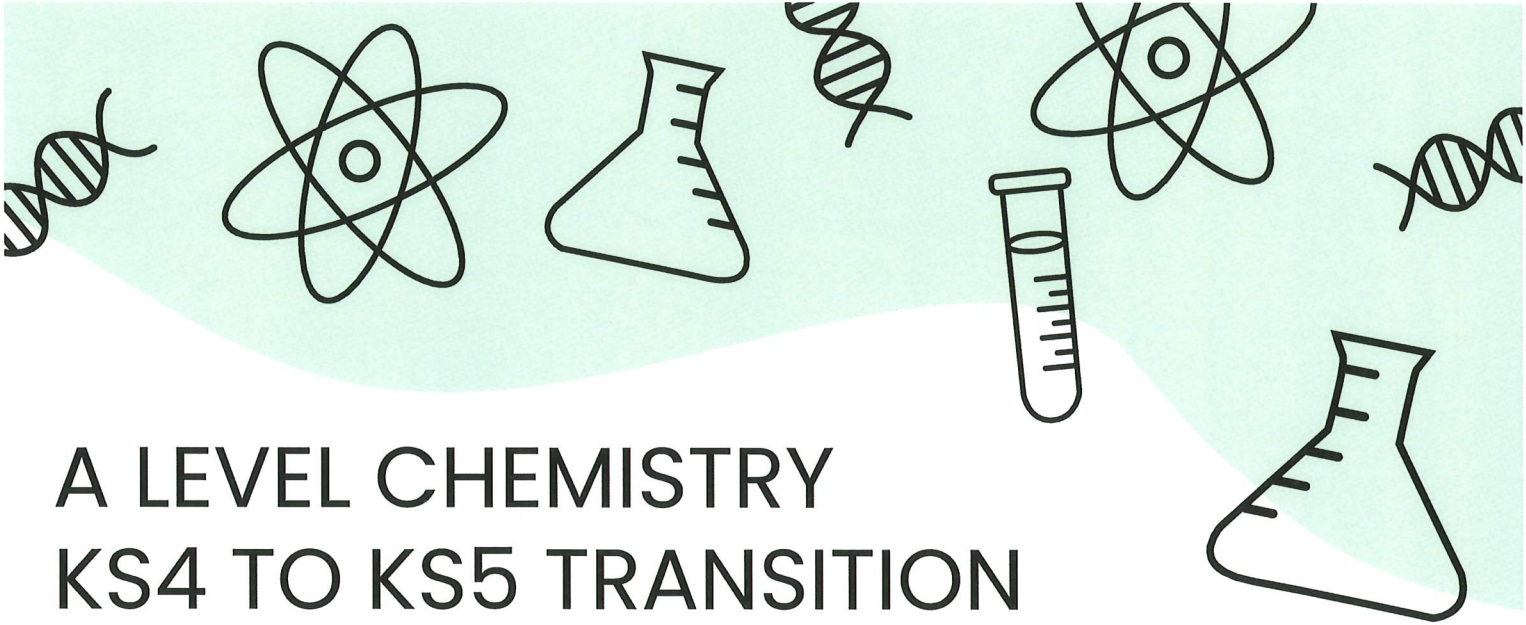




A LEVEL CHEMISTRY KS4 TO KS5 TRANSITION

Summer Bridging Work- ESSENTIAL

1. Download and print the OCRA Chemistry Specification from the OCR website:
<https://www.ocr.org.uk/qualifications/as-and-a-level/chemistry-a-h032-h432-from-2015/#as-level>

Read through this to begin to familiarize yourself with the course.

Summer Bridging Work- RECOMMENDED

Below is a list of recommended reading. It is not compulsory for you to purchase all of these books, you may wish to purchase a few and read them over the summer to give you an idea of what to expect during your A Level studies.

Books

Elegant Solutions: Ten beautiful experiments in Chemistry

Molecules at an Exhibition

Vanity, Vitality and Virility: The Science behind the products you love to buy

Nature's Building Blocks

Mauve

Oxygen: The molecule that made the world

Right Hand Left Hand: Origins of asymmetry in brains, bodies, atoms & cultures

Molecules That Changed The World

Mendeleyev's Dream: The quest for the elements

Philip Ball

John Emsley

John Emsley

John Emsley

Simon Garfield

Nick Lane

Chris McManus

KC Nicolaou & T Montagnon

Paul Strathern

Magazines/Periodicals

Chemistry Review

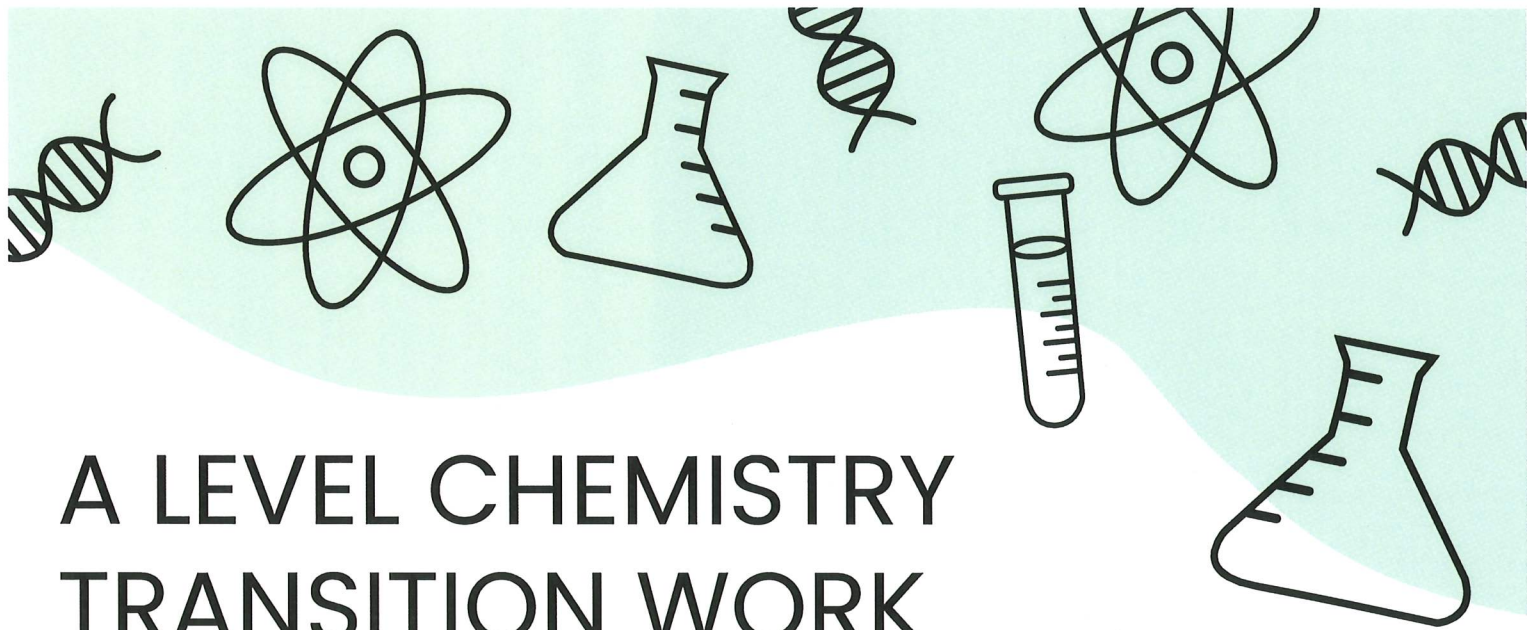
New Scientist

Scientific American

Websites

RSC Education <http://www.rsc.org/Education/SchoolStudents/index.asp>

Chemguide <http://www.chemguide.co.uk/>



A LEVEL CHEMISTRY TRANSITION WORK

HOW TO COMPLETE THIS TRANSITION BOOKLET **STEP 1 – OCR KS4–KS5 TRANSITION GUIDES**

COMPLETE THE FOUR OCR TRANSITION GUIDES:

