GCSE to AS Bridging Materials

Balancing equations

Aims

A word equation simply tells you what substances you have at the start of a reaction (the reactants) and what they have turned into at the end (the products). To explain more about what is really happening you need to be able to write balanced symbol equations. Balanced symbol equations show what is happening to all the atoms involved.

Example

When a chemical reaction happens, all the atoms which are present at the start, on the left-hand side of the arrow, must be there at the end, on the right-hand side of the arrow. A balanced symbol equation should show this. If the numbers don't balance, you need to balance the equation.

Start with the word equation for the reaction of magnesium with oxygen.

magnesium + oxygen → magnesium oxide

Mg + O_2 → MgO

Now count the atoms each side of the arrow:

Mg + → Mg

\+ OO → O

One of the oxygen atoms is missing from the right-hand side. With two oxygen atoms on the left we must be able to make whole units of magnesium oxide. Remember, you cannot change the formula of the molecule. MgO_2 is *not* magnesium oxide. You can add more molecules though, by putting large numbers in front of the molecule.

Let's add another magnesium oxide to the right-hand side and see what happens:

Mg + O_2 → 2MgO

Mg + → MgMg

\+ OO → OO

Remember, 2MgO means two times MgO. Now the oxygen atoms match but we have two magnesium atoms on the right and only one on the left. How can we solve that problem?

If you said put a '2' in front of Mg, you were correct.

2Mg + O_2 → 2MgO

MgMg + → MgMg

\+ OO → OO

Now the equation balances.

Try these questions for yourself. Don't forget to show your working and keep counting the atoms each time you change something.

Questions

Balance the following symbol equations.

1 $H_2 + Br_2 \rightarrow HBr$

2 $Na + Cl_2 \rightarrow NaCl$

3 $CH_4 + O_2 \rightarrow CO_2 + H_2O$

4 $P + Cl_2 \rightarrow PCl_3$

5 $CaCO_3 \rightarrow CO_2 + CaO$

6 $Fe + H_2O \rightarrow H_2 + Fe_3O_4$

Crude oil and fuels

1 The table shows some information about the first four alkanes.

Name of alkane	Formula	Boiling point in °C
Methane	CH_4	–162
	C_2H_6	–88
Propane	C_3H_8	
Butane		0

a **i** Name the alkane missing from the table.

..... (1)

ii What is the formula of butane?

..... (1)

iii Estimate the boiling point of propane.

..... (1)

b Which one of the following is the formula of the alkane with 6 carbon atoms?

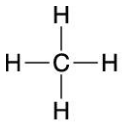
C_6H_6 C_6H_{10} C_6H_{14} C_6H_{16}

..... (1)

c Explain why alkanes are hydrocarbons.

..... (1)

d A molecule of methane can be represented as:



Draw a molecule of propane in the same way.

(2)

2 Some crude oil was distilled in a fractionating column. The table shows the boiling ranges of three of the fractions that were collected.

Fraction	Boiling range in °C
A	60–120
B	160–230
C	240–320

a Which of these fractions is the most flammable?

..... (1)

b Which of these fractions is the most viscous?

..... (1)

c Which of these fractions has the smallest hydrocarbon molecules?

..... (1)

d Why do the fractions have boiling ranges and not boiling points?

..... (1)

3 Some land-fill sites produce a gas that can be collected and burned as a fuel. The gas is mainly methane.

a Choose the word from the list to complete the sentence.

condensed ***distilled*** ***oxidised***

During the combustion of methane the elements in the fuel are .....

(1)

b Write a word equation for the complete combustion of methane, CH_4.

.....

..... (2)

c Under what conditions could methane burn to produce carbon monoxide?

