Wigston College A level Chemistry

Transition Pack

Name: ……………………………………

Symbols of Common Atomic and Molecular Ions

Atomic Ions		Molecular Ions	
Name	**Symbol**	**Name**	**Symbol**
aluminium	Al^{3+}	ammonium	NH_4^+
barium	Ba^{2+}	carbonium	R^+
calcium	Ca^{2+}	hydroxonium	H_3O^+
cobalt (II)	Co^{2+}	amide	NH_2^-
copper (II)	Cu^{2+}	carbonate	CO_3^{2-}
hydrogen	H^+	carboxylate	$RCOO^-$
iron (II)	Fe^{2+}	hydrogencarbonate	HCO_3^-
iron (III)	Fe^{3+}	hydrogensulphate (VI) (hydrogensulphate)	HSO_4^-
lead (II)	Pb^{2+}	hydroxide	OH^-
magnesium	Mg^{2+}	nitrate (V) (nitrate)	NO_3^-
manganese (II)	Mn^{2+}	nitrate (III) (nitrite)	NO_2^-
mercury (II)	Hg^{2+}	sulphate (VI) (sulphate)	SO_4^{2-}
potassium	K^+	sulphate (IV) (sulphite)	SO_3^{2-}
silver	Ag^+	chlorate (I) (hypochlorite)	ClO^-
sodium	Na^+	chlorate (V) (chlorate)	ClO_3^-
bromide	Br^-	vanadate (V)	VO_3^-
chloride	Cl^-	manganate (VII) (permanganate)	MnO_4^-
hydride	H^-	chromate (VI)	CrO_4^{2-}
iodide	I^-	dichromate (VI)	$Cr_2O_7^{2-}$
nitride	N^{3-}		
oxide	O^{2-}		
phosphide	P^{3-}		
sulphide	S^{2-}		

Introduction.

This transition pack deals with what we might call the "language of chemistry". Without being able to handle formulae and equations most of chemistry will be very difficult indeed. Consider waking up one day without the facility you have in the English language. You decide to read your favourite book, and… well: you can imagine the trouble you will encounter! A very high proportion of the problems you solve as part of AS chemistry will need an equation for a reaction. Usually you will have to work this out for yourself but, even if it is given in the question, you have to be able to interpret it properly. If you became adept at writing equations at GCSE then feel relieved. If not, take your time working through this material. There is no short cut – it just takes patience and practice. Patience: to write out lists of ions and learn them (eg all the 1+ ones, then all the 1- ones, then all the 2+ ones etc.). Practice: to do this over and over again until you get full marks every time.

Formulae.

Working out formulae for ionic compounds.

You can't write equations until you can write formulae. The formulae for common covalent substances such as methane, carbon dioxide, sulphuric acid and water have to be remembered and will rarely have to be worked out. That isn't true for ionic compounds. You need to know the symbols and charges of the common ions and how to combine them into a formula.

The need for equal numbers of "pluses" and "minuses".

Ions are atoms or groups of atoms (molecules) which carry electrical charges – either positive (cations) or negative (anions). Compounds are uncharged (electrically neutral). In an ionic compound there must therefore be exactly the right number of each sort of ion so that the total charge is zero (pluses equal minuses). Obviously, then, to work out a formula you need to know the charges on the ions. There are some ideas from GCSE that will help you.

Atomic ions deduced from position in the Periodic Table.
For a main group metal: charge is positive and equals the group number;

For a non-metal: charge is negative and equals 8 – the group number.

Transition elements (mainly!): a Roman numeral (I, II, III, V etc.) tells you the charge. It will be positive, like all metals.

Molecular ions.
These have to be learnt but you will already be familiar with many of them. A good idea is to put them on flashcards with the name on one side and the formula on the other. Get someone at home to work with you – your family will be delighted to help (although you will probably have to train them in pronunciation!) They show you one side or the other and you give them the name or formula visible to them. Keep going until you get 100% right!

Care with endings.
Anions such as sulphide and sulphate are often confused. If the ending is "-ide" then the anion is that element only. The ending " –ate" means there is another element present – usually oxygen but not always. Thus magnesium sulphide is MgS but magnesium sulphate is $MgSO_4$. There's another ending – "ite" – which shows oxygen is there again, but less than before. Hence magnesium sulphite is $MgSO_3$. You will see from the table that the use of these endings doesn't always imply the same amount of oxygen. A consistent modern way of naming compounds has been developed using Roman numerals again but until we study Oxidation Number a little way into the AS course it won't make much sense. The modern names appear first in the table with the older name

in brackets. For the time being, learn the latter – chemists still use them as they're more convenient!