- AMOUNT OF SUBSTANCE
- ATOMIC STRUCTURE
- BONDING AND STRUCTURE
- ENTHALPY CHANGES

STEP 2 – ROYAL SOCIETY OF CHEMISTRY COMPETENCIES

COMPLETE:

- BASIC CHEMISTRY COMPETENCIES
- BASIC MATHEMATICAL COMPETENCIES

STEP 3 – LANGUAGE OF MEASUREMENT (OCR)

READ THE LANGUAGE OF MEASUREMENT RESOURCE AND BECOME FAMILIAR WITH:
ACCURACY, PRECISION, RELIABILITY, REPEATABILITY, REPRODUCIBILITY, VALIDITY AND UNCERTAINTY.

STEP 4 – MACHEMGUY PREPARATION VIDEOS

WATCH THE RECOMMENDED PREPARATION VIDEOS, MAKE NOTES, COMPLETE ANY QUESTIONS AND REVISIT DIFFICULT TOPICS.

STEP 5 – OCR CANDIDATE EXEMPLARS AND EXAM HINTS

REVIEW EXEMPLAR ANSWERS, EXAM HINTS AND THE GCSE CHEMISTRY SPECIFICATION CHECKLIST TO IDENTIFY STRENGTHS AND AREAS FOR DEVELOPMENT.

STEP 6 – KS4 TO A LEVEL CHEMISTRY TRANSITION TEST

COMPLETE THE TRANSITION ASSESSMENT, SELF-ASSESS USING THE MARK SCHEME AND CREATE AN ACTION PLAN BASED ON YOUR RESULTS.

Checkpoint Task

Amount of substance

Student Activity

Introduction

Often learners have very different levels of understanding when it comes to chemical calculations and the mole. This activity will probe your understanding of the words used to describe chemical quantities and amounts, and how they relate to the symbols (balanced equations), calculations and observations that happen in chemical reactions. You may find that your ideas change and evolve as you discuss the activity, so don't be concerned if you find some of the concepts difficult.

Task 1

Read through each of the ten statements below. With a partner or in a small group, discuss whether you think each statement is true or false and make a note of your answers.

1. The total number and type of atoms present are the same at the start and end of a reaction.
2. The amount of substance, measured in moles, is the same at the start and end of a reaction.
3. The total mass of reactants is equal to the total mass of products for any reaction.
4. The total volume of gas is the same at the start and the end of a reaction.
5. The amount in moles is proportional to the number of particles for that substance.
6. One mole of methane molecules (CH_4) contains $\frac{1}{5}$ mole of carbon atoms and $\frac{4}{5}$ mole of hydrogen atoms.
7. One mole of methane molecules (CH_4) contains 1 mole of carbon atoms and 4 moles of hydrogen atoms.
8. 100 cm^3 of methane gas contains the same number of molecules as 100 cm^3 hydrogen gas at room temperature and pressure.

CHEMISTRY A AND CHEMISTRY B (SALTERS)

Student Activity

9. 100 cm³ of methane gas at room temperature and pressure has the same mass as 100 cm³ of hydrogen gas under the same conditions.
10. If 0.1 mol of magnesium atoms reacts with a solution containing 0.1 mol of hydrochloric acid, 0.1 mol of hydrogen molecules will be produced. (Hint – you may need to look up or work out the balanced equation for this reaction.)

Task 2

Now for the difficult bit! For each of the statements you will need to justify your true/false answer with an explanation or example. If you have decided that a statement is true, try to give an explanation using the chemical concepts and definitions you know. If you have decided that a statement is false, you could find an example of a chemical process, reaction or balanced equation where it is not the case. You are free to look up information using whatever resources you have available to assist you with your explanations.

Extension

Read through the statements again and imagine you are trying to teach the concept of 'amount of substance' to a class of younger pupils who are having difficulty understanding. What practical demonstrations / activities / everyday examples can you think of that will help them understand?

CHEMISTRY A AND CHEMISTRY B (SALTERS)

Learner Activity

Checkpoint Task

Atomic Structure

Running the Activity

Work in groups of two or three.

Read through the statements on the next page and decide upon the simplest model of the atom that is still sufficiently detailed to explain the observation. For example, the production of a beam of charged particles from the heating of a metal can be explained simply by the fact that atoms contain electrons, but periodic properties can only be explained if the Bohr model of the atom is used.

CHEMISTRY A AND CHEMISTRY B (SALTERS)

Learner Activity

When liquids are heated they turn into a gas – when this gas is cooled again, it turns back into a liquid.

Increasing the temperature increases the rate of a chemical reaction.

Particles of dust or smoke appear to move randomly through water or air, changing direction all the time (Brownian motion).

Many chemicals can be split up into separate substances, but there is a limit to this – eventually you will get a 'pure' substance.

The first ionisation energy of sodium is much lower than the first ionisation energy of neon.

When light of a specific frequency is shone on the surface of a metal, charged particles are given off (this is known as the photoelectric effect).

When positively charged alpha particles are fired at a thin piece of gold foil, most of them pass straight through but some are deflected straight back.

The second ionisation energy of magnesium is much lower than the second ionisation energy of sodium.

The first ionisation energy of oxygen is slightly lower than the first ionisation energy of nitrogen.

Atoms of the same element, with the same chemical properties, can have different masses.

The properties of elements show periodicity when the elements are placed in order of increasing atomic number.

Metal electrodes can give off tiny particles that are attracted to a positive plate.

The total mass of substances at the end of a chemical reaction is the same as the total mass at the beginning.

Two chemical reactions in separate containers can produce a potential difference (voltage) if connected by a wire.

The first ionisation energy of aluminium is slightly lower than the first ionisation energy of magnesium.

The absorption and emission spectra of hydrogen consist of discrete lines.

AS and A LEVEL
CHEMISTRY A AND CHEMISTRY B (SALTERS)
 Learner Activity

Timeline

Democritus  Everything is made up of tiny particles called atoms. The atom is indivisible.	John Dalton  Atoms cannot be created or destroyed. Elements are made up of only one type of atom. Atoms join together in chemical reactions.	J.J. Thomson  Atoms contain tiny negatively charged particles called electrons. The rest of the atom is positive to balance out the charge, and the electrons are embedded in this like pieces of fruit in a pudding.	Ernest Rutherford  The positive charge and mass of the atom is concentrated in a tiny nucleus in the centre of the atom. The electrons exist randomly in the space around the nucleus.

AS and A LEVEL
CHEMISTRY A AND CHEMISTRY B (SALTERS)
Learner Activity

Niels Bohr 	James Chadwick 	Louis de Broglie 
Electrons are not randomly arranged around the atom. They exist in specific shells – like the orbits of the planets.	Some of the mass of the atom is accounted for by an uncharged particle, called a neutron. The neutron does not affect chemical properties of an element.	Just as waves can sometimes behave like particles, very small particles – like electrons – can behave like waves.

