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Richard Harwood and Ian Lodge

Cambridge IGCSE®

Physical Science

Chemistry Workbook

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Physical Science

Chemistry Workbook

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Introduction

This workbook contains exercises designed to help you develop the skills needed for success in Cambridge IGCSE® Physical Science.

The examination tests three different Assessment Objectives, or AOs for short. These are:

AO1 Knowledge with understanding

AO2 Handling information and problem solving

AO3 Experimental skills and investigations.

In the examination, about 50% of the marks are for AO1, 30% for AO2 and 20% for AO3. Just learning your work and remembering it is therefore not enough to make sure that you get the best possible grade in the exam. Half of all the marks are for AO2 and AO3. You need to be able to use what you've learnt in unfamiliar contexts (AO2) and to demonstrate your experimental skills (AO3).

This workbook contains exercises to help you to develop AO2 and AO3 further. There are some questions that just involve remembering things you have been taught (AO1), but most of the questions require you to use what you've learnt to work out, for example, what a set of data means, or to suggest how an experiment might be improved.

These exercises are not intended to be exactly like the questions you will get on your exam papers. This is because they are meant to help you to develop your skills, rather than testing you on them.

There's an introduction at the start of each exercise that tells you the purpose of it – which skills you will be working with as you answer the questions.

For some parts of the exercises, there are self-assessment checklists. You can try marking your own work using these. This will help you to remember the important points to think about. Your teacher should also mark the work and will discuss with you whether your own assessments are right.

The exercises cover both Core and Supplement material of the syllabus. The Supplement material can be identified by the Supplement bar in the margin (as shown). This indicates that the exercise is intended for students who are studying the Supplement content of the syllabus as well as the Core.

The Periodic Table

Key

atomic number **atomic symbol** name relative atomic mass

Group																	
I	II											III	IV	V	VI	VII	VIII
							1 **H** hydrogen 1										2 **He** helium 4
3 **Li** lithium 7	4 **Be** beryllium 9											5 **B** boron 11	6 **C** carbon 12	7 **N** nitrogen 14	8 **O** oxygen 16	9 **F** fluorine 19	10 **Ne** neon 20
11 **Na** sodium 23	12 **Mg** magnesium 24											13 **A*l*** aluminium 27	14 **Si** silicon 28	15 **P** phosphorus 31	16 **S** sulfur 32	17 **C*l*** chlorine 35.5	18 **Ar** argon 40
19 **K** potassium 39	20 **Ca** calcium 40	21 **Sc** scandium 45	22 **Ti** titanium 48	23 **V** vanadium 51	24 **Cr** chromium 52	25 **Mn** manganese 55	26 **Fe** iron 56	27 **Co** cobalt 59	28 **Ni** nickel 59	29 **Cu** copper 64	30 **Zn** zinc 65	31 **Ga** gallium 70	32 **Ge** germanium 73	33 **As** arsenic 75	34 **Se** aelenium 79	35 **Br** bromine 80	36 **Kr** krypton 84
37 **Rb** rubidium 85	38 **Sr** strontium 88	39 **Y** yttrium 89	40 **Zr** zirconium 91	41 **Nb** niobium 93	42 **Mo** molybdenum 96	43 **Tc** technetium –	44 **Ru** ruthenium 101	45 **Rh** rhodium 103	46 **Pd** palladium 106	47 **Ag** silver 108	48 **Cd** cadmium 112	49 **In** indium 115	50 **Sn** tin 119	51 **Sb** antimony 122	52 **Te** tellurium 128	53 **I** iodine 127	54 **Xe** xenon 131
55 **Cs** caesium 133	56 **Ba** barium 137	57–71 lanthanoids	72 **Hf** hafnium 179	73 **Ta** tantalum 181	74 **W** tungsten 184	75 **Re** rhenium 186	76 **Os** osmium 190	77 **Ir** indium 192	78 **Pt** platinum 195	79 **Au** gold 197	80 **Hg** mercury 201	81 **T*l*** thallium 204	82 **Pb** lead 207	83 **Bi** bismuth 209	84 **Po** polonium –	85 **At** astatine –	86 **Rn** radon –
87 **Fr** francium –	88 **Ra** radium –	89–103 actinoids –	104 **Rf** rutherfordium –	105 **Db** dubnium –	106 **Sg** seaborgium –	107 **Bh** bohrium –	108 **Hs** hassium –	109 **Mt** meitnerium –	110 **Ds** darmstadtium –	111 **Rg** roentgenium –	112 **Cn** copernicium –		114 **F*l*** flerovium –		116 **Lv** livermorium –		