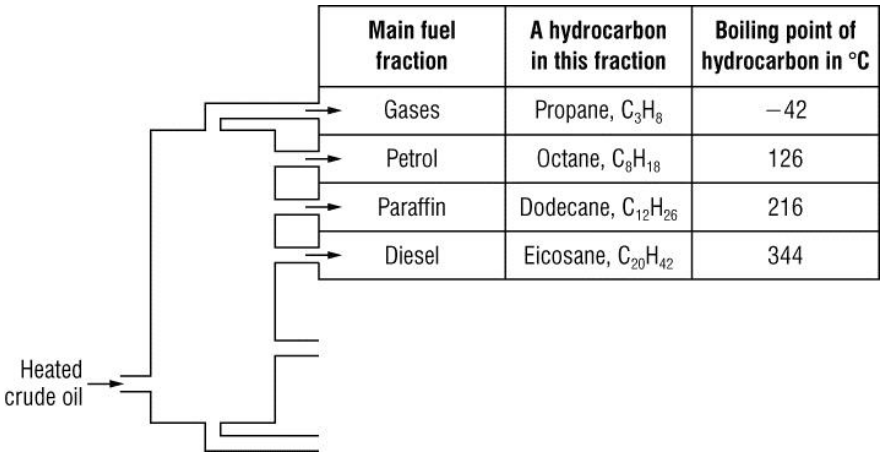
..... (1)

d A sample of land-fill gas was burned. The waste gases contained sulfur dioxide. Explain why.

..... (1)

4 Crude oil is a resource from which fuels can be separated.

a The name of the main fuel fractions and one of the hydrocarbons in each fraction are shown in the table.



Main fuel fraction	A hydrocarbon in this fraction	Boiling point of hydrocarbon in °C
Gases	Propane, C_3H_8	−42
Petrol	Octane, C_8H_{18}	126
Paraffin	Dodecane, $C_{12}H_{26}$	216
Diesel	Eicosane, $C_{20}H_{42}$	344

i How does the number of carbon atoms in a hydrocarbon affect its boiling point?

..... (1)

ii Suggest the lowest temperature to which crude oil needs to be heated to vaporise all the hydrocarbons in the table.

Temperature = ... °C? (1)

iii Dodecane boils at 216 °C. At what temperature will dodecane gas condense to liquid?

Temperature = ... °C? (1)

b *In this question you will be assessed on using good English, organising information clearly and using scientific terms where appropriate.*

Describe and explain how the fractions are separated in a fractionating column.

.....

.....

.....

.....

..... (6)

Fundamental ideas

1 Use numbers from the list to complete the table to show the charge on each subatomic particle. (3)

+2 +1 0 –1 –2

Subatomic particle	Charge
electron	
neutron	
proton	

2 Use the periodic table at the back of your book to help you to answer this question.

a How many protons are in an atom of fluorine?

..... (1)

b How many electrons are in an atom of carbon?

..... (1)

c Complete the electronic structure of aluminium: 2,8, ... (1)

d What is the electronic structure of potassium?

..... (1)

3 Neon is a noble gas.

a What does this tell you about its electronic structure?

..... (1)

b Draw a diagram to show the electronic structure of neon.

(2)

4 **a** Magnesium has the electronic structure 2,8,2. Explain, in terms of its electronic structure, why magnesium is in Group 2 of the periodic table.

..... (1)

b Give **one** way in which the electronic structures of the atoms of Group 2 elements are:

i the same

..... (1)

ii different.

..... (1)

c When magnesium is heated in air it burns with a bright flame and produces magnesium oxide.

Calcium is also in Group 2. Describe what you expect to happen and what would be produced when calcium is heated in air.

.....

..... (2)

5 Sodium reacts with water to produce sodium hydroxide and hydrogen.

The word equation for this reaction is:

sodium + water → sodium hydroxide + hydrogen

a Name one substance in this equation that is:

i an element

..... (1)

ii a compound

..... (1)

iii has ionic bonds

..... (1)

iv has covalent bonds

..... (1)

b If 2.3 g of sodium reacted with 1.8 g of water, what would be the total mass of sodium hydroxide and hydrogen produced? Explain your answer.

.....

..... (2)

c Balance the symbol equation for this reaction.

..... Na + ... H_2O → ..... NaOH + H_2 (1)

d Lithium is in the same group of the periodic table as sodium.

i Write a word equation for the reaction of lithium with water.

..... (1)

ii What is the formula of lithium hydroxide?

..... (1)

iii How many atoms are shown in the formula of lithium hydroxide you have written?

..... (1)

Structure and bonding

Use a periodic table and a table of charges on ions to help you to answer these questions.