Checkpoint Task

Bonding and structure

Student Activity

Introduction

In your study of Bonding and Structure at A Level, you will be building a lot on ideas that you have already covered previously. Because bonding is a complex subject that is often simplified at GCSE, many learners can have unclear ideas or misconceptions about the topic. This activity will encourage you to explore what you already understand about chemical bonding, and to identify those areas that you still struggle with or require refinement at A Level.

Task 1

Here are twenty statements about chemical bonding. Discuss each statement within your pair or group and decide whether the statement is always true (unbreakable rule) or usually true (rule of thumb).

Separate the statements into two piles – always true or usually true. Make sure that you discuss the statements with your partner or in a group as you may have different ideas. It is more important to think carefully about each statement than to get to the end of the activity.

Task 2

For the statements that you think are not always true, try to think up some exceptions to the rule. You could use an equation or example element or compound to illustrate the 'exception to the rule'. Feel free to consult textbooks or other resources to help you with this.

Extension

If you have confidently identified all of the 'rules of thumb' and provided each with an exception to the rule, now see if you can think of any other parts of chemistry where we use 'rules of thumb', analogies or simplifications that are not strictly true. Some topics you could think about include atomic structure, reactivity, solubility, or acid–base theory.

CHEMISTRY A AND CHEMISTRY B (SALTERS)

Student Activity

Statements for use in activity

A. The atoms of Group 2 elements have two electrons in their outer shell. 	B. Noble gases do not form any types of bonds because they have full outer shells. 
C. Ionic substances have higher melting points than covalent substances. 	D. Oppositely charged ions attract. 
E. Delocalised electrons are more stable than electrons in fixed atomic orbitals. 	F. Energy is released when ionic bonds form. 
G. In an ionic compound, ions are combined in proportions which balance out the electrical charges. 	H. Energy is needed to break covalent bonds. 
I. Energy is required to form positive ions from atoms. 	J. Energy is released when negative ions are formed from atoms. 

CHEMISTRY A

Student Activity

Statements for use in activity

K. Bonding within compounds is either ionic or covalent. 	L. Electrons shared between atoms (in molecular orbitals) are more stable than electrons in atomic orbitals. 
M. Electrons that are closer to the nucleus experience less shielding and are more strongly attracted than electrons further away. 	N. A covalent bond is formed from a shared pair of electrons; one electron comes from each atom within the bond. 
O. Compounds are more stable than elements. 	P. Elements always react to form ions with noble gas electron configurations. 
Q. Ionic compounds are formed when metals react with non-metals. 	R. Covalent compounds are formed when non-metals react with other non-metals. 
S. Hydrogen atoms form ions by losing one electron and becoming H^+. 	T. Within a covalent compound, all elements except hydrogen have eight electrons in their outer shells. 

Checkpoint Task

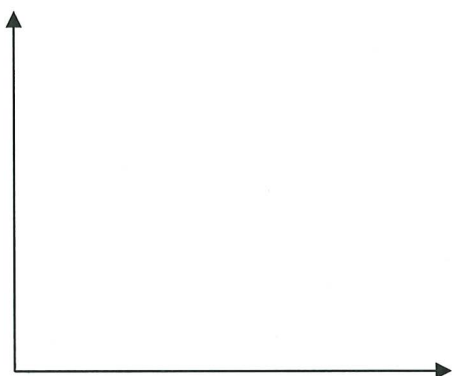
Enthalpy changes

Learner Activity

Exothermic reactions

1. Write a definition of an exothermic reaction.

2. Draw an enthalpy profile diagram for an exothermic reaction.
Label the axes, ΔH and the activation energy.



3. Give an example of an exothermic reaction.

CHEMISTRY A AND CHEMISTRY B (SALTERS)

Learner Activity

Endothermic reactions

4. Write a definition of an endothermic reaction.

5. Draw an enthalpy profile diagram for an endothermic reaction.

Label the axes, ΔH and the activation energy.



6. Give an example of an endothermic reaction.

Bond enthalpy

7. Write a definition of bond enthalpy. (You might know this term as 'bond energy'.)

CHEMISTRY A AND CHEMISTRY B (SALTERS)

Learner Activity

8. In a chemical reaction, bonds in the reactants are broken, and new bonds are formed to make the products. Complete the following sentences.

Energy is to break bonds.

Energy is when bonds are formed.

The overall energy change of a reaction is the

Calculations

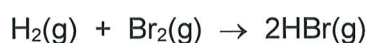
Remember:

enthalpy change = energy required to break bonds – energy released in making bonds

or

$\Delta_r H = \Sigma(\text{bond enthalpies in reactants}) - \Sigma(\text{bond enthalpies in products})$

9. Use bond enthalpies to calculate the enthalpy change for the following reaction.



Bond	H–H	Br–Br	H–Br
Bond enthalpy / kJ mol ⁻¹	438	193	366

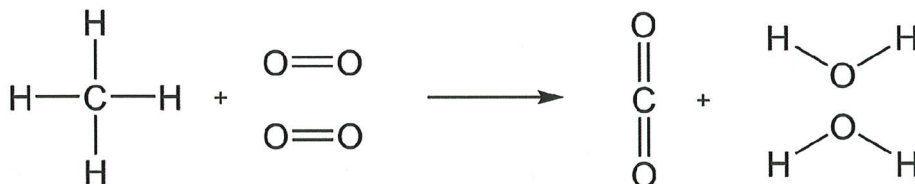
Energy required to break bonds:

Energy released in forming new bonds:

Enthalpy change:

CHEMISTRY A AND CHEMISTRY B (SALTERS)**Learner Activity**

10. Use bond enthalpies to calculate the enthalpy change for the combustion of methane.



Bond	C-H	C-C	O-H	C=O	O=O
Bond enthalpy / kJ mol ⁻¹	413	347	464	805	498

Energy required to break bonds:

Energy released in forming new bonds:

Enthalpy change:

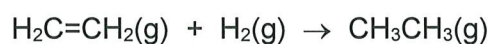
CHEMISTRY A AND CHEMISTRY B (SALTERS)
Learner Activity

11.

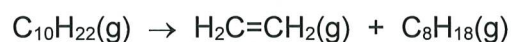
Bond	C-H	C-C	H-H	C=C
Bond enthalpy / kJ mol ⁻¹	413	347	436	612

Use the bond energies above to calculate

a) the enthalpy change for the hydrogenation of ethene



b) the enthalpy change for the cracking of decane



12. Explain in terms of bond breaking and bond formation why combustion reactions are exothermic but cracking reactions are endothermic.

Transition skills – basic chemistry competencies question sheet

Balance the equations below.

1.C +O₂ $\longrightarrow$ CO
2.Ba +H₂O $\longrightarrow$ Ba(OH)₂ +H₂
3.C₂H₆ +O₂ $\longrightarrow$ CO₂ +H₂O
4.HCl +Mg(OH)₂ $\longrightarrow$ MgCl₂ + H₂O
5.N₂ +O₂ $\longrightarrow$ NO
6.Fe₂O₃ +C $\longrightarrow$ Fe +CO₂
7.CH₃CH₂OH +[O] $\longrightarrow$ CH₃COOH +H₂O
8.HNO₃ +CuO $\longrightarrow$ Cu(NO₃)₂ + H₂O
9.Al³⁺ +e⁻ $\longrightarrow$ Al
10.[Fe(H₂O)₆]³⁺ +CO₃²⁻ $\longrightarrow$ Fe(OH)₃(H₂O)₃ +CO₂ +H₂O

(10 marks)

Constructing ionic formula

1. For each of the following ionic salts, determine the cation and anion present and use these to construct the formula of the salt.
(5 marks)
 - a. Magnesium oxide
 - b. Sodium sulfate
 - c. Calcium hydroxide
 - d. Aluminium oxide
 - e. Copper(I) oxide
2. When an acid is added to water it dissociates to form H^+ ions (which make it acidic) and an anion. These acidic hydrogen atoms can be used to determine the charge on the anion.

