As Level Chemistry - Flying Start

Subject:	Qualification/Level:	Examination Board
Chemistry	A-Level	OCR
Linear or Modular A level?	**Linear**	

The Summer Transition 'CHALLENGE'
• **To be able to use significant figures and standard form** • **To be able to balance equations** • **To be able to calculate the number of moles of a substance** • **To be able to predict reacting masses**
How the work produced will fit into subsequent work and the specification as a whole.
Part of Module 2
How the work should be presented.
Students should read the instructions and follow the examples to complete the **answers on lined paper**
How the work will be assessed and marked.
A mark scheme will be provided and should be marked with areas of weakness identified in green pen
Success criteria.
(a) Be able to convert into and out of standard form (b) Be able to balance equations accurately (c) Be able to use the correct equation to calculate number of moles (d) Be able to calculate number of moles (e) Be able to use a balanced equation to calculate number of moles – use stoichiometry (f) Be able to calculate mass from number of moles
Resources to be used for this work.
The internet, AS Chemistry head start book **from CGP – ISBN – 978 1 782942801**
Who to contact if you should require further assistance with the work before the end of term?
Mr **A Williams and Miss S Channer**
What equipment will be needed for the subject?
Scientific calculator (Casio fx-85 recommended) **Purchase A level Chemistry book Year 1 book – ISBN – 978-0198351962** **Or** **Purchase A level chemistry book – full course book for 2 year course – ISBN - 978-0198351979**
Extension
In order to extend you knowledge further, please purchase the CGP head start in A level chemistry
To understand more about this subject at a high level:-
- *If you fancy buying a**n additional** book **to the one required for the course,** you should read –* *Calculations in AS/A level chemistry by Jim Clark* *CGP OCR revision guide for AS (then A2)* *Advanced Chemistry for you by Lawrie Ryan* - *Alternatively take a look at some of these websites – **http://www.chemguide.co.uk/*** - ***http://www.docbrown.info/page04/page04.htm*** *or* ***http://www.knockhardy.org.uk/sci.htm***

Standard form and significant figures

Introduction

In the calculations you will be asked to perform as part of your AS studies you will need to be confident with both representing numbers in standard form and giving them to a certain number of significant figures.

When numbers are very large or very small they are written in **standard form**. In standard form a number is written in the format:

$a \times 10^n$ where $1 \leq a < 10$ and n is an integer.

In an experiment, or from a calculation, you may only be able to give your answer with a certain amount of accuracy. This accuracy is shown by giving your answer to a certain number of **significant figures**.

Worked example: Standard form

Question

Express 0.00268 in standard form.

Answer

Step 1

Identify the value for '*a*.' In this case it will be 2.68.

Step 2

Work out how many places the decimal place must be moved to form this number.

0 . 0 0 2 6 8

The decimal place must move 3 places to the right to become 2.68.

This number of places is the value for the integer '*n*.' If the decimal point moves to the right '*n*' is negative. If the decimal place moves to the left '*n*' is positive.

Step 3

Substitute your values into the general format, $a \times 10^n$

Therefore in standard form 0.00268 is 2.68×10^{-3}.

Worked example: Significant figures

Question

Express 0.56480900 to 3 significant figures.

Answer

Step 1

Identify the numbers which are significant using the rules below:

Rule 1 Any number that isn't 0 is significant.

Rule 2 Any 0 that is between two numbers that are not 0 is significant.

Rule 3 Any 0 that is before all the non-zero digits is not significant.

Rule 4 Any 0 that is after all of the non-zero digits is only significant if there is a decimal point.

In this case the significant numbers are 0.**564 809** 00.

Step 2

Identify the three most significant figures. These are the significant numbers which are furthest to the left (have the biggest values), i.e., 0.**564** 809 00.

Step 3

Look at the next number. If this number is 5 or above, then round up. If this number is 4 or less, do not round up.

In this case the next number is 8, so we round up to 0.**565**.