Working out the formula of an ionic compound – examples.

1.Sodium oxide:

sodium is in group 1 so its ion is Na^{+};

oxygen is in group 6 so its ion is O^{2-}.

To get equal numbers of positive and negative charges there have to be two sodium ions for each oxide ion so: Na_2O.

2. Calcium nitrate:

calcium is in group 2 so its ion is Ca^{2+};

nitrate ion is NO_3^- (has to be learnt).

To get equal numbers of positive and negative charges there have to be two

nitrate ions for each calcium ion so: $Ca(NO_3)_2$.

Notice the brackets around the molecular ion. They are necessary if there are more than one molecular ion but are never needed for atomic ions.

3.Ammonium carbonate:

ammonium ion is NH_4^+ (has to be learnt);

carbonate ion is CO_3^{2-} (has to be learnt).

To get equal numbers of positive and negative charges there have to be two ammonium ions for each carbonate ion so: $(NH_4)_2CO_3$

Iron (III) sulphate:

iron (III) tells you the ion is Fe^{3+};

sulphate ion is SO_4^{2-} (has to be learnt).

To get equal numbers of positive and negative charges there have to be two

iron (III) ions for three sulphate ions so: $Fe_2(SO_4)_3$

Where have all the charges gone?
They're still there! In fact you sometimes see them written if there's a particular point to be made: Li^+Br^- But they're left out most of the time.

Exercise 1.
Work out the formulae of the following compounds:

Lead (II) oxide, sodium bromide, magnesium sulphate, zinc chloride, potassium carbonate, ammonium sulphide, calcium nitrate, iron (III) hydroxide, iron (II) sulphate, copper (II) carbonate, aluminium sulphate, calcium hydroxide, cobalt (II) chloride, calcium oxide, silver nitrate, iron (III) fluoride, ammonium nitrate, rubidium iodide, sodium sulphate, chromium (III) oxide, magnesium phosphate.

Writing Equations.

What all the numbers mean.

There are two types of number in equations. The little ones that appear subscripted in formulae only apply to the atom just before them. They show how many of that atom there are in the formula eg in H_2SO_4 the 2 applies only to the hydrogen atoms and tells you that there are 2 in the sulphuric acid molecule. The 4 only applies to the oxygen and tells you that there are 4 atoms of it in the molecule. Clearly, these numbers are fixed – the formula is what the formula is and cannot be changed! As in maths, brackets mean that everything between them is multiplied by the number outside eg in $Ca(OH)_2$ there are 2 oxygen atoms and 2 hydrogens. Writing $CaOH_2$ means 1 oxygen and 2 hydrogens. In fact, this substance does not exist! Where there is no number it means only 1 of that atom: so in the formulae above there is 1 sulphur atom (in H_2SO_4) and one calcium atom (in $Ca(OH)_2$).

The second type of number appears in front of a formula and applies to the whole of that formula, multiplying it up. For example, $2H_2O$ means 4 hydrogen atoms and 2 oxygen ones. $4HNO_3$ means 4 hydrogen atoms, 4 nitrogen atoms and 12 oxygen atoms. Unlike the numbers in a formula you can write any one you need in front of a formula. The rather grand-sounding name for these numbers is stoichiometric coefficients! (SCs from now on).

Balancing Equations.

This means putting SCs before formulae to make sure there is the same number of atoms of each type on both sides of the "gives" arrow (NB don't say "equals" or "goes to". These are both wrong, despite what you may have learned already).

There are no rules for this – but be organised and use common sense:

- Work along the equation from left to right.
- Check each element in turn unless an element appears in several places in the equation - the rest of the balancing often sorts out elements like this.
- Leave any element on its own until last – its amount can be altered without affecting any other elements.
- If there's a group of atoms that stays together (eg sulphate ion, ammonium ion)from one side to the other, count it as a group – don't count the individual atoms (ie sulphurs and oxygens; nitrogens and hydrogens).
- Check at the end to make sure the equation is balanced.
- SCs don't have to be whole numbers. Leaving them as fractions isn't wrong – in fact some equations need this – but it is unusual. Multiply up the SCs to eliminate fractions.

Writing equations - examples.

1. $Zn + HCl \rightarrow ZnCl_2 + H_2$
   Working left to right, zinc balances. Only one hydrogen on the left and two on the right so we have to put 2HCl as we can't do H_2Cl:

$Zn + 2HCl \rightarrow ZnCl_2 + H_2$

Notice how the chlorine is now balanced too. Bonus!