Deduce the charge on the anions in the following acids. The acidic H atoms, H^+ , have been underlined for you.

(5 marks)

- a. $\underline{\text{H}}_2\text{SO}_3$
- b. $\underline{\text{H}}\text{NO}_3$
- c. $\underline{\text{H}}_3\text{PO}_4$
- d. $\text{HCOO}\underline{\text{H}}$
- e. $\underline{\text{H}}_2\text{CO}_3$

Writing equations from text

The following questions contain a written description of a reaction. In some cases the products may be missing as you will be expected to predict the product using your prior knowledge.

For more advanced equations you may be given some of the formula you need.

For each one, write a balanced symbol equation for the process.

(10 marks)

1. The reaction between silicon and nitrogen to form silicon nitride Si_3N_4 .

.....

2. The neutralisation of sulfuric acid with sodium hydroxide.

.....

3. The preparation of boron trichloride from its elements.

.....

4. The reaction of nitrogen and oxygen to form nitrogen monoxide.

.....

5. The combustion of ethanol ($\text{C}_2\text{H}_5\text{OH}$) to form carbon dioxide and water only.

.....

6. The formation of silicon tetrachloride (SiCl_4) from SiO_2 using chlorine gas and carbon.

.....

7. The extraction of iron from iron(III) oxide (Fe_2O_3) using carbon monoxide.

.....

8. The complete combustion of methane.

.....

9. The formation of one molecule of ClF_3 from chlorine and fluorine molecules.

.....

10. The reaction of nitrogen dioxide with water and oxygen to form nitric acid.

.....

Basic mathematical competencies question sheet

Rearranging equations

1. The amount of substance in moles (n) in a solution can be calculated when the concentration given in mol/dm^3 (c) and volume (v) in cm^3 are known by using the equation:

$$n = \frac{cv}{1000}$$

- a. Rearrange this equation making c the subject of the equation. (1 mark)
b. Rearrange this equation making v the subject of the equation. (1 mark)

2. The density of a substance can be calculated from its mass (m) and volume (v) using the equation:

$$d = \frac{m}{v}$$

- a. Rearrange this equation so that the mass of a substance can be calculated given its density and volume. (1 mark)

Chemists most commonly work with masses expressed in grams and volumes in cm^3 . However, the SI unit for density is kg/m^3 .

- b. Write an expression for the calculation of density in the SI unit of kg/m^3 when the mass (m) of the substance is given in g and the volume (v) of the substance is given in cm^3 . (2 marks)

3. The de Broglie relationship relates the wavelength of a moving particle (λ) with its momentum (p) through Planck's constant (h):

$$\lambda = \frac{h}{p}$$

- a. Rearrange this equation to make momentum (p) the subject of the formula. (1 mark)

Momentum can be calculated from mass and velocity using the following equation.

$$p = mv$$

- b. Using this equation and the de Broglie relationship, deduce the equation for the velocity of the particle. (2 marks)

4. The kinetic energy (KE) of a particle in a time of flight mass spectrometer can be calculated using the following equation.

$$\text{KE} = \frac{1}{2}mv^2$$

Rearrange this equation to make v the subject of the equation.

(2 marks)

BODMAS (order of operations)

The order of operations for a calculation is very important. If operations are carried out in the wrong order then this could lead to the wrong answer. Most modern calculators will anticipate BODMAS issues when operations are entered but human beings can override the calculator's instincts.

1. Do the following calculations in your head.

- (a) $3 + 5 \times 5 =$
- (b) $6 \times 6 + 4 =$
- (c) $20 - 6 \times 2 =$
- (d) $48 - 12 \div 4 =$
- (e) $4 + 4 \div 2 =$
- (f) $100 - (20 \times 3) =$

(6 marks)

2. The molecular formula of glucose is $C_6H_{12}O_6$. Three students entered the following into their calculators to calculate the relative formula mass of glucose. Repeat their calculations as shown.

- (a)

12	×	6	+	1	×	12	+	16	×	6	=
----	---	---	---	---	---	----	---	----	---	---	---
- (b)

12	×	6	=	+	1	=	×	12	=	+	16
=	×	6	=								
- (c)

(	12	×	6	)	+	(	12	×	1	)	+
(	16	×	6	)	=						

(d) Write a sentence summing up why the answers differ.
(4 marks)

Quantity calculus (unit determination)

1. Determine the units of density given that

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

(1 mark)

2. Determine the units of concentration given that

$$\text{concentration} = \frac{\text{number of moles}(mol)}{\text{volume}(dm^3)}$$

(1 mark)

3. Pharmacists often calculate the concentration of substances for dosages. In this case the volumes are smaller, measured in cm^3 , and the amount is given as a mass in grams. Determine the units of concentration when

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

(1 mark)

4. Rate of reaction is defined as the 'change in concentration per unit time'. Determine the units for rate when concentration is measured in $mol\ dm^{-3}$ and time in seconds.

(1 mark)

5. Pressure is commonly quoted in pascals (Pa) and can be calculated using the formula below. The SI unit of force is newtons (N) and area is m^2 .

$$\text{pressure} = \frac{\text{force}}{\text{area}}$$

Use this formula to determine the SI unit of pressure that is equivalent to the Pascal.

(1 mark)

6. Determine the units for each of the following constants (K) by substituting the units for each part of the formula into the expression and cancelling when appropriate. For this exercise you will need the following units [] = $mol\ dm^{-3}$, rate = $mol\ dm^{-3}\ s^{-1}$, p = kPa.

a. $K_c = \frac{[A][B]^2}{[C]}$

b. $K = \frac{\text{rate}}{[A][B]}$

c. $K_p = \frac{(pA)^{0.5}}{(pB)}$

d. $K_w = [H^+][OH^-]$

e. $K_a = \frac{[H^+][X^-]}{[HX]}$

Expressing large and small numbers

Standard form and scientific form

Large and small numbers are often expressed using powers of ten to show their magnitude. This saves us from writing lots of zeros, expresses the numbers more concisely and helps us to compare them.

In standard form a number is expressed as;

$$a \times 10^n$$

where **a** is a number between 1 and 10 and **n** is an integer.

Eg, 160 000 would be expressed as 1.6×10^5

Sometimes scientists want to express numbers using the same power of ten. This is especially useful when putting results onto a graph axis. This isn't true standard form as the number could be smaller than 1 or larger than 10. This is more correctly called **scientific form**.

Eg, 0.9×10^{-2} , 2.6×10^{-2} , 25.1×10^{-2} and 101.6×10^{-2} are all in the same scientific form.

1. Express the following numbers using standard form.

- a. 1 060 000
- b. 0.001 06
- c. 222.2

(3 marks)

2. The following numbers were obtained in rate experiments and the students would like to express them all on the same graph axes. Adjust the numbers to a suitable scientific form.

0.1000

0.0943

0.03984

0.00163

(3 marks)

3. Calculate the following without using a calculator. Express all values in standard form.

a. $\frac{10^9}{10^5}$

b. $\frac{10^7}{10^{-7}}$

c. $\frac{1.2 \times 10^6}{2.4 \times 10^{17}}$

d. $(2.0 \times 10^7) \times (1.2 \times 10^{-5})$

(4 marks)

Significant figures, decimal places and rounding

For each of the numbers in questions 1–6, state the number of significant figures and the number of decimal places.