Questions

1 This question is about expressing numbers in standard form.

- **a** Express the following numbers in standard form. (*4 marks*)
  - **i** 0.0023
  - **ii** 1032
  - **iii** 275 000 0
  - **iv** 0.000528
- **b** Write out the following numbers in ordinary form. (*4 marks*)
  - **i** 2.01×10^{3}
  - **ii** 5.2×10^{-2}
  - **iii** 8.41×10^{2}
  - **iv** 1.00×10^{-4}

c For each of the pairs of numbers below identify which is the bigger number. (*3 marks*)

i 1.43×10^{23} or 1.43×10^{24}

ii 5.16×10^{-3} or 5.16×10^{-4}

iii 12.4×10^{23} or 1.50×10^{24}

2 Express the following numbers to the number of significant figures indicated. (*6 marks*)

a 4.74861 to two significant figures

b 507980 to three significant figures

c 809972 to three significant figures

d 06.345 to three significant figures

e 7840 to three significant figures

f 0.007319 to three significant figures

3 Carry out the following calculations expressing the numbers in **standard form** to the degree of accuracy indicated: (*4 marks*)

a $(4.567 \times 10^{5}) \times (2.13 \times 10^{-3})$ to three significant figures

b $(1.567 \times 10^{3}) \div (2.245 \times 10^{-1})$ to four significant figures

c $(5.4 \times 10^{-1}) \div (2.7 \times 10^{-3})$ to one significant figure

d $(2.00 \times 10^{-2}) \times (2.00 \times 10^{-4})$ to three significant figures

Introduction

The *stoichiometry* of a reaction is the whole number ratio in which reactants react and products are produced. We show this stoichiometry for any reaction in a balanced symbol equation. For example the balanced symbol equation for the complete combustion of ethane is:

$$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$$

This means that the ethane and oxygen combine in a molar ratio of 2:7 in the reaction and carbon dioxide and water are produced in a molar ratio of 4:6. At GCSE you might have been taught that only whole numbers can be used to balance symbol equations. However as we now know that we are talking about the number of moles of species and not individual species it is equally correct to show this balanced symbol equation as;

$$C_2H_6 + 3\frac{1}{2}O_2 \rightarrow 2CO_2 + 3H_2O$$

What is important is that the reactants and products are shown in the correct ratio. We use this ratio when calculating amounts of substances reacting.

Worked example

Question

Balance the symbol equation below.

$$Mg_3N_2 + H_2O \rightarrow MgO + NH_3$$

Answer

Step 1

Write out the number of atoms of each element in the reactants and products in the equation as it currently stands:

$Mg_3N_2 + H_2O$		→	$MgO + NH_3$	
Reactants		→	**Products**	
Mg	3		Mg	1
N	2		N	1
H	2		H	3
O	1		O	1

Step 2

Choose one element to balance. Add a big number in front of any of the species until the number of the element in question is the same on either side of the arrow. Remember you cannot change the formula of any species. It is usually easiest to start by choosing an element that is in only one of the reactant species, and generally leave hydrogen and oxygen until later.

In this case we will start by balancing the 'Mg' atoms. By adding a 3 before the MgO we also change the number of 'O' atoms on the right:

$Mg_3N_2 + H_2O$		→	**3** $MgO + NH_3$	
Reactants		→	**Products**	
Mg	3		Mg	~~1~~ 3
N	2		N	1
H	2		H	3
O	1		O	~~1~~ 3

Step 3

Work through each of the elements in turn, balancing the number of atoms on either side of the equation. You may need to also go back and revisit elements that were previously balanced.

In this case we will balance the 'N' atoms followed by the 'H' and finally 'O' atoms.

Balance the 'N' atoms by adding a 2 before the ammonia;

$Mg_3N_2 + H_2O$		→	$3\ MgO + \mathbf{2}\ NH_3$	
Reactants		→	**Products**	
Mg	3		Mg	~~1~~ 3
N	2		N	~~1~~ 2
H	2		H	~~3~~ 6
O	1		O	~~1~~ 3

Balance the 'H' atoms by adding a 3 before the H_2O on the left. This also balances out the 'O' atoms.