lanthanoids	57 **LA** lanthanium 139	58 **Ce** cerium 140	59 **Pr** praseodymium 141	60 **Nd** neodymium 144	61 **Pm** promethium	62 **Sm** samarium 150	63 **Eu** europium 152	64 **Gd** gadolinium 157	65 **Tb** terbium 159	66 **Dy** dysprosium 163	67 **Ho** holmium 165	68 **Er** erbium 167	69 **Tm** thulium 169	70 **Yb** ytterbium 173	71 **Lu** lutetium 175
actinoids	89 **AC** actinium –	90 **Th** thorium 232	91 **Pa** protactinium 231	92 **U** uranium 238	93 **Np** neptunium –	94 **Pu** plutonium –	95 **Am** americium –	96 **Cm** curium –	97 **Bk** berkelium –	98 **Cf** californium –	99 **Es** einsteinium –	100 **Fm** fermium –	101 **Md** mendelevium –	102 **No** nobelium –	103 **Lr** lawrencium –

C1: The particulate nature of matter

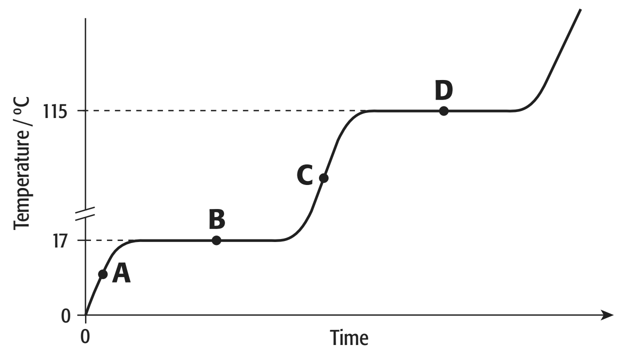
DEFINITIONS TO LEARN

physical state: the three states of matter are solid, liquid and gas
condensation: the change of state from gas to liquid
melting: the change of state from solid to liquid
freezing: the change of state from liquid to solid at the melting point
boiling: the change of state from liquid to gas at the boiling point of the liquid
evaporation: the change of state from liquid to gas below the boiling point
sublimation: the change of state directly from solid to gas (or the reverse)
crystallisation: the formation of crystals when a saturated solution is left to cool

Exercise C1.1 Changing physical state

This exercise will develop your understanding of the kinetic model and the energy changes involved in changes of physical state.

The graph shows the heating curve for a pure substance. The temperature rises with time as the substance is heated.



a What physical state(s) is the substance in at points A, B, C and D?

A .... C ....

B .... D ....

b What is the melting point of the substance? ....

c What is its boiling point? ....

d What happens to the temperature while the substance is changing state?

....

e The substance is not water. How do we know this from the graph?

....

f Complete the passage using the words given below.

different	**diffusion**	**gas**	**spread**	**particles**
diffuse	**random**	**lattice**	**vibrate**	**temperature**

The kinetic **model** states that the .... in a liquid and a .... are in constant motion. In a gas, the particles are far apart from each other and their motion is said to be .... The particles in a solid are held in fixed positions in a regular .... In a solid, the particles can only .... about their fixed positions.

Liquids and gases are fluid states. When particles move in a fluid, they can collide with each other. When they collide, they bounce off each other in .... directions. If two gases or liquids are mixed, the different types of particle .... out and get mixed up. This process is called ....