		Significant figures	Decimal places
1	3.131 88		
2	1000		
3	0.000 65		
4	1006		
5	560.0		
6	0.000 480		

(6 marks)

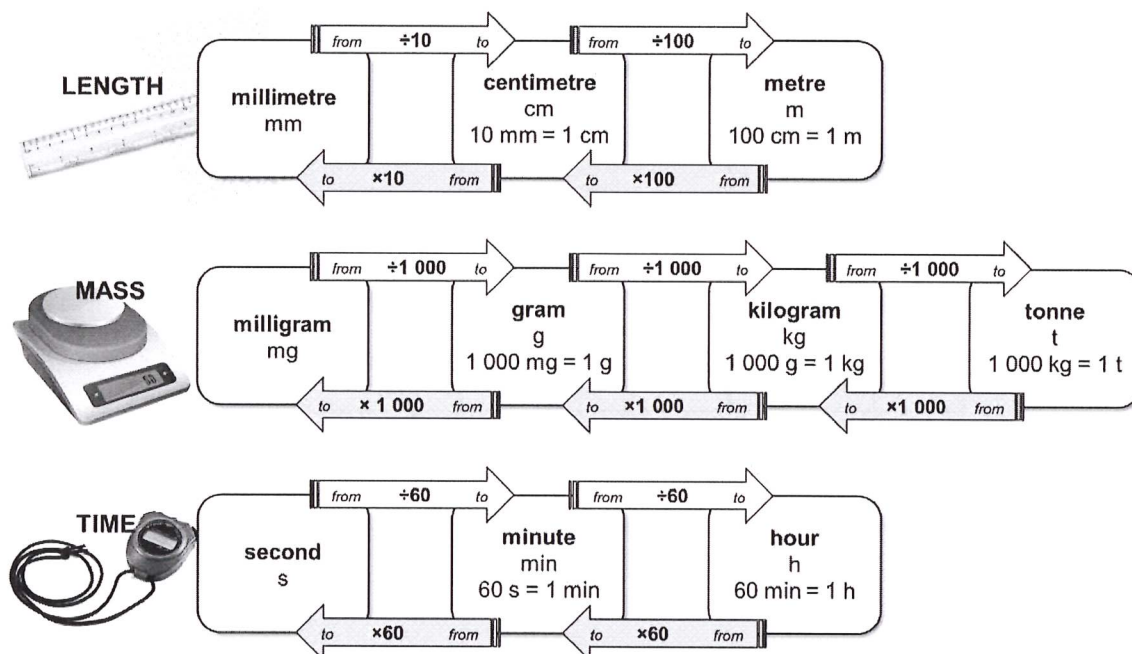
7. Round the following numbers to (i) 3 significant figures and (ii) 2 decimal places.

- a. 0.075 84
- b. 231.456

(4 marks)

Unit conversions 1 – Length, mass and time

Mo's teacher has drawn a diagram on the board to help him with converting quantities from one unit into another.



For example, to convert a length in millimetres into units of centimetres, divide by 10, eg $10\text{ mm} = 1\text{ cm}$.

Use the diagram to help with the following unit conversions.

(10 marks)

1. A block of iron has a length of 1.2 cm. Calculate its length in millimetres.
2. The width of the classroom is 7200 cm. Calculate its length in metres.
3. A reaction reaches completion after $4\frac{1}{2}$ minutes. Convert this time into seconds.
4. The stop clock reads 2 min 34 s. Convert this time into seconds.
5. A method states that a reaction needs to be heated under reflux for 145 min. Calculate this time in hours and minutes.
6. A factory produces 15 500 kg of ammonia a day. Calculate the mass of ammonia in tonnes.
7. A paper reports that 0.0265 kg of copper oxide was added to an excess of sulfuric acid. Convert this mass of copper oxide into grams.
8. A packet of aspirin tablets states that each tablet contains 75 mg of aspirin. Calculate the minimum number of tablets that contain a total of 1 g of aspirin.
9. A student measures a reaction rate to be 0.5 g/s. Convert the rate into units of g/min.
10. A factory reports that it produces fertiliser at a rate of 10.44 kg/h. Calculate the rate in units of g/s

Unit conversions 2 – Volume

The SI unit for volume is **metre cubed, m³**. However as volumes in chemistry are often smaller than 1 m³, fractions of this unit are used as an alternative.

centimetre cubed, cm ³	decimetre cubed, dm ³
centi- <i>prefix</i> one hundredth	deci- <i>prefix</i> one tenth
1 cm = $\frac{1}{100}$ m so,	1 dm = $\frac{1}{10}$ m so,
1 cm ³ = $\left(\frac{1}{100}\right)^3$ m ³ = $\left(\frac{1}{1\,000\,000}\right)$ m ³	1 dm ³ = $\left(\frac{1}{10}\right)^3$ m ³ = $\left(\frac{1}{1\,000}\right)$ m ³

1. Complete the table by choosing the approximate volume from the options in bold for each of the everyday items (images not drawn to scale).

(1 mark)

	1 cm ³	1 dm ³	1 m ³
			
	drinks bottle	sugar cube	washing machine
Approx. volume			

2. Complete the following sentences;

(1 mark)

To convert a volume in **cm³** into a volume in **dm³**, divide by.....

To convert a volume in **cm³** into a volume in **m³**, divide by.....

3.

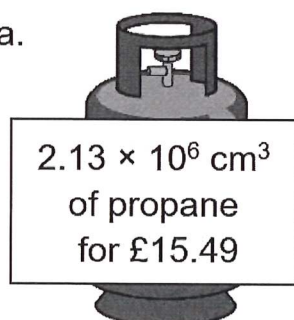
- A balloon of helium has a volume of 1600 cm³. What is its volume in units of dm³?
- The technician has prepared 550 cm³ of HCl(aq). What is its volume in units of m³?
- An experimental method requires 1.35 dm³ of NaOH(aq). What volume is this in cm³?
- A swimming pool has a volume of 375 m³. What volume is this in cm³?
- A 12 g cylinder of CO₂ contains 6.54 dm³ of gas. What volume of gas is this in units of m³?

(5 marks)

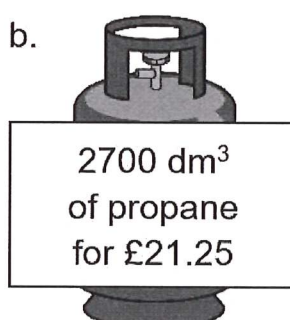
4. Which cylinder of propane gas is the best value for money?

(3 marks)

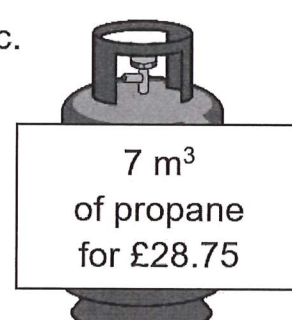
a.



b.



c.



Moles and mass

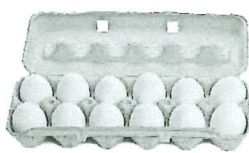
One mole of a substance is equal to 6.02×10^{23} atoms, ions or particles of that substance. This number is called the **Avogadro constant**.

The value of the Avogadro constant was chosen so that the relative formula mass of a substance weighed out in grams is known to contain exactly 6.02×10^{23} particles. We call this mass its **molar mass**.

We can use the equation below when calculating an amount in moles:

$$\text{amount of substance (mol)} = \frac{\text{mass (g)}}{\text{molar mass (g mol}^{-1}\text{)}}$$

How is a mole similar to a dozen?



