Formulae of Compounds

Deducing the Formulae of Ionic Compounds

The formula of a compound indicates the ratio of the elements in the compound. This ratio is fixed and for ionic compounds it is easy to work out the formula from the charges on the ions.

Metal ions (and hydrogen ions) always carry a positive charge, whilst non-metal ions carry a negative charge. If you imagine that a positive charge is a 'hook' and a negative charge is an 'eye' then the formula can be deduced by exactly matching up the hooks and eyes.

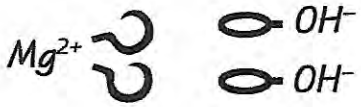
Na^+ *(sodium ion) has +1 charge so 1 hook* OH^- *(hydroxide ion) has -1 charge so 1 eye*
Mg^{2+} *(magnesium ion) has +2 charge so 2 hooks* O^{2-} *(oxide ion) has -2 charge so 2 eyes*

Example 1: What is the formula of sodium oxide?

We need an extra Na^+ to give us a second hook to match the second of the eyes on the O^{2-} ion.

We have 2 Na^+ ions to every O^{2-} ion, so the formula is Na_2O.

Example 2: What is the formula of magnesium hydroxide?



Note the use of a bracket to show 2 lots of OH which is not the same as OH_2. Brackets are most often used when the non-metallic ion contains more than one element.

There are 2 OH^- ions to every Mg^{2+} ion so the formula is $Mg(OH)_2$.

Now try these:

Use the charges on the ions at the bottom of the box to deduce the formulae of the following ionic compounds.

1) *sodium chloride*
2) *calcium bromide*
3) *sodium carbonate*
4) *aluminium oxide*
5) *iron(II) chloride*
6) *potassium oxide*
7) *aluminium chloride*
8) *potassium nitrate*
9) *aluminium sulphate*
10) *iron(III) nitrate*

aluminium: Al^{3+} *bromide: Br^-* *calcium: Ca^{2+}* *carbonate: CO_3^{2-}*
chloride: Cl^- *iron(ii): Fe^{2+}* *iron(iii): Fe^{3+}* *nitrate: NO_3^-*
oxide: O^{2-} *potassium: K^+* *sodium: Na^+* *sulphate: SO_4^{2-}*

Writing and Balancing Equations

Rules for Working out the Products Formed in Reactions

In order to write a balanced symbol equation from scratch you need to be aware of the different ways that compounds react. Many examples involve the reactions of acids to form salts, and it helps if you are aware of some of the rules for working out the names of the products formed from particular reactants.

Making Salts:

1. If *sulphuric acid* is used the salt will be a '_____' sulphate where '_____' is a metal.
2. If *hydrochloric acid* is used the salt will be a '_____' chloride where '_____' is a metal.
3. If *nitric acid* is used the salt will be a '_____' nitrate where '_____' is a metal.

(Sulphuric acid = H_2SO_4 Hydrochloric acid = HCl Nitric acid = HNO_3)

Reactions Involving Acids:

4. Metal + acid → salt + hydrogen
5. Metal oxide + acid → salt + water
6. Metal hydroxide + acid → salt + water
7. Metal carbonate + acid → salt + water + carbon dioxide

Some Other General Rules:

8. Combustion reactions result in the formation of oxides.
9. When fuels burn, carbon dioxide (CO_2) and water (H_2O) are normally produced.
10. Atoms in gases often go round in pairs: H_2, N_2, O_2, Cl_2

Use the ions on the previous page and the rules above to answer the following:

Give the names and formulae of all the products formed in these reactions.

1) aluminium + nitric acid
2) potassium hydroxide + sulphuric acid
3) the complete combustion of propanol (C_3H_7OH) in oxygen
4) calcium carbonate + hydrochloric acid
5) aluminium oxide + sulphuric acid
6) sodium hydroxide + nitric acid
7) zinc + hydrochloric acid

Writing and Balancing Equations

Writing Balanced Equations

To write a balanced symbol equation where reactants are given there are 5 simple steps:

1. Write out the word equation first.
2. Write the correct formula for each compound below its name (see page 26).
3. Go through each element in turn, making sure the number of atoms on each side of the equation balances.
4. If you changed any numbers, do step 3 again.
5. Keep doing this until all the elements balance.

Doing the third step:

If the atoms in the equation don't balance you can't change the molecular formulae — only the numbers in front of them.

For example:

$$MgO + 2HCl \rightarrow MgCl_2 + H_2O$$

There are two Cl on the right of the equation, so we need to have two HCl on the left-hand side. This also doubles the number of hydrogen atoms on the left-hand side, so that the hydrogens balance as well. This always works. If you can't get an equation to balance then it's wrong.

The examples below use the rules from the previous page to write out the word and symbol equations. Read through them and then try the questions on the next page.

Example 1: Write a balanced equation for the combustion of methane (CH_4) in oxygen.

Step 1: (using rule 9) — Methane + oxygen → carbon dioxide + water

Step 2: (using rule 10) — $CH_4 + O_2 \rightarrow CO_2 + H_2O$

Step 3: — $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

(the Cs already balance, put a 2 in front of H_2O to balance the Hs, now put a 2 in front of O_2 to balance the Os. Check that all still balances.)

Example 2: Write a balanced equation for the reaction of magnesium with hydrochloric acid.

Step 1: (using rules 2 and 4) — Magnesium + hydrochloric acid → magnesium chloride + hydrogen

Step 2: (using rule 10) — $Mg + HCl \rightarrow MgCl_2 + H_2$

Step 3: — $Mg + 2HCl \rightarrow MgCl_2 + H_2$

(the Mgs already balance, put a 2 in front of HCl to balance the Hs and Cls. Check that all still balances.)

Writing and Balancing Equations

Combine what you've learnt on the previous three pages to answer the following:

Write balanced symbol equations for these reactions.
(The charges on the ions are given at the bottom of the question box.)

1) *the complete combustion of propane (C_3H_8) in oxygen*
2) *the complete combustion of ethanol (C_2H_5OH) in oxygen*
3) *sodium hydroxide + nitric acid*
4) *potassium oxide + hydrochloric acid*
5) *sodium hydroxide + sulphuric acid*
6) *magnesium carbonate + nitric acid*
7) *sodium carbonate + sulphuric acid*
8) *potassium carbonate + nitric acid*
9) *the complete combustion of octane (C_8H_{18}) in oxygen*
10) *calcium hydroxide + hydrochloric acid*

sodium: Na^+	*chloride: Cl^-*	*oxide: O^{2-}*
carbonate: CO_3^{2-}	*nitrate: NO_3^-*	*magnesium Mg^{+2}*
hydrogen: H^+	*hydroxide: OH^-*	*sulphate: SO_4^{2-}*
potassium: K^+	*calcium: Ca^{2+}*	