Transition from GCSE to A Level

Moving from GCSE Science to A Level can be a daunting leap. You'll be expected to remember a lot more facts, equations, and definitions, and you will need to learn new maths skills and develop confidence in applying what you already know to unfamiliar situations.

This worksheet aims to give you a head start by helping you:

- to pre-learn some useful knowledge from the first chapters of your A Level course
- understand and practice of some of the maths skills you'll need.

Learning objectives

After completing the worksheet you should be able to:

- define practical science key terms
- recall the answers to the retrieval questions
- perform maths skills including:
  - converting between units and standard form and decimals
  - balancing chemical equations
  - rearranging equations
  - calculating moles and masses
  - calculating percentage yield and percentage error
  - interpreting graphs of reactions.

Retrieval questions

You need to be confident about the definitions of terms that describe measurements and results in A Level Chemistry.

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many answers as you can. Check and repeat.

Practical science key terms

When is a measurement valid?	when it measures what it is supposed to be measuring
When is a result accurate?	when it is close to the true value
What are precise results?	when repeat measurements are consistent/agree closely with each other
What is repeatability?	how precise repeated measurements are when they are taken by the *same* person, using the *same* equipment, under the *same* conditions
What is reproducibility?	how precise repeated measurements are when they are taken by *different* people, using *different* equipment
What is the uncertainty of a measurement?	the interval within which the true value is expected to lie
Define measurement error	the difference between a measured value and the true value
What type of error is caused by results varying around the true value in an unpredictable way?	random error
What is a systematic error?	a consistent difference between the measured values and true values
What does zero error mean?	a measuring instrument gives a false reading when the true value should be zero
Which variable is changed or selected by the investigator?	independent variable
What is a dependent variable?	a variable that is measured every time the independent variable is changed
Define a fair test	a test in which only the independent variable is allowed to affect the dependent variable
What are control variables?	variables that should be kept constant to avoid them affecting the dependent variable

Atoms, ions, and compounds

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many answers as you can. Check and repeat.

What does an atom consist of?	a nucleus containing protons and neutrons, surrounded by electrons
What are the relative masses of a proton, neutron, and electron?	1, 1, and $\frac{1}{1836}$ respectively
What are the relative charges of a proton, neutron, and electron?	+1, 0, and -1 respectively
How do the number of protons and electrons differ in an atom?	they are the same because atoms have neutral charge
How does the number of protons differ between atoms of the same element?	it does not differ – all atoms of the same element have the same number of protons
What force holds an atom nucleus together?	strong nuclear force
What is the proton number / atomic number of an element?	the number of protons in the atom's nucleus of an element
What is the mass number of an element?	number of protons + number of neutrons
What is an isotope?	an atom with the same number of protons but different number of neutrons
What is the equation for relative isotopic mass?	$\text{relative isotopic mass} = \dfrac{\text{mass of an isotope}}{\frac{1}{12}^{\text{th}} \text{ mass of 1 atom of } ^{12}\text{C}}$
What is the equation for relative atomic mass (A_r)?	$\text{relative atomic mass} = \dfrac{\text{weighted mean mass of 1 atom}}{\frac{1}{12}^{\text{th}} \text{ mass of 1 atom of } ^{12}\text{C}}$
What is the equation for relative molecular mass (M_r)?	$\text{relative molecular mass} = \dfrac{\text{average mass of 1 molecule}}{\frac{1}{12}^{\text{th}} \text{ mass of 1 atom of } ^{12}\text{C}}$
What is an ion?	an atom or group of atoms with a charge (a different number of electrons to protons)
Define the term cation	a positive ion (atom with fewer electrons than protons)
Define the term anion	a negative ion (atom with more electrons than protons)
What is the function of a mass spectrometer?	it accurately determines the mass and abundance of separate atoms or molecules, to help us identify them
What is a mass spectrum?	the output from a mass spectrometer that shows the different isotopes that make up an element
What is a binary compound?	a compound which contains only two elements

Maths skills

1 Core mathematical skills

A practical chemist must be proficient in standard form, significant figures, decimal places, SI units, and unit conversion.

1.1 Standard form

In science, very large and very small numbers are usually written in standard form. Standard form is writing a number in the format $A \times 10^x$ where A is a number from 1 to 10 and x is the number of places you move the decimal place.

For example, to express a large number such as 50 000 mol dm^{-3} in standard form, A = 5 and x = 4 as there are four numbers after the initial 5.

Therefore, it would be written as 5×10^4 mol dm^{-3}.