Stating the amount of substance in moles is just the same as describing a quantity of eggs in dozens. You could say you had 24 or 2 dozen eggs.

Use the equation above to help you answer the following questions.

1. Calculate the amount of substance, in moles, in:

(3 marks)

- a. 32 g of methane, CH_4 (molar mass, 16.0 g mol^{-1})
- b. 175 g of calcium carbonate, CaCO_3
- c. 200 mg of aspirin, $\text{C}_9\text{H}_8\text{O}_4$

2. Calculate the mass in grams of:

(3 marks)

- a. 20 moles of glucose molecules (molar mass, 180 g mol^{-1})
- b. 5.00×10^{-3} moles of copper ions, Cu^{2+}
- c. 42.0 moles of hydrated copper sulfate, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$

- 3.

- a. 3.09 g of a transition metal carbonate was known to contain 0.0250 mol.

- i. Determine the molar mass of the transition metal carbonate.

(1 mark)

- ii. Choose the most likely identity for the transition metal carbonate from the list

below:



(1 mark)

c. 4.26 g of a sample of chromium carbonate was known to contain 0.015 mol.

Which of the following is the correct formula for the chromium carbonate? (2 marks)



BONUS QUESTION

If you had 1 mole of pennies which you could share with every person on earth how much could you give each person? Approximate world population = 7 500 000 000.

Moles and concentration

To calculate the concentration of a solution we use the equation:

$$\text{concentration (mol dm}^{-3}\text{)} = \frac{\text{amount of substance (mol)}}{\text{volume (dm}^3\text{)}}$$

Use the equation to help you complete each of the statements in the questions below.

- a) 1.5 mol of NaCl dissolved in 0.25 dm³ of water produces a solution with a concentration of mol dm⁻³.
- a) 250 cm³ of a solution of HCl(aq) with a concentration of 0.0150 mol dm⁻³ contains moles.
- b) A solution with a concentration of 0.85 mol dm⁻³ that contains 0.125 mol has a volume of dm³.

(1 mark each)

In this question you will need to convert between an amount in moles and a mass as well as using the equation above.

Space for working is given beneath each question.

- a. 5.0 g of NaHCO₃ dissolved in 100 cm³ of water produces a solution with a concentration of mol dm⁻³.

(2 marks)

- b. 25.0 cm³ of a solution of NaOH(aq) with a concentration of 3.8 mol dm⁻³ contains g of NaOH.

(2 marks)

- c. The volume of a solution of cobalt(II) chloride, CoCl₂, with a concentration of 1.3 mol dm⁻³ that contains 2.5 g of CoCl₂ is cm³.

(3 marks)

Control variable

The same initial mass is used when the procedure is repeated.

Accuracy

It's easier to read the scale of gas syringe than it is to read the scale of a measuring cylinder if the gas was collected over water. The readings are likely to be more accurate.

However, the accuracy of the results could still be affected by random or systematic errors.

Control variable

The same concentration and volume of HCl is used for repeats.

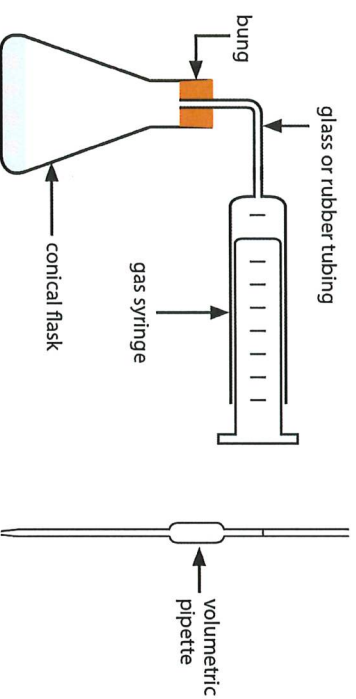
Dependent variable

The variable that's measured.

Independent variable

The time changes during the procedure as measurements are made.

Determining rate of a reaction from volume of gas produced



Method

1. 10 grams of marble chips are weighed and placed in a Buchner flask. The side-arm of the Buchner flask is connected to a piece of rubber tubing which is then connected to a gas syringe.
2. 20 cm³ of 2.00 mol dm⁻³ HCl(aq) are measured using a pipette.
3. The acid is poured into the Buchner flask. A bung is placed in the top of the Buchner flask, and the initial volume of gas in the gas syringe is recorded.
4. The volume of gas in the gas syringe is recorded every ten seconds until the volume remains constant.
5. The procedure is repeated to gain additional sets of results.

Accuracy

Using a volumetric pipette to measure volumes is more accurate than using a measuring cylinder.

Random error

The volume of gas that escapes between the timer starting and the bung being placed in the flask is a source of random error.

Systematic error

Problems with apparatus calibration can introduce a systematic error. These are consistent, repeatable errors associated with equipment.

Random error

The time between reading the time and taking the gas syringe reading is another source of random error in this procedure.

Precision

Repeating results allows precision to be determined. Just repeating results does not improve accuracy.

Glossary of terms

Term	Definition	Notes
accuracy	a measurement result is considered accurate if it is judged to be close to the true/acceptable value	Accuracy is a property of a single result. Random and systematic errors reduce accuracy.
anomaly (outlier)	value in a set of results that is judged not to be part of the inherent variation	Calculate the mean without the anomaly if you suspect an anomaly due to an error or due to different conditions. If you identify an anomaly during the practical, then consider repeating the measurement. In Maths , you may use the term 'outlier'.
control variable	variables other than the independent and dependent variables which are kept the same	These are quantities or conditions that are kept the same in a practical. Changes in these conditions could affect the validity of your method and results.
dependent variable	variable which is measured whenever there is a change in the independent variable	The dependent variable is recorded as either numerical values with units (quantitative) or in the form of descriptive comments (qualitative).
independent variable	variable which is deliberately changed or selected by the person in the planning of a practical activity	The independent variable is recorded in the first column of a results table. The dependent variable is recorded to the right with processed data in the far right columns. In a graph, the independent variable is usually plotted on the x-axis with the dependent variable on the y-axis.
line of best fit	a line drawn on a graph that passes as close as possible to the data points. It represents the best estimate of the underlying relationship between the variables.	A line of best fit can be a straight line or a curve. This differs from GCSE Maths , where a line of best fit is always a straight line.
precision	a quality denoting the closeness of agreement between measured values obtained by repeated measurements	Precision refers to more than one value. Precise results are clustered together. You can only determine if your results are precise by repeating the measurement. Reducing the effect of random errors improves precision. A systematic error does not affect precision, as it is the same error each time. You may have precise results with a systematic error, but not accurate results.
random error	error in a measurement due to small uncontrollable effects	We can't correct random errors, but we can reduce their effect by making more measurements and calculating the mean. Random errors contribute to uncertainty.