$Mg_3N_2 + \mathbf{3}\ H_2O$		→	$3\ MgO + 2\ NH_3$	
Reactants		→	**Products**	
Mg	3		Mg	~~1~~ 3
N	2		N	~~1~~ 2
H	~~2~~ 6		H	~~3~~ 6
O	~~1~~ 3		O	~~1~~ 3

The final balanced symbol equation is therefore;

$Mg_3N_2 + 3H_2O \rightarrow 3MgO + 2NH_3$

Questions

4 Balance the equations below, by balancing the atoms in the order suggested;

- **a** $CH_4 + O_2 \rightarrow CO_2 + H_2O$: balance C, then H, then O
- **b** $KClO_4 \rightarrow KCl + O_2$: balance K, then Cl, then O (*2 marks*)

5 Balance the equations below;

- **a** $Cl_2O_7 + H_2O \rightarrow HClO_4$
- **b** $Ca(OH)_2 + H_3PO_4 \rightarrow Ca_3(PO_4)_2 + H_2O$
- **c** $Al + H_2SO_4 \rightarrow Al_2(SO_4)_3 + H_2$
- **d** $Fe_2O_3 + C \rightarrow Fe + CO_2$ (*4 marks*)

6 Balance the equations below.

HINT. Balance the equations as far as you can using the rules and then increase the reactant species containing the unbalanced atoms 1 mole at a time until the whole equation balances.

- **a** $Cu + HNO_3 \rightarrow Cu(NO_3)_2 + NO_2 + H_2O$
- **b** $S + HNO_3 \rightarrow H_2SO_4 + NO_2 + H_2O$ (*2 marks*)

Introduction

When an equation is balanced it gives us information about the amount of substances that react together and that are produced.

For example, look at the balanced equation for the reaction between magnesium and hydrochloric acid;

$$Mg(s) + 2\ HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

From the equation we know that 1 mol of Mg reacts with 2 mol of HCl to give 1 mol of $MgCl_2$ and 1 mol of H_2 gas. The magnesium reacts with the acid in a 1 : 2 molar ratio.

You'll notice that the total number of moles of reactant does not equal the total number of moles of product. This is because some species may contain more moles of certain atoms than others. For example, 1 mol of HCl contains 1 mol of Cl atoms whereas 1 mol of $MgCl_2$ contains 2 mol of Cl atoms. When balancing an equation we balance the number of individual atoms.

Worked example

Question

Calculate the mass of carbon monoxide needed to produce 11.2 g of iron from the reduction of iron oxide. The equation for the reaction is given below.

$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

Answer

Step 1

Calculate the number of moles in 11.2 g of iron;

$$\text{Moles} = \frac{11.2\ \text{g}}{55.8\ \text{g mol}^{-1}} = 0.2007\ \text{mol}$$

Note: Carry intermediate numbers through as accurately as you can and where possible use the 'Ans' function on your calculator. In this example intermediate values have been written down to one significant figure more than you are going to give the final answer to, but have been carried through on the calculator using the 'Ans' function.

Step 2

Use ratios to determine the number of moles of carbon monoxide required to produce this number of moles of iron. The ratio of CO to Fe is:

3 mol CO : 2 mol of Fe

Divide both sides by 2 to find out how much CO is needed for 1 mol of Fe:

1.5 mol CO : 1 mol Fe

Multiply both sides by 0.2007 to find out how much CO is needed for 0.2007 mol of Fe:

0.3011 mol CO : 0.2007 mol Fe

Step 3

Convert the number of moles of CO into a mass of CO:

$0.3011 \text{ mol} \times 28.0 \text{ g mol}^{-1} = 8.430 \text{ g} = 8.43 \text{ g}$ (to 3 significant figures)

Give your final answer to the same degree of accuracy as the least accurate value given in the question. In this case 3 significant figures.

Questions

7 Sodium hydrogen carbonate can be neutralised by an excess of sulfuric acid as shown by the equation below:

$$2\,NaHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2\,H_2O + 2\,CO_2$$

a Calculate the number of moles in 105 g of $NaHCO_3$. (*1 mark*)

b Hence calculate the amount in moles of Na_2SO_4 which will be produced by the neutralisation of this sample of $NaHCO_3$. (*1 mark*)

c State the mass of Na_2SO_4 which will therefore be produced by this sample of $NaHCO_3$. (*1 mark*)

8 Lead nitrate will react with potassium iodide in a very unusual solid–solid reaction. The equation for the reaction is:

$$Pb(NO_3)_2 + 2\,KI \rightarrow PbI_2 + 2\,KNO_3$$

Calculate the mass of lead iodide that will be produced by the reaction of 14.1 g of potassium iodide with an excess of lead nitrate. (*3 marks*)