To give a small number such as 0.000 02 Nm^2 in standard form, A = 2 and there are five numbers before it so x = −5.

So it is written as 2×10^{-5} Nm^2.

Practice questions

1 Change the following values to standard form.

a boiling point of sodium chloride: 1413 °C

b largest nanoparticles: 0.0 001$\times10^{-3}$ m

c number of atoms in 1 mol of water: 1806$\times10^{21}$

2 Change the following values to ordinary numbers.

a 5.5×10^{-6} **b** 2.9×10^2 **c** 1.115×10^4 **d** 1.412×10^{-3} **e** 7.2×10^1

1.2 Significant figures and decimal places

In chemistry, you are often asked to express numbers to either three or four significant figures. The word significant means to ‘have meaning’. A number that is expressed in significant figures will only have digits that are important to the number’s precision.

It is important to record your data and your answers to calculations to a reasonable number of significant figures. Too many and your answer is claiming an accuracy that it does not have, too few and you are not showing the precision and care required in scientific analysis.

For example, 6.9301 becomes 6.93 if written to three significant figures.

Likewise, 0.000 434 56 is 0.000 435 to three significant figures.

Notice that the zeros before the figure are *not* significant – they just show you how large the number is by the position of the decimal point. Here, a 5 follows the last significant digit, so just as with decimals, it must be rounded up.

Any zeros between the other significant figures are significant. For example, 0.003 018 is 0.003 02 to three significant figures.

Sometimes numbers are expressed to a number of decimal places. The decimal point is a place holder and the number of digits afterwards is the number of decimal places.

For example, the mathematical number pi is 3 to zero decimal places, 3.1 to one decimal place, 3.14 to two decimal places, and 3.142 to three decimal places.

Practice questions

3 Give the following values in the stated number of significant figures (s.f.).

a 36.937 (3 s.f.) **b** 258 (2 s.f.) **c** 0.043 19 (2 s.f.) **d** 7 999 032 (1 s.f.)

4 Use the equation:

number of molecules = number of moles × 6.02 × 10^{23} molecules per mole

to calculate the number of molecules in 0.5 moles of oxygen. Write your answer in standard form to 3 s.f.

5 Give the following values in the stated number of decimal places (d.p.).

a 4.763 (1 d.p.) **b** 0.543 (2 d.p.) **c** 1.005 (2 d.p.) **d** 1.9996 (3 d.p.)

1.3 Converting units

Units are defined so that, for example, every scientist who measures a mass in kilograms uses the same size for the kilogram and gets the same value for the mass. Scientific measurement depends on standard units – most are *Système International* (SI) units.

If you convert between units and round numbers properly it allows quoted measurements to be understood within the scale of the observations.

Multiplication factor	Prefix	Symbol
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n

Unit conversions are common. For instance, you could be converting an enthalpy change of 488 889 J mol^{-1} into kJ mol^{-1}. A kilo is 10^3 so you need to divide by this number or move the decimal point three places to the left.

488 889 ÷ 10^3 kJ mol^{-1} = 488.889 kJ mol^{-1}

Converting from mJ mol^{-1} to kJ mol^{-1}, you need to go from 10^3 to 10^{-3}, or move the decimal point six places to the left.

333 mJ mol^{-1} is 0.000 333 kJ mol^{-1}

If you want to convert from 333 mJ mol^{-1} to nJ mol^{-1}, you would have to go from 10^{-9} to 10^{-3}, or move the decimal point six places to the right.

333 mJ mol^{-1} is 333 000 000 nJ mol^{-1}

Practice question

6 Calculate the following unit conversions.

a 300 µm to m

b 5 MJ to mJ

c 10 GW to kW

2 Balancing chemical equations

2.1 Conservation of mass

When new substances are made during chemical reactions, atoms are not created or destroyed – they just become rearranged in new ways. So, there is always the same number of each type of atom before and after the reaction, and the total mass before the reaction is the same as the total mass after the reaction. This is known as the conservation of mass.

You need to be able to use the principle of conservation of mass to write formulae, and balanced chemical equations and half equations.

2.2 Balancing an equation

The equation below shows the correct formulae but it is not balanced.

$H_2 + O_2 \rightarrow H_2O$

While there are two hydrogen atoms on both sides of the equation, there is only one oxygen atom on the right-hand side of the equation against two oxygen atoms on the left-hand side. Therefore, a two must be placed before the H_2O.

$H_2 + O_2 \rightarrow 2H_2O$

Now the oxygen atoms are balanced but the hydrogen atoms are no longer balanced. A two must be placed in front of the H_2.

