarrow$ calcium chloride + carbon dioxide + water
$CaCO_3 + HCl \rightarrow CaCl_2 + CO_2 + H_2O$

Ca	1	1
C	1	1
O	3	3
H	1	2
Cl	1	2

2 in front of HCl balances the equation

$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$

Adding state symbols

$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$

Topic 1c – Calculations
Revision Notes

1. Molar Mass

- Molar mass is calculated by adding up the masses of the atoms in the formula
- The percentage of the total made up by a particular element can also be calculated

Example - sodium carbonate, Na_2CO_3

Na	2 x 23.0	= 46.0
C	1 x 12.0	= 12.0
O	3 x 16.0	= 48.0
Total		= 106.0
% by mass of oxygen		= 48.0 x 100/106.0
		= 45.3%

2. Empirical & Molecular Formulae

- Write down mass or % of each element
- Divide each one by the atomic mass of that element
- Find the ratio of the numbers (divide them all by the smallest one)

In a substance containing only sodium, sulphur and oxygen, the composition is found to be 32.4% sodium and 45.0% oxygen. Calculate the substance's empirical formula.

% sulphur = 100 – 32.4 – 45.0
= 22.6%

	Na	S	O
Composition	32.4	22.6	45.0
R.a.m.	23.0	32.1	16.0
Comp/r.a.m.	1.41	0.70	2.81
÷ by smallest	2.01	1	4.01

Empirical formula is Na_2SO_4

- Molecular formula is a multiple of empirical formula

Empirical formula = CH_2O & M_r = 60. Find molecular formula. Empirical mass = 30 so molecular formula = 2 x empirical formula = $C_2H_4O_2$

3) Atom economy

$$\textbf{Atom economy} = \frac{\textbf{Molecular mass of desired product}}{\textbf{Molecular masses of all products}} \times 100\%$$

Example

Bromoethane, CH_3CH_2Br, reacts with sodium hydroxide to produce ethanol, CH_3CH_2OH.

$$CH_3CH_2Br + NaOH \rightarrow CH_3CH_2OH + NaBr$$

In the above example

Molecular mass of desired product	= 46.0
Molecular masses of all products	= 46.0 + 102.9
	= 148.9
Atom economy	= 46.0/148.9 x 100%
	= 30.9%

- Chemical processes with a high atom economy produce fewer waste materials
- Atom economy can be improved by finding a use for waste product