At the same .... particles that have a lower mass move faster than those with higher mass. This means that the lighter particles will spread and mix more quickly; the lighter particles are said to ....faster than the heavier particles.

g Use the data given for the substances listed below to answer the questions that follow on their physical state at a room temperature of 25 °C and atmospheric pressure.

Substance	Melting point / °C	Boiling point / °C
sodium	98	883
radon	−71	−62
ethanol	−117	78
cobalt	1492	2900
nitrogen	−210	−196
propane	−188	−42
ethanoic acid	16	118

i Which substance is a liquid over the smallest range of temperature? ....

ii Which **two** substances are gaseous at −50 °C?

.... and ....

iii Which substance has the lowest freezing point? ....

iv Which substance is liquid at 2500 °C? ....

v A sample of ethanoic acid was found to boil at 121 °C at atmospheric pressure. Use the information in the table to comment on this result.

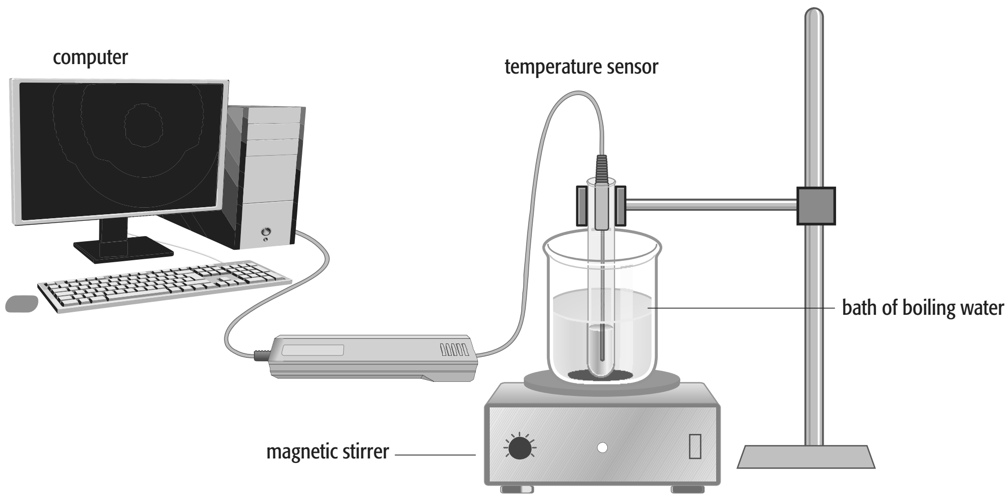
....

....

Exercise C1.2 Plotting a cooling curve

This exercise presents data obtained practically for plotting a cooling curve. It will help develop your skills in handling the data and interpreting what changes the different regions of the curve represent. Examples of sublimation are also discussed.

A student, carried out the following data-logging experiment using the apparatus shown below, as part of a project on changes of state. An organic crystalline solid was melted by placing it in a tube in a boiling water bath. A temperature sensor was placed in the sample tube.



The temperature change was followed as the liquid was allowed to cool down. The data shown in the table below are taken from the computer record of the temperature change as the liquid cooled down to room temperature.

Time / min	0	0.5	1.0	1.5	2.0	2.2	2.4	2.6	2.8	3.0	3.5	4.0	4.5	5.0
Temperature / °C	96.1	89.2	85.2	82.0	80.9	80.7	80.6	80.6	80.5	80.3	78.4	74.2	64.6	47.0

a On the grid below, plot a graph of the temperature change taking place in this experiment.

b What change is taking place over the second minute of the experiment?

....

c Why does the temperature remain almost constant over this period of time? Give your explanation in terms of what is happening to the organisation of the molecules of the substance.

....

....

....

....

d What change would need to be made to carry out the experiment using a compound with a melting point greater than 100 °C?

....

e A similar experiment was carried out to demonstrate the cooling curve for paraffin wax.

i In the space below, sketch the shape of the graph you would expect to produce.

ii Explain why the curve is the shape you have drawn.

....