$2H_2 + O_2 \rightarrow 2H_2O$

The number of hydrogen and oxygen atoms is the same on both sides, so the equation is balanced.

Practice question

1 Balance the following equations.

a $C + O_2 \rightarrow CO$

b $N_2 + H_2 \rightarrow NH_3$

c $C_2H_4 + O_2 \rightarrow H_2O + CO_2$

2.3 Balancing an equation with fractions

To balance the equation below:

$C_2H_6 + O_2 \rightarrow CO_2 + H_2O$

- Place a two before the CO_2 to balance the carbon atoms.
- Place a three in front of the H_2O to balance the hydrogen atoms.

  $C_2H_6 + O_2 \rightarrow 2CO_2 + 3H_2O$

There are now four oxygen atoms in the carbon dioxide molecules plus three oxygen atoms in the water molecules, giving a total of seven oxygen atoms on the product side.

- To balance the equation, place three and a half in front of the O_2.

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

- Finally, multiply the equation by 2 to get whole numbers.

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

Practice question

2 Balance the equations below.

a $C_6H_{14} + O_2 \rightarrow CO_2 + H_2O$

b $NH_2CH_2COOH + O_2 \rightarrow CO_2 + H_2O + N_2$

2.4 Balancing an equation with brackets

$Ca(OH)_2 + HCl \rightarrow CaCl_2 + H_2O$

Here the brackets around the hydroxide (OH^-) group show that the $Ca(OH)_2$ unit contains one calcium atom, two oxygen atoms, and two hydrogen atoms.

To balance the equation, place a two before the HCl and another before the H_2O.

$Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$

Practice question

3 Balance the equations below.

a $Mg(OH)_2 + HNO_3 \rightarrow Mg(NO_3)_2 + H_2O$

b $Fe(NO_3)_2 + Na_3PO_4 \rightarrow Fe_3(PO_4)_2 + NaNO_3$

3 Rearranging equations and calculating concentrations

3.1 Rearranging equations

In chemistry, you sometimes need to rearrange an equation to find the desired values.

For example, you may know the amount of a substance (*n*) and the mass of it you have (*m*), and need to find its molar mass (*M*).

The amount of substance (*n*) is equal to the mass you have (*m*) divided by the molar mass (*M*):

$$n = \frac{m}{M}$$

You need to rearrange the equation to make the molar mass (*M*) the subject.

Multiply both sides by the molar mass (*M*):

$$M \times n = m$$

Then divide both sides by the amount of substance (*n*):

$$m = \frac{m}{N}$$

Practice questions

1 Rearrange the equation $c = \frac{n}{V}$ to make:

a *n* the subject of the equation

b *V* the subject of the equation.

2 Rearrange the equation $PV = nRT$ to make:

a *n* the subject of the equation

b *T* the subject of the equation.

3.2 Calculating concentration

The concentration of a solution (a solute dissolved in a solvent) is a way of saying how much solute, in moles, is dissolved in 1 dm^3 or 1 litre of solution.

Concentration is usually measured using units of mol dm^{-3}. (It can also be measured in g dm^3.)

The concentration of the amount of substance dissolved in a given volume of a solution is given by the equation:

$$c = \frac{n}{V}$$

where *n* is the amount of substance in moles, *c* is the concentration, and *V* is the volume in dm^3.

The equation can be rearranged to calculate:

- the amount of substance *n*, in moles, from a known volume and concentration of solution
- the volume *V* of a solution from a known amount of substance, in moles, and the concentration of the solution.

Practice questions

3 Calculate the concentration, in mol dm^{-3}, of a solution formed when 0.2 moles of a solute is dissolved in 50 cm^3 of solution.

4 Calculate the concentration, in mol dm^{-3}, of a solution formed when 0.05 moles of a solute is dissolved in 2.0 dm^3 of solution.

5 Calculate the number of moles of NaOH in an aqueous solution of 36 cm^3 of 0.1 mol dm^{-3}.

4 Molar calculations

4.1 Calculating masses and gas volumes

The balanced equation for a reaction shows how many moles of each reactant and product are involved in a chemical reaction.

If the amount, in moles, of one of the reactants or products is known, the number of moles of any other reactants or products can be calculated.

The number of moles (*n*), the mass of the substance (*m*), and the molar mass (*M*) are linked by:

$$n = \frac{m}{M}$$

Note: The molar mass of a substance is the mass per mole of the substance. For $CaCO_3$, for example, the atomic mass of calcium is 40.1, carbon is 12, and oxygen is 16. So the molar mass of $CaCO_3$ is:

40.1 + 12 + (16 × 3) = 100.1. The units are g mol^{-1}.