Term	Definition	Notes
range (of a variable)	the maximum and minimum values of the independent or dependent variables	In Maths the range is the difference between the biggest and smallest value of a variable.
repeatability	precision obtained when measurement results are produced in one laboratory, by a single operator, using the same conditions, over a short timescale	A measurement is repeatable when repetition under the same conditions gives similar results. Anomalous results can be identified by repeating the measurement. However, never discard data simply because it does not correspond with expectations.
reproducibility	precision obtained when measurement results are produced by different laboratories and therefore by different operators using different pieces of equipment	A measurement is reproducible when similar results are produced by different groups or different equipment or altered methods. If the results are reproducible then you can be more confident in the quality of the results.
resolution	smallest change in the input quantity being measured by a measuring instrument that gives a perceptible change in the reading of the measuring instrument	For example, the resolution of a ruler is 1 mm and the resolution of a burette is 0.1 cm ³ . It is not correct to describe equipment with a higher resolution as being more precise, as precision is a property of repeated results.
systematic error	error due to the measured value differing from the true value by the same amount each time	Methods or equipment may introduce systematic errors, producing consistent errors in results. Using the same equipment each time avoids introducing more systematic errors. Calibrating equipment where appropriate reduces systematic errors. A zero error is when the measuring device indicates a value when the quantity being measured is zero. Systematic errors contribute to uncertainty.
uncertainty	interval within which the true value can be expected to lie, with a given level of confidence or probability	Uncertainties depend on a range of factors, including systematic and random errors. Analogue apparatus have an uncertainty of $\pm$ half the smallest graduation. The uncertainty of digital apparatus is $\pm$ the resolution of the apparatus. The A Level Practical Skills handbooks contain further guidance on uncertainties.
validity (of an experiment)	suitability of the method used to answer the question being asked	To ensure validity, identify control variables and keep them constant to avoid affecting the dependent variables. In field studies there are naturally changing variables. Ensure the control variables are as similar as possible when repeating.



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General Tips

MgO



MgO

 Al_2O_3 Al_2O_3

Use capital letters where appropriate when writing chemical symbols. The first letter of an element symbol is always a capital.

a. ~~~~~ X

b. ~~~~~ ✓

c. ~~~~~ X

For MCQs, if you don't know the answer try eliminating options by annotating. Don't leave MCQ answers blank!

Your answer:  e

If changing the answer for an MCQ completely cross out the wrong letter write the correct one anew. Use upper letters only

Hydrocarbons contain carbon and hydrogen X

Hydrocarbons contain carbon and hydrogen only ✓

The value of A is greater than that of B

Use the information in the table to **describe** and **compare** the motion of the students.

Use precise terminology, so your answer shows the whole picture.

When a question asks you to make a comparison, make sure you clearly describe differences and/or similarities.

For Level of Response, answer each part of the question roughly equally. Check you have answered the whole question



CON

Longer answers don't always lead to more marks. If correct responses are contradicted, marks can be lost.



Concise responses are the best responses. All marks can be obtained within the answer space provided.

Describe and compare the bonding of the materials and suggest which of them would be best to use, giving reasons for your answer

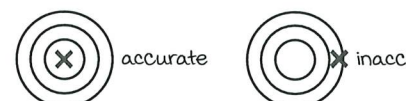
Underlining or circling key information in questions will help you remember, as will jotting down ideas and equations

Practical skills

This shows the results are reliable X

This shows the results are repeatable ✓

This shows the results are reproducible ✓



Use of the term 'reliability' is not encouraged. 'Repeatability', 'confidence' and 'reproducibility' are more appropriate.

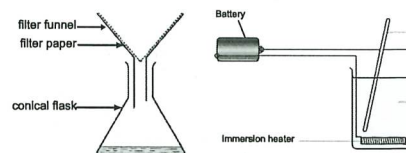
Remember that precision is the closeness of agreement between different results. It is not the same as accuracy.

Accuracy is a measure of how close a result is to the true value.