2. $AgNO_3 + CaCl_2 \rightarrow Ca(NO_3)_2 + AgCl$
   Working left to right, silver balances. As the nitrate ion is unchanged it can be left intact. Two are needed on the left:

   $2AgNO_3 + CaCl_2 \rightarrow Ca(NO_3)_2 + AgCl$

   Continuing left to right, calcium is fine but chlorine isn't. Two on the left and one on the right means we need 2AgCl:

   $2AgNO_3 + CaCl_2 \rightarrow Ca(NO_3)_2 + 2AgCl$

   This also balances the silver which became unbalanced after the nitrate was dealt with. This doesn't always happen which is why the equation should be checked at the end for balance – elements that balanced earlier may become unbalanced!

3. $Pb(NO_3)_2 \rightarrow PbO + NO_2 + O_2$

   Work left to right: lead balances. There are two nitrogens on the left but only one on the right so:

   $Pb(NO_3)_2 \rightarrow PbO + 2NO_2 + O_2$

   Finally balance the oxygen. Six on the left but seven on the right. Here's a wheeze: halving the oxygen molecule on the right solves the problem:

   $Pb(NO_3)_2 \rightarrow PbO + 2NO_2 + 1/2O_2$

   Now, this does look odd. Just doubling everything gets rid of the half though; and, of course, the equation is still balanced:

   $2Pb(NO_3)_2 \rightarrow 2\ PbO + 4NO_2 + O_2$

Check it yourself!

Exercise 2.

Balance the following equations:

a) $Ca + H_2O \rightarrow Ca(OH)_2 + H_2$
b) $Al + Cr_2O_3 \rightarrow Al_2O_3 + Cr$
c) $Fe_2O_3 + CO \rightarrow Fe + CO_2$
d) $CH_4 + O_2 \rightarrow CO_2 + H_2O$
e) $C_8H_{18} + O_2 \rightarrow CO_2 + H_2O$
f) $NaHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + CO_2 + H_2O$
g) $NH_3 + O_2 \rightarrow NO + H_2O$

Exercise 3.

Rewrite the following word equations as balanced symbol equations:

a) Potassium + chlorine → potassium chloride
b) Rubidium + water → rubidium hydroxide + hydrogen
c) Caesium hydroxide + sulphuric acid → caesium sulphate + water
d) Lithium carbonate + hydrochloric acid → lithium chloride + carbon dioxide + water
e) Iron (III) oxide + nitric acid → iron (III) nitrate + water.
f) Ammonium dichromate → Chromium (III) oxide + water + nitrogen

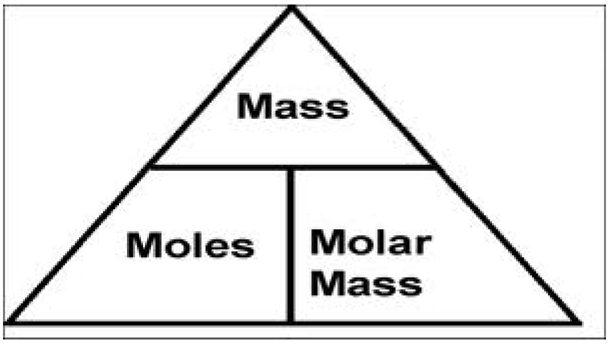
How can you work out how many moles you have?

a) From a measurement of **MASS**:

You can find the number of moles of a substance if you are given its **mass** and you know its **molar mass**:

number of moles = mass/molar mass

$n = m/m_r$



Mass MUST be measured in grams!

Molar mass has units of $gmol^{-1}$

1. Calculate the number of moles present in:	2. Calculate the mass of:	3. Calculate the molar mass of the following substances:
a) 2.3 g of Na	a) 0.05 moles of Cl_2	a) 0.015 moles, 0.42 g
b) 2.5 g of O_2	b) 0.125 moles of KBr	b) 0.0125 moles, 0.50 g
c) 240 kg of CO_2	c) 0.075 moles of $Ca(OH)_2$	c) 0.55 moles, 88 g
d) 12.5 g of $Al(OH)_3$	d) 250 moles of Fe_2O_3	d) 2.25 moles, 63 g
e) 5.2 g of PbO_2	e) 0.02 moles of $Al_2(SO_4)_3$	e) 0.00125 moles, 0.312 g