Look at this worked example. A student heated 2.50 g of calcium carbonate, which decomposed as shown in the equation:

$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

The molar mass of calcium carbonate is 100.1 g mol^{-1}.

a Calculate the amount, in moles, of calcium carbonate that decomposes.

$$n = \frac{m}{M} = 2.50/100.1 = 0.025\ \text{mol}$$

b Calculate the amount, in moles, of carbon dioxide that forms.

From the balanced equation, the number of moles of calcium carbonate = number of moles of carbon dioxide = 0.025 mol

Practice questions

1 In a reaction, 0.486 g of magnesium was added to oxygen to produce magnesium oxide.

$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

a Calculate the amount, in moles, of magnesium that reacted.

b Calculate the amount, in moles, of magnesium oxide made.

c Calculate the mass, in grams, of magnesium oxide made.

2 Oscar heated 4.25 g of sodium nitrate. The equation for the decomposition of sodium nitrate is:

$2NaNO_3(s) \rightarrow 2NaNO_2(s) + O_2(g)$

a Calculate the amount, in moles, of sodium nitrate that reacted.

b Calculate the amount, in moles, of oxygen made.

3 0.500 kg of magnesium carbonate decomposes on heating to form magnesium oxide and carbon dioxide. Give your answers to 3 significant figures.

$MgCO_3(s) \rightarrow MgO(s) + CO_2(g)$

a Calculate the amount, in moles, of magnesium carbonate used.

b Calculate the amount, in moles, of carbon dioxide produced.

5 Percentage yields and percentage errors

5.1 Calculating percentage yield

Chemists often find that an experiment makes a smaller amount of product than expected. They can predict the amount of product made in a reaction by calculating the percentage yield.

The percentage yield links the actual amount of product made, in moles, and the theoretical yield, in moles:

$$\text{percentage yield} = \frac{\text{actual amount (in moles) of product}}{\text{theoretical amount (in moles) of product}} \times 100$$

Look at this worked example. A student added ethanol to propanoic acid to make the ester, ethyl propanoate, and water.

$C_2H_5OH + C_2H_5COOH \rightarrow C_2H_5COOC_2H_5 + H_2O$

The experiment has a theoretical yield of 5.00 g.

The actual yield is 4.50 g.

The molar mass of $C_2H_5COOC_2H_5$ = 102.0 g mol^{-1}

Calculate the percentage yield of the reaction.

Actual amount of ethyl propanoate: $n = \frac{m}{M}$ = 4.5/102 = 0.0441 mol

Theoretical amount of ethyl propanoate: $n = \frac{m}{M}$ = 5.0/102 = 0.0490 mol

percentage yield = (0.0441/0.0490) × 100% = 90%

Practice questions

1 Calculate the percentage yield of a reaction with a theoretical yield of 4.75 moles of product and an actual yield of 3.19 moles of product. Give your answer to 3 significant figures.

2 Calculate the percentage yield of a reaction with a theoretical yield of 12.00 moles of product and an actual yield of 6.25 moles of product. Give your answer to 3 significant figures.

5.3 Calculating percentage error in apparatus

The percentage error of a measurement is calculated from the maximum error for the piece of apparatus being used and the value measured:

$$\text{percentage error} = \frac{\text{maximum error}}{\text{measured value}} \times 100\%$$

Look at this worked example. In an experiment to measure temperature changes, an excess of zinc powder was added to 50 cm^3 of copper(II) sulfate solution to produce zinc sulfate and copper.

$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$

The measuring cylinder used to measure the copper(II) sulfate solution has a maximum error of ±2 cm^3.

a Calculate the percentage error.

percentage error = (2/50) × 100% = 4%

b A thermometer has a maximum error of ±0.05 °C.

Calculate the percentage error when the thermometer is used to record a temperature rise of 3.9 °C. Give your answer to 3 significant figures.

percentage error = (2 × 0.05)/3.9 × 100% = 2.56%

(Notice that two measurements of temperature are required to calculate the temperature change so the maximum error is doubled.)