HEAT

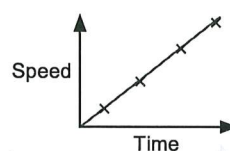
- ~~~~~
- ~~~~~
- ~~~~~



Scientific diagrams of equipment should be schematic and factual (not three-dimensional and artistic).

If describing a practical method use bullet points to give a list of simple, clear instructions someone else can follow.

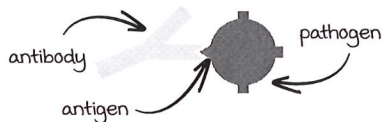
Practice applying what you know to new situations. Unfamiliar experiments will require you to use apparatus and techniques you know



speed increases steadily as time increases

When describing data (graphs/tables) comment on trends, patterns and correlations, not just single data points.

Biology



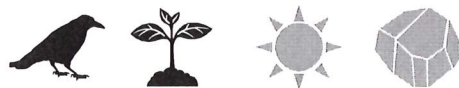
Antibodies made by our immune system recognise and bind to the antigens found on the outside of foreign organisms.



Food chains show the direction energy moves between organisms. Pyramids of biomass show total energy in each level.

	A	a
A	AA	Aa
a	Aa	aa

Make sure that your capital letters in Punnett square are much bigger than lower-case letters.

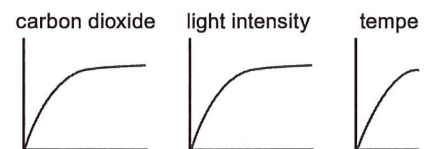


biotic abiotic

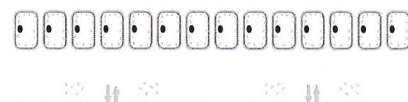
Remember living things are biotic, non-living things are abiotic.



Students didn't know names of cell types and structure of organs. Practise matching diagrams of cells/organs to their functions.

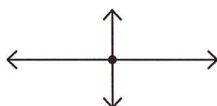


Carry out different experiments and draw graphs to understand how limiting factors affect photosynthesis.

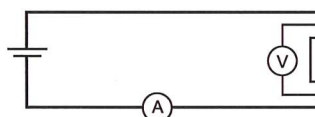


Many students did not understand the function of guard cells and the stomata.

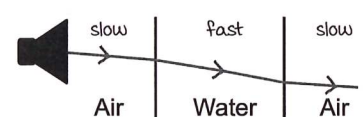
Physics



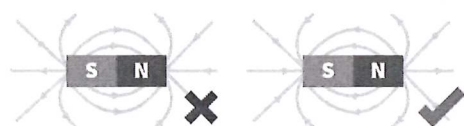
A free body diagram is the scientific way to show the forces acting on an object. Most students showed artistic sketches instead.



In circuit diagrams components must be connected and in the correct position. Ammeter in series, voltmeter in parallel.



Sound waves move faster in denser mediums. e.g. Sound waves move faster in water than in air.



When drawing magnetic field lines, the arrows go from the north pole to the south pole and should not overlap.



Energy can be stored or transferred between stores. There are not different types of energy – only different stores.



The National Grid uses step-up and step-down transformers to reduce the current and increase voltage in transmission.

Force is equal to mass times the acceleration, so...

vs

$$F = ma, \text{ so...}$$

Using equations to help communicate your answer can be quicker than several sentences saying the same thing.

Chemistry

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 <i>same</i> person, using the <i>same</i> equipment, under the <i>same</i> conditions
What is reproducibility?	how precise repeated measurements are when they are taken by <i>different</i> people, using <i>different</i> 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?	relative isotopic mass = $\frac{\text{mass of an isotope}}{\frac{1}{12} \text{ mass of 1 atom of } ^{12}\text{C}}$
What is the equation for relative atomic mass (A_r)?	relative atomic mass = $\frac{\text{weighted mean mass of 1 atom}}{\frac{1}{12} \text{ mass of 1 atom of } ^{12}\text{C}}$
What is the equation for relative molecular mass (M_r)?	relative molecular mass = $\frac{\text{average mass of 1 molecule}}{\frac{1}{12} \text{ mass of 1 atom of } ^{12}\text{C}}$
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 $50\,000 \text{ mol dm}^{-3}$ in standard form, $A = 5$ and $x = 4$ as there are four numbers after the initial 5.

Therefore, it would be written as $5 \times 10^4 \text{ mol dm}^{-3}$.

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

So it is written as $2 \times 10^{-5} \text{ Nm}^2$.

Practice questions

- Change the following values to standard form.
 - boiling point of sodium chloride: 1413°C
 - largest nanoparticles: $0.0\,001 \times 10^{-3} \text{ m}$
 - number of atoms in 1 mol of water: 1806×10^{21}
- Change the following values to ordinary numbers.
 - 5.5×10^{-6}
 - 2.9×10^2
 - 1.115×10^4
 - 1.412×10^{-3}
 - 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 $\times 6.02 \times 10^{23}$ 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 $488\,889\text{ J mol}^{-1}$ 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.

$$488\,889 \div 10^3\text{ kJ mol}^{-1} = 488.889\text{ kJ mol}^{-1}$$

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.

$$333\text{ mJ mol}^{-1} \text{ is } 0.000\,333\text{ kJ mol}^{-1}$$

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.

$$333\text{ mJ mol}^{-1} \text{ is } 333\,000\,000\text{ nJ mol}^{-1}$$

Practice question

- 6 Calculate the following unit conversions.
- a** $300\text{ }\mu\text{m}$ to m
b 5 MJ to mJ
c 10 GW to kW

2 Balancing chemical equations

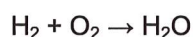
2.1 Conservation of mass

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.

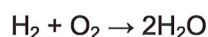
You need to be able to use the principle of conservation of mass to write formulae, and balanced chemical equations and half equations.

2.2 Balancing an equation

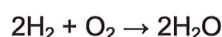
The equation below shows the correct formulae but it is not balanced.



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 .



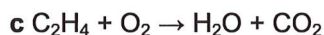
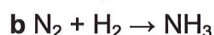
Now the oxygen atoms are balanced but the hydrogen atoms are no longer balanced. A two must be placed in front of the H_2 .



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.

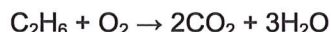


2.3 Balancing an equation with fractions

To balance the equation below:

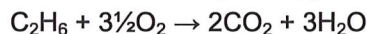


- Place a two before the CO_2 to balance the carbon atoms.
- Place a three in front of the H_2O to balance the hydrogen atoms.

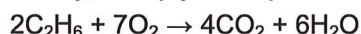


There are now four oxygen atoms in the carbon dioxide molecules plus three oxygen atoms in the water molecules, giving a total of seven oxygen atoms on the product side.

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

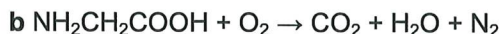
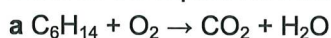


- Finally, multiply the equation by 2 to get whole numbers.

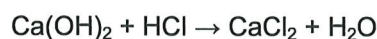


Practice question

2 Balance the equations below.

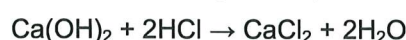


2.4 Balancing an equation with brackets



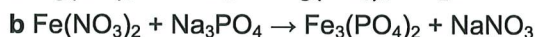
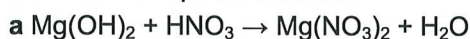
Here the brackets around the hydroxide (OH^-) group show that the $\text{Ca}(\text{OH})_2$ unit contains one calcium atom, two oxygen atoms, and two hydrogen atoms.

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



Practice question

3 Balance the equations below.



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 dm³ 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 dm³.

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 cm³ 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 dm³ of solution.
- 5 Calculate the number of moles of NaOH in an aqueous solution of 36 cm³ 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 CaCO₃, for example, the atomic mass of calcium is 40.1, carbon is 12, and oxygen is 16. So the molar mass of CaCO₃ is:

$40.1 + 12 + (16 \times 3) = 100.1$. 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:



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

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

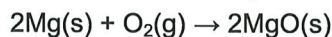
$$n = \frac{m}{M} = 2.50/100.1 = 0.025 \text{ mol}$$

- 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.



- 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:



- 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.



- 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

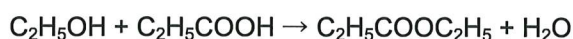
5.1 Calculating percentage yield

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.



The experiment has a theoretical yield of 5.00 g.

The actual yield is 4.50 g.

The molar mass of $\text{C}_2\text{H}_5\text{COOC}_2\text{H}_5 = 102.0 \text{ g mol}^{-1}$

Calculate the percentage yield of the reaction.

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

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

percentage yield = $(0.0441/0.0490) \times 100\% = 90\%$

Practice questions

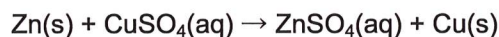
- 1 Calculate the percentage yield of a reaction with a theoretical yield of 4.75 moles of product and an actual yield of 3.19 moles of product. Give your answer to 3 significant figures.
- 2 Calculate the percentage yield of a reaction with a theoretical yield of 12.00 moles of product and an actual 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.



The measuring cylinder used to measure the copper(II) sulfate solution has a maximum error of $\pm 2 \text{ cm}^3$.

- a** Calculate the percentage error.

$$\text{percentage error} = (2/50) \times 100\% = 4\%$$

- b** A thermometer has a maximum error of $\pm 0.05 \text{ }^\circ\text{C}$.

Calculate the percentage error when the thermometer is used to record a temperature rise of $3.9 \text{ }^\circ\text{C}$. Give your answer to 3 significant figures.

$$\text{percentage error} = (2 \times 0.05)/3.9 \times 100\% = 2.56\%$$

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

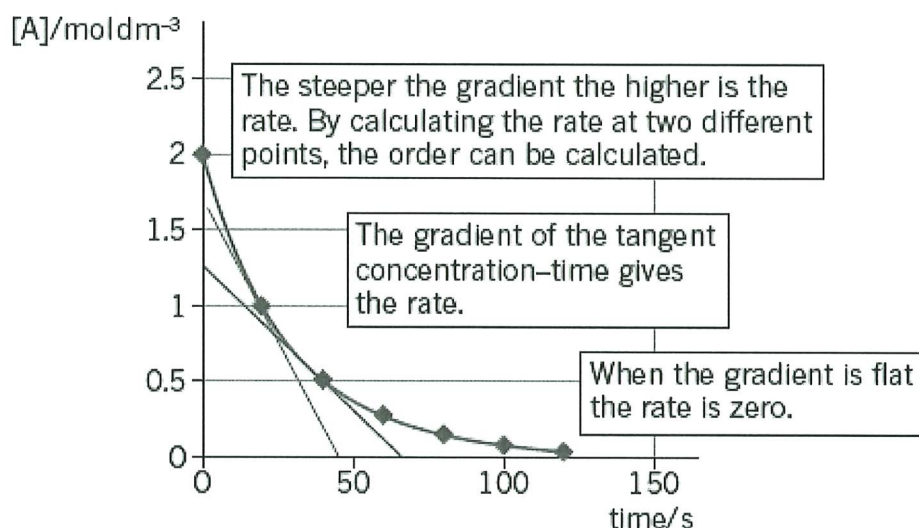
Practice questions

- 3 A gas syringe has a maximum error of $\pm 0.5 \text{ cm}^3$. 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 $\pm 0.5 \text{ }^\circ\text{C}$. Calculate the maximum percentage error when recording these temperature rises. Give your answers to 3 significant figures.
a $12.0 \text{ }^\circ\text{C}$ **b** $37.6 \text{ }^\circ\text{C}$

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 $0.0365 \text{ mol dm}^{-3} \text{ s}^{-1}$.

Practice question

- 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 Br₂ concentration by drawing tangents.
c Find the half-life at two points and deduce the order of the reaction.