ORGANIC CHEMISTRY

Some key definitions-

- Hydrocarbon - a compounds that is made from hydrogen and carbon only
- Alkane - a hydrocarbon that only has single bonds in it.
- Alkene - a compound that has at least one double bond
- General Formula - the simplest algebraic formula for a compound
- Empirical Formula - a formula showing the lowest whole number ratios of elements in a compound.
- Structural Formula - The minimal amount of detail needed to determine the special arrangement of elements in a compound
- Unsaturated - a compounds that has double or triple bonds
- Alkyl group - a side chain that has been forms from an alkane by removing a hydrogen
- Functional group - the part of an organic compound that is responsible for the properties
- Saturated - a compound that only has single bonds
- Aromatic - a compound that contains a benzene ring
- Alkynes - A compound that has a least one triple bond
- Radical - an element or compound that has an unpaired electron
- Homologous Series - a set of organic compounds with the same functional group
- Displayed formula - This shows that position of all atoms and the bonding between them
- Addition polymerisation - A long chain formed of repeating units, eg alkenes

Naming Organic Compounds – The Rules

The prefix of the name indicates the number of carbon atoms present in the molecule.

The functional group, and hence the homologous series to which the compound belongs is usually indicated by the suffix of the name.

1. Find the longest carbon - carbon chain (not always straight).

2. Identify the side branches.

3. Circle all the functional groups and identify them.

4. Number the chain so that the branch with the highest priority functional group has the lowest number possible.

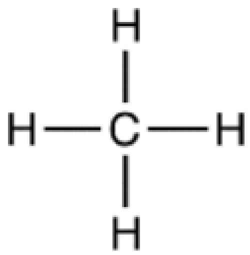
5. Di-, tri etc used for more than one branch of same kind.

6. Branches in alphabetical order.

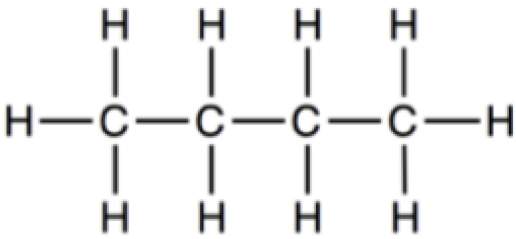
7. Comma's between numbers eg 2,2 or 2,3.

8. Hyphens separate numbers from letters eg 2,2-dimethyl and no gaps between names eg methylpropane

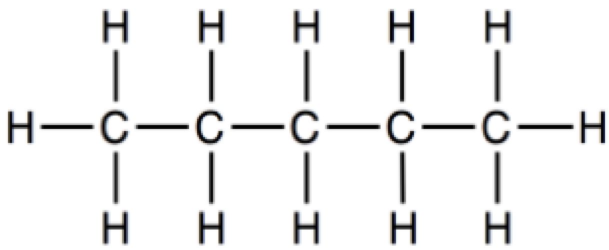
Naming alkanes


1.

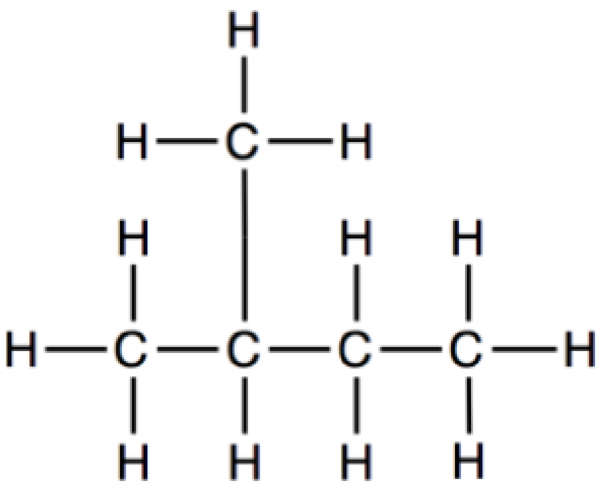
a. methane
b. ethane
c. propane
d. butane


2.

a. butane
b. propane
c. pentane
d. ethane


3.

a. 2-ethylpropane
b. 1-methylbutane
c. pentane
d. 2-methylpentane


4.

a. pentane
b. 2-methylbutane
c. 1-methylbutane
d. 3-methylbutane

You need to familiarise yourself with functional groups of organic chemistry.

The ones that you would come across in AS level are: alkanes, alkenes, alcohols, aldehydes, ketones, esters and carboxylic acids. You should have an understanding of their general formula and be try to identify these functional groups.