Practice questions

3 A gas syringe has a maximum error of ±0.5 cm^3. Calculate the maximum percentage error when recording these values. Give your answers to 3 significant figures.

a 21.0 cm^3 **b** 43.0 cm^3

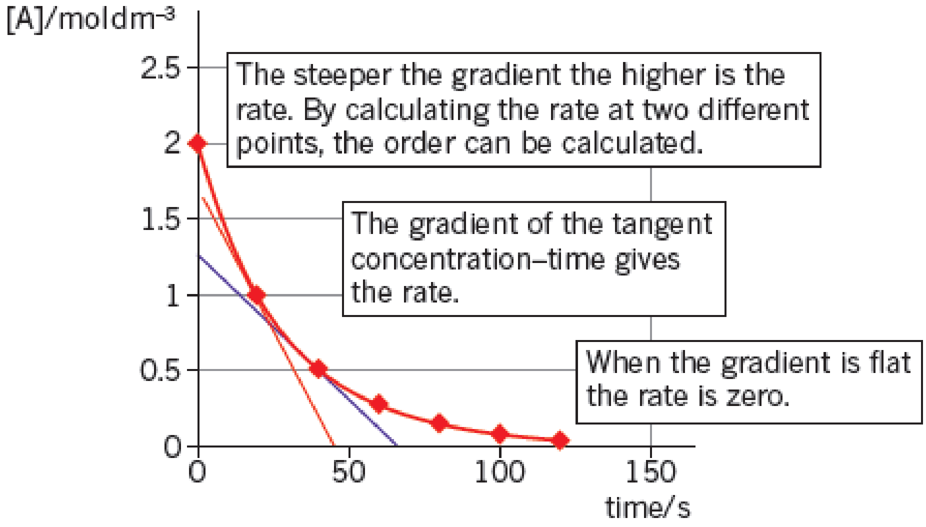
4 A thermometer has a maximum error of ±0.5 °C. Calculate the maximum percentage error when recording these temperature rises. Give your answers to 3 significant figures.

a 12.0 °C **b** 37.6 °C

6 Graphs and tangents

6.1 Deducing reaction rates

To investigate the reaction rate during a reaction, you can measure the volume of the product formed, such as a gas, or the colour change to work out the concentration of a reactant during the experiment. By measuring this concentration at repeated intervals, you can plot a concentration–time graph.



Note: When a chemical is listed in square brackets, it just means 'the concentration of' that chemical. For example, $[O_2]$ is just shorthand for the concentration of oxygen molecules.

By measuring the gradient (slope) of the graph, you can calculate the rate of the reaction. In the graph above, you can see that the gradient changes as the graph is a curve. If you want to know the rate of reaction when the graph is curved, you need to determine the gradient of the curve. So, you need to plot a tangent.

The tangent is the straight line that just touches the curve. The gradient of the tangent is the gradient of the curve at the point where it touches the curve.

Looking at the graph above. When the concentration of A has halved to 1.0 mol dm^{-3}, the tangent intercepts the *y*-axis at 1.75 and the *x*-axis at 48.

The gradient is $\frac{-1.75}{48} = -0.0365$ (3 s.f.).

So the rate is 0.0365 mol dm^{-3} s^{-1}.

Practice question

1 Using the graph above, calculate the rate of reaction when the concentration of A halves again to 0.5 mol dm^{-3}.

6.2 Deducing the half-life of a reactant

In chemistry, half-life can also be used to describe the decrease in concentration of a reactant in a reaction. In other words, the half-life of a reactant is the time taken for the concentration of the reactant to fall by half.

Practice question

2 The table below shows the change in concentration of bromine during the course of a reaction.

Time / s	$[Br_2]$ / mol dm^{-3}
0	0.0100
60	0.0090
120	0.0066
180	0.0053
240	0.0044
360	0.0028

a Plot a concentration–time graph for the data in the table.

b Calculate the rate of decrease of Br_2 concentration by drawing tangents.

c Find the half-life at two points and deduce the order of the reaction.

ANSWERS to Transition Sheets – self mark your answers and complete WWW/EBI/Areas to improve

Maths skills

1 Core mathematics

Practice questions

1 **a** 1.413×10^3 °C **b** 1.0×10^{-7} m
c 1.806×10^{21} atoms
2 **a** 0.000 0055 **b** 290
c 11150 **d** 0.001 412
e 72
3 **a** 36.9 **b** 260
c 0.043 **d** 8 000 000
4 Number of molecules = 0.5 moles × 6.022×10^{23} = 3.011×10^{23} = 3.01×10^{23}
5 **a** 4.8 **b** 0.54
c 1.01 **d** 2.000
6 **a** 0.0003 m **b** 5×10^9 mJ
c 1×10^7 kW