....

f Sublimation occurs when a substance passes between the solid and gaseous states without going through the liquid phase. Both carbon dioxide and water can sublime under certain conditions of temperature and pressure.

'Dry ice' is the solid form of carbon dioxide used in commercial refrigeration. At atmospheric pressure it has a 'sublimation point' of –78.5 °C.

i What difference can you see between solid carbon dioxide and water ice at atmospheric pressure?

....

....

ii If you gently shake a carbon dioxide fire extinguisher, you will feel the presence of liquid within the extinguisher. What conditions within the extinguisher mean that the CO_2 is liquid in this case?

....

....

iii Complete the following paragraph about a particular type of frost using the words listed below.

surrounding	**liquid**	**colder**	**humid**
white	**crystals**	**ice**	

Hoar frost is a powdery .... frost caused when solid .... forms from .... air. The solid surface on which it is formed must be .... than the .... air. Water vapour is deposited on a surface as fine ice .... without going through the .... phase.

C2: Experimental techniques

DEFINITIONS TO LEARN

filtration: the separation of a solid from a liquid using filter paper

distillation: the separation of a liquid from a mixture using differences in boiling point

fractional distillation: the separation of a mixture of liquids using differences in boiling point

diffusion: the random movement of particles in a fluid (liquid or gas) leading to the complete mixing of the particles

chromatography: the separation of a mixture of soluble (coloured) substances using paper and a solvent

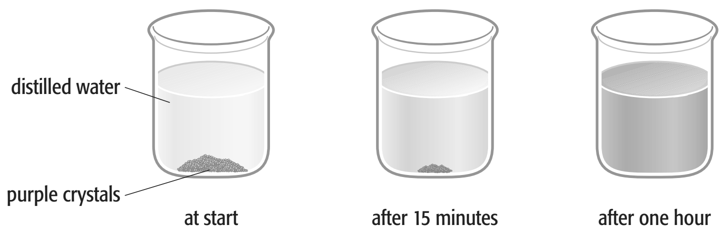
Exercise C2.1 Diffusion, solubility and separation

The processes of diffusion and dissolving in a solvent are linked. This exercise explores the basis of these processes in terms of the kinetic (particle) theory. The separation of a solvent mixture by fractional distillation is also discussed.

A student placed some crystals of potassium manganate(VII) at the bottom of a beaker of distilled water. She then left the contents of the beaker to stand for one hour.

a The diagram below shows what she saw during the experiment.

After one hour, all the solid crystals had disappeared and the solution was purple throughout.



i Use the ideas of the kinetic theory to explain her observations.

....

....

....

....

....

ii If warm water at 50 °C had been used, would the observations have taken place in a longer or shorter time? Explain your answer.

....

....

....

b The process of dissolving can be used to separate and purify chemical compounds. Organic solvents such as propanone can be used to extract pigments from plants. Some grass is crushed and mixed with the propanone. The colour pigments are extracted to give a dark green solution.

i Given a pure sample of chlorophyll, describe how could you show that the green solution from the grass contained chlorophyll and other coloured pigments?

....

....

....

....

ii Draw a labelled diagram that describes the method of separating coloured pigments that you have discussed in part **i**.

Use the checklist below to give yourself a mark for your drawing. For each point, award yourself:

- **2 marks if you did it really well**
- **1 mark if you made a good attempt at it, and partly succeeded**
- **0 marks if you did not try to do it, or did not succeed.**

Self-assessment checklist for drawings

Check point	Marks awarded	
	You	Your teacher
You have made a large drawing, using the space provided.		
There are no obvious errors – liquids missing, flasks open when they should be closed, etc.		
You have drawn single lines with a sharp pencil, not many tries at the same line (and erased mistakes).		
You have used a ruler for the lines that are straight.		
Your diagram is in the right proportions.		
You have drawn label lines with a ruler, touching the item being labelled.		
You have written the labels horizontally and neatly, well away from the diagram itself.		
Total (out of 14)		

12–14 Excellent.

10–11 Good.

7–9 A good start, but you need to improve quite a bit.

5–6 Poor. Try this same drawing again, using a new sheet of paper.