1 Choose a word from the list to complete each sentence.

a When metals react with non-metals electrons are ……

combined ***shared*** ***transferred*** (1)

b When non-metal elements combine their atoms are held together by …… bonds.

covalent ***ionic*** ***metallic*** (1)

2 Choose a description from the list for each of the substances.

giant covalent ***giant ionic*** ***metal*** ***simple molecule***

a ammonia, NH_3 ……..

b diamond, C …….

c lithium, Li …….

d sodium oxide, Na_2O …… (4)

3 Choose a number from the list to complete each sentence.

0 1 2 3 4 6 7

a The elements in Group …. in the periodic table all form ions with a charge of 1^+. (1)

b The elements in Group …. in the periodic table all form ions with a charge of 2^-. (1)

c The elements in Group 4 in the periodic table all form …. covalent bonds. (1)

d The aluminium ion has a charge of ….$^+$ (1)

4 **a** Choose the correct formula from the list for iron(III) chloride.

FeCl ***Fe_3Cl*** ***$FeCl_3$*** ***Fe_3Cl_3*** (1)

b Choose the formula from the list for each of these ionic compounds.

NaS ***$NaSO_4$*** ***$Na(SO_4)_2$*** ***Na_2S*** ***NaS_2*** ***Na_2SO_4***

i sodium sulfide …….. (1)

ii sodium sulfate …….. (1)

5 Calcium hydroxide, $Ca(OH)_2$, is an ionic compound.

Which of the ions in the list are the ions in calcium hydroxide?

Ca^+ ***Ca^{2+}*** ***Ca^{4+}*** ***OH^-*** ***OH_2^-*** ***OH^{2-}***

..... (2)

6 Sodium reacts with chlorine. The reaction forms sodium chloride.

a Use words from the list to answer the questions.

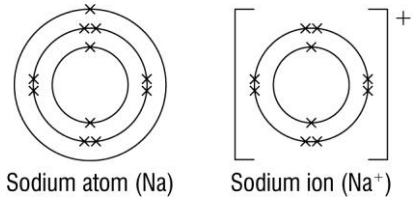
compound ***element*** ***hydrocarbon*** ***mixture***

Which word best describes:

i sodium …… (1)

ii sodium chloride? …… (1)

b When sodium reacts with chlorine the sodium atoms change into sodium ions. The diagrams represent a sodium atom and a sodium ion.

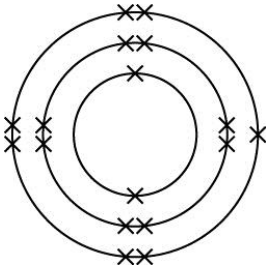


Use the diagrams to help you explain how a sodium atom turns into a sodium ion.

.....

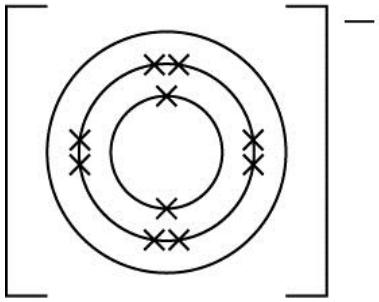
..... (2)

c **i** The diagram below represents a chlorine atom.



When chlorine reacts with sodium the chlorine forms negative chloride ions.

Copy and complete the diagram below to show how the outer electrons are arranged in a chloride ion (Cl^-). (1)



ii Chloride ions are strongly attracted to sodium ions in sodium chloride.

Explain why.

.....

..... (1)

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7 Chlorine can form compounds with ionic or covalent bonds.

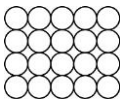
a Potassium chloride, KCl, has ionic bonds. Draw dot and cross diagrams to show what happens to potassium atoms and chlorine atoms when they react to form potassium chloride. You only need to show the outer electrons in your diagrams.

..... (4)

b Hydrogen chloride, HCl, has covalent bonds. Draw a dot and cross diagram to show the bonding in hydrogen chloride.

..... (2)

8 Sodium metal is a giant structure of sodium atoms.



Explain how the atoms are held together in sodium metal.

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..... **[H]** (3)