2 Balancing chemical equations

Practice questions

1 **a** $2C + O_2 \rightarrow 2CO$ **b** $N_2 + 3H_2 \rightarrow 2NH_3$
c $C_2H_4 + 3O_2 \rightarrow 2H_2O + 2CO_2$
2 **a** $C_6H_{14} + 9\frac{1}{2}O_2 \rightarrow 6CO_2 + 7H_2O$ **or** $2C_6H_{14} + 19O_2 \rightarrow 12CO_2 + 14H_2O$
b $2NH_2CH_2COOH + 4\frac{1}{2}O_2 \rightarrow 4CO_2 + 5H_2O + N_2$
or $4NH_2CH_2COOH + 9O_2 \rightarrow 8CO_2 + 10H_2O + 2N_2$
3 **a** $Mg(OH)_2 + 2HNO_3 \rightarrow Mg(NO_3)_2 + 2H_2O$
b $3Fe(NO_3)_2 + 2Na_3PO_4 \rightarrow Fe_3(PO_4)_2 + 6NaNO_3$

3 Rearranging equations and calculating concentrations

Practice questions

1 **a** $n = cv$ **b** $v = \frac{n}{c}$

2 **a** $n = \frac{PV}{RT}$ **b** $T = \frac{PV}{nR}$

3 $\frac{0.2}{0.050} = 4.0\ \text{mol dm}^{-3}$

4 $\frac{0.05}{2} = 0.025\ \text{mol dm}^{-3}$

5 $\frac{36}{1000} \times 0.1 = 3.6 \times 10^{-3}\ \text{mol}$

4 Molar calculations

Practice questions

1 **a** $\frac{0.486}{24.3} = 0.02$ mol **b** 0.02 mol

c 0.02 × 40.3 = 0.806 g

2 **a** $\frac{4.25}{85} = 0.05$ mol **b** $\frac{0.05}{2} = 0.025$ mol

3 **a** $\frac{500}{84.3} = 5.93$ mol **b** 5.93 mol

5 Percentage yields and percentage errors

Practice questions

1 3.19/4.75 × 100 = 67.2%

2 6.25/12.00 × 100 = 52.1%

3 **a** 0.5/21 × 100 = 2.38% **b** 0.5/43 × 100 = 1.16%

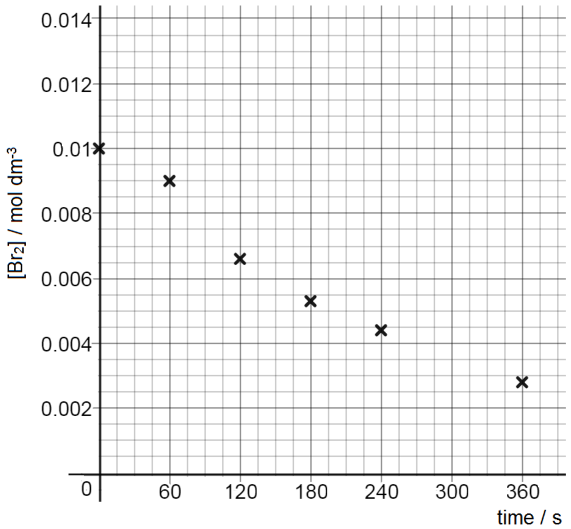
4 **a** 0.5 × (2/12) × 100 = 8.33% **b** 0.5 × (2/37.6) × 100 = 2.66%

6 Graphs and tangents

Practice questions

1 $\frac{-1.25}{65} = -0.0192$

2 **a**



b Half-life is approximately 180 seconds

c The reaction is first order

Standard form and significant figures Worksheet

Specification references

- *M0.1 Recognise and use expressions in standard and ordinary form*
- *M0.4 Use calculators to find and use power, exponential and logarithmic functions*
- *M1.1 Use an appropriate number of significant figures*

Learning outcomes

After completing the worksheet you should be able to:

- convert between numbers in standard and ordinary form
- state numbers to a certain degree of accuracy.

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:

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

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

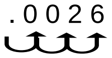
Step 1

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*)

v 1.43×10^{23} or 1.43×10^{24}

vi 5.16×10^{-3} or 5.16×10^{-4}

vii 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

Maths skills links to other areas

You will use these skills throughout the Amount of Substance topics.

Standard form and significant figures Worksheet - ANSWERS

Maths skills links to other areas

These skills will be used throughout Chapter 3: Amount of substance.