9 Solid copper can be prepared from copper oxide by its reaction with ammonia. The equation for the reaction is:

$$3\,CuO + 2\,NH_3 \rightarrow 3\,Cu + N_2 + 3\,H_2O$$

Calculate the mass of copper oxide which would react with 0.425 g of ammonia. (*3 marks*)

Answers

1. **a** **I** 2.3×10^{-3} (*1 mark*)
   ii 1.032×10^{3} (*1 mark*)
   iii 2.75×10^{6} (*1 mark*)
   iv 5.28×10^{-4} (*1 mark*)
   b **i** 2010 (*1 mark*)
   ii 0.052 (*1 mark*)
   iii 841 (*1 mark*)
   iv 0.0001 (*1 mark*)
   c **i** 1.43×10^{24} (*1 mark*)
   ii 5.16×10^{-3} (*1 mark*)
   iii 1.50×10^{24} (*1 mark*)

2.
a 4.7 (*1 mark*)
b 508 000 (*1 mark*)
c 810 000 (*1 mark*)
d 6.35 (*1 mark*)
e 7840 (*1 mark*)
f 0.007 32 (*1 mark*)

3.
a 9.73×10^{2} (*1 mark*)
b 6.980×10^{3} (*1 mark*)
c 2×10^{2} (*1 mark*)
d 4.00×10^{-6} (*1 mark*)

4 **a** $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$ (*1 mark*)
b $KClO_4 \rightarrow KCl + 2\ O_2$ (*1 mark*)

5 **a** $Cl_2O_7 + H_2O \rightarrow 2\ HClO_4$ (*1 mark*)
Balance in the order Cl, H, O
b $3\ Ca(OH)_2 + 2\ H_3PO_4 \rightarrow Ca_3(PO_4)_2 + 6\ H_2O$ (*1 mark*)
Balance in the order Ca, P, H, O
c $2\ Al + 3\ H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3\ H_2$ (*1 mark*)
Balance in the order Al, S, H, O
d $2\ Fe_2O_3 + 3\ C \rightarrow 4\ Fe + 3\ CO_2$ (*1 mark*)
Balance in the order Fe, C, O

6 **a** $Cu + 4\ HNO_3 \rightarrow Cu(NO_3)_2 + 2\ NO_2 + 2\ H_2O$ (*1 mark*)
Balance in the order Cu, N, H, O
b $S + 6\ HNO_3 \rightarrow H_2SO_4 + 6\ NO_2 + 2\ H_2O$ (*1 mark*)
Balance in the order S, N, H, O

7 **a** moles of $NaHCO_3 = \frac{105\ g}{84.0\ g\ mol^{-1}} = 1.25$ mol (*1 mark*)

b 2 $NaHCO_3$: 1 Na_2SO_4, ∴ 1 $NaHCO_3$: 0.5 Na_2SO_4 and

∴ 1.25 mol $NaHCO_3$: 0.625 mol Na_2SO_4 (*1 mark*)

c 0.625 mol × 142.1 g mol^{-1} = 88.81 g = 88.8 g (to 3 significant figures) (*1 mark*)

8 No. of moles in 14.1 g of KI = $\frac{14.1\ g}{166.0\ g\ mol^{-1}} = 0.08494$ mol (*1 mark*)

2KI : 1PbI_2, therefore moles of PbI_2 produced = $\frac{0.08494\ mol}{2} = 0.04247$ mol (*1 mark*)

Mass of PbI_2 produced = 0.04247 mol × 461.0 g mol^{-1} = 19.57 g = 19.6 g (to 3 significant figures) (*1 mark*)

9 No. of moles in 0.425 g of $NH_3 = \frac{0.425\ g}{17.0\ g\ mol^{-1}} = 0.025$ mol (*1 mark*)

3 CuO : 2 NH_3, therefore moles of CuO needed = $\frac{0.025}{2} \times 3 = 0.0375$ mol (*1 mark*)

Mass of CuO needed = 0.0375 mol × 79.5 g mol^{-1} = 2.981 g = 2.98 g (to 3 significant figures). (*1 mark*)