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*)

Avogadro's Constant Worksheet

Specification reference

- *2.1.3 a) (i) (ii) (iii)*
- *M0.0 Recognise and make use of appropriate units in calculations*
- *M0.1 Recognise and use expressions in decimal and ordinary form*
- *M1.1 Use an appropriate number of significant figures*
- *M2.2 Change the subject of an equation*

Learning outcomes

After completing the worksheet you should be able to:

- carry out calculations using the Avogadro constant
- carry out calculations using numbers in standard and ordinary form
- substitute numerical values into algebraic equations, and change the subject of equations
- report calculations to an appropriate number of significant figures.

Introduction

One mole of any substance contains the same number of particles as the number of atoms in 12 g of carbon-12. This number of particles is a huge number and is called the *Avogadro constant*. It has a value of 6.02×10^{23} and is given the units of mol^{-1} (per mole).

The relative atomic mass of an element in grams contains 6.02×10^{23} atoms or one mole of that element. The relative formula mass of a compound in grams contains 6.02×10^{23} particles (molecules or ions) or one mole of that compound. Therefore we use the term *molar mass* to describe the relative atomic or formula mass of a substance in grams and give it the unit g mol^{-1}.

To calculate the number of particles in a certain mass of a substance we can use the following equation.

$$\text{Number of particles} = \frac{\text{mass } m \text{ (g)}}{\text{molar mass } M \text{ (g mol}^{-1}\text{)}} \times 6.02 \times 10^{23} (\text{mol}^{-1})$$

Worked example

Question 1

How many molecules are there in 42.5 g of ammonia, NH_3?

Answer

Step 1

Calculate the molar mass of ammonia using the relative atomic masses of nitrogen and hydrogen from the periodic table.

Relative atomic masses: nitrogen 14.0, hydrogen 1.0

$NH_3 = (1 \times N) + (3 \times H) = (1 \times 14.0) + (3 \times 1.0) = 17.0\ g\ mol^{-1}$

Note: Remember to give all molar masses to one decimal place.

This means 17.0 g of ammonia contains 1 mol of ammonia or 6.02×10^{23} molecules.

Step 2

Substitute the values into the equation:

$$\text{amount, } n = \frac{42.5\ g}{17.0\ g\ mol^{-1}} \times 6.02 \times 10^{23}\ mol^{-1}$$

$$= 1.505 \times 10^{24}$$

$$= 1.51 \times 10^{24} \text{ (to 3 significant figures)}$$

Note: You can only give your answer to the same degree of accuracy (significant figures) as the least accurate value used in the calculation. In this case to three significant figures.

$$\text{Density } (g\ cm^{-3}) = \frac{\text{mass (g)}}{\text{volume (cm}^3\text{)}}$$

Questions

1 **a** Calculate the molar mass of glucose, $C_6H_{12}O_6$. Give your answer to one decimal place. (*1 mark*)

b If the molar mass of glucose weighed out in grams contains 6.02×10^{23} molecules of glucose, calculate the number of molecules in (*3 marks*)

i 90 g of glucose

ii 360 g of glucose

iii 45 g of glucose.

2 Calculate the following:

Give all answers in standard form to the same number of significant figures as used for the information in the question. (*5 marks*)

a the number of atoms in 20.2 g of neon

b the number of atoms in 80.2 g of calcium

c the number of oxygen atoms in 48.0 g of oxygen

d the number of oxygen molecules in 49.6 g of oxygen gas

e the number of ions in 310 g of magnesium ions, Mg^{2+}.

3 Calculate the following:

Give all answers in standard form to the same number of significant figures as used for the information in the question. (*6 marks*)

a the number of atoms of oxygen in 132 g of carbon dioxide, CO_2

b the number of chloride ions in 129.9 g of iron(III) chloride, $FeCl_3$

c the number of hydroxide ions in 198 g of barium hydroxide, $Ba(OH)_2$

d the number of molecules of water in 150 g of hydrated copper sulfate, $CuSO_4{\bullet}5H_2O$

e the number of molecules in 1 cm^3 of water (density of water = 1 g cm^{-3})

f the number of atoms of helium in a balloon with a volume of 5 dm^3 (assume the density of helium to be 0.17 g dm^{-3}).

4 Calculate the mass in grams of the following:

a 10 million atoms of gold (*1 mark*)

b 1 molecule of water. (*1 mark*)

5 From OCR Chemistry A F321/01 Atoms, bonds and groups June 2012 (Question 1)

Solid sulfur exists as a lattice of S_8 molecules. Each S_8 molecule is a ring of eight atoms.

How many atoms of sulfur are there in 0.0210 mol of S_8 molecules? (*2 marks*)

Maths skills links to other areas

You will be required to express answers to calculations in standard form and to an appropriate number of significant figures throughout Chapter 3: Amount of substance.

Avogadro's Constant Worksheet - ANSWERS

Maths skills links to other areas

These skills will be used throughout Chapter 3: Amount of substance.

Answers

1 **a** 180.0 g mol^{-1} (*1 mark*)

b **i** 3.01×10^{23} molecules (*1 mark*)

ii 1.204×10^{23} molecules (*1 mark*)

iii 1.505×10^{23} molecules (*1 mark*)

2 Students are asked to give all answers in standard form and to the same number of significant figures as used for the information in the question.

a $\frac{20.2\text{ g}}{20.2\text{ g mol}^{-1}} \times 6.02 \times 10^{23}\text{ mol}^{-1} = 6.02 \times 10^{23}$ (*1 mark*)

b $\frac{80.2\text{ g}}{40.1\text{ g mol}^{-1}} \times 6.02 \times 10^{23}\text{ mol}^{-1} = 1.20 \times 10^{24}$ (*1 mark*)

c $\frac{48.0\text{ g}}{16.0\text{ g mol}^{-1}} \times 6.02 \times 10^{23}\text{ mol}^{-1} = 1.81 \times 10^{24}$ (*1 mark*)

d $\frac{49.6\text{ g}}{32.0\text{ g mol}^{-1}} \times 6.02 \times 10^{23}\text{ mol}^{-1} = 9.33 \times 10^{23}$ (*1 mark*)

e $\frac{310\text{ g}}{24.3\text{ g mol}^{-1}} \times 6.02 \times 10^{23}\text{ mol}^{-1} = 7.7 \times 10^{24}$ (*1 mark*)

3 Students are asked to give all answers in standard form and to the same number of significant figures as used for the information in the question

a $\frac{132\text{ g}}{44.0\text{ g mol}^{-1}} \times 6.02 \times 10^{23}\text{ mol}^{-1} = 1.81 \times 10^{24}$ molecules of CO_2

$= 3.61 \times 10^{24}$ atoms of oxygen (*1 mark*)

b $\frac{129.9\text{ g}}{162.3\text{ g mol}^{-1}} \times 6.02 \times 10^{23}\text{ mol}^{-1} = 4.818 \times 10^{23}$ particles of $FeCl_3$,

$= 1.445 \times 10^{24}$ chloride ions (*1 mark*)

c $\frac{198\text{ g}}{171.3\text{ g mol}^{-1}} \times 6.02 \times 10^{23}\text{ mol}^{-1} = 6.96 \times 10^{23}$ particles of $Ba(OH)_2$

$= 1.39 \times 10^{24}$ hydroxide ions (*1 mark*)

d $\frac{150\text{ g}}{249.6\text{ g mol}^{-1}} \times 6.02 \times 10^{23}\text{ mol}^{-1} = 3.62 \times 10^{23}$ particles of $CuSO_4{\bullet}5H_2O$,

$= 1.8 \times 10^{24}$ molecules of water (*1 mark*)

e 1 cm^3 of water has a mass of 1 g.

$\frac{1\text{ g}}{18.0\text{ g mol}^{-1}} \times 6.02 \times 10^{23}\text{ mol}^{-1} = 3 \times 10^{22}$ molecules of water (*1 mark*)

f 5 dm^3 of helium has a mass of $0.17\text{ g dm}^{-3} \times 5\text{ dm}^3 = 0.85\text{ g}$

$\frac{0.85\text{ g}}{4.0\text{ g mol}^{-1}} \times 6.02 \times 10^{23}\text{ mol}^{-1} = 1.3 \times 10^{23}$ atoms of helium (*1 mark*)

4 **a** $(10000000 \times 197.0\text{ g mol}^{-1}) \div 6.02 \times 10^{23}\text{ mol}^{-1} = 3.27 \times 10^{-15}\text{ g}$ (*1 mark*)

b $(1 \times 18.0\text{ g mol}^{-1}) \div 6.02 \times 10^{23}\text{ mol}^{-1} = 2.99 \times 10^{-23}\text{ g}$ (*1 mark*)

5 From OCR Chemistry A F321/01 Atoms, bonds and groups Mark scheme June 2012 (Question 1)

Number of S_8 molecules in 0.0120 mol = $0.0120\text{ mol} \times (6.02 \times 10^{23}\text{ mol}^{-1})$

$= 7.224 \times 10^{21}$ molecules (*1 mark*)

No. of sulfur atoms = $(7.224 \times 10^{21}) \times 8$

$= 5.78 \times 10^{22}$ atoms