1–4 Very poor. Read through all the criteria again, and then try the same drawing.

c Propanone is a very useful solvent that mixes well with water even though it is an organic compound. A propanone:water (65%:35%) mixture used for cleaning laboratory apparatus can be separated using fractional distillation.

A total volume of 80 cm^3 of the mixture was distilled.

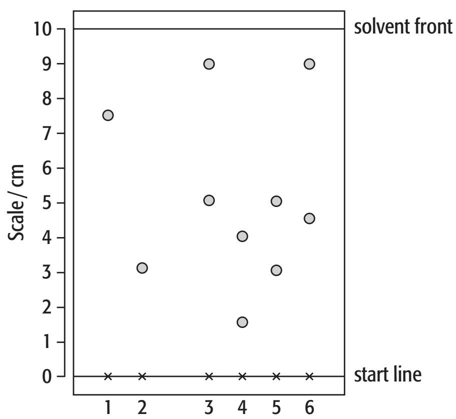
Sketch below a graph of the temperature readings against the volume of distillate collected for the distillation carried out. The thermometer is placed at the connection between the fractionating column and the condenser. The boiling point of propanone is 56 °C.

Exercise C2.2 Chromatography at the races

This exercise will help you understand aspects of chromatography by considering an unfamiliar application of the technique.

Chromatography is used by the 'Horse Racing Forensic Laboratory' to test for the presence of illegal drugs in racehorses.

A concentrated sample of urine is spotted on to chromatography paper on the start line. Alongside this, known drugs are spotted. The chromatogram is run using methanol as the solvent. When finished, the paper is read by placing it under ultraviolet light. A chromatogram of urine from four racehorses is shown below.



Spot	Description
1	caffeine
2	paracetamol
3	urine sample horse A
4	urine sample horse B
5	urine sample horse C
6	urine sample horse D

a State **two** factors which determine the distance a substance travels up the paper.

....

....

b The results show that the sample from one horse contains an illegal substance. State which horse and the drug that is present.

....

c Give a reason for the use of this drug.

....

d The results for known drugs are given as 'R_f values'.

$$R_f = \frac{\text{distance travelled by the substance}}{\text{distance travelled by the solvent}}$$

Calculate the R_f value for caffeine.

C3:
Atoms, elements and compounds

DEFINITIONS TO LEARN

atom: the smallest part of an element that can take part in a chemical change

proton number (atomic number): the number of protons in the nucleus of an atom of an element

nucleon number (mass number): the number of protons and neutrons in the nucleus of an atom

electron arrangement: the organisation of electrons in their different energy levels (shells)

isotopes: atoms of the same element which have the same proton number but a different nucleon number

element: a substance containing only one type of atom

compound: a substance made of two, or more, elements chemically combined together

Periodic Table: the table in which the elements are organised in order of increasing proton number and electron arrangement

group: a vertical column of elements in the Periodic Table; elements in the same group have similar properties

period: a horizontal row of elements in the Periodic Table

valency: the number of chemical bonds an atom can make

Exercise C3.1 Atomic structure

This exercise helps familiarise you with aspects of atomic structure including the organisation of electrons into energy levels (or shells), and the uses of radioactivity.

a Choose from the words below to fill in the gaps in the passage. Words may be used once, more than once or not at all.

proton **electrons** **nucleon** **isotopes** **protons**

neutrons **nucleus** **energy levels**

Atoms are made up of three different particles: .... which are positively charged; .... which have no charge; and .... which are negatively charged.

The negatively charged particles are arranged in different .... (shells) around the .... of the atom. The particles with a negligible mass are the .... All atoms of the same element contain the same number of .... and .... Atoms of the same element with different numbers of .... are known as ....

b This part of the exercise is concerned with electron arrangements and the structure of the Periodic Table. Complete these sentences by filling in the blanks with words or numbers.

The electrons in an atom are arranged in a series of .... around the nucleus. These shells are also called .... levels. In an atom, the shell .... to the nucleus fills first, then the next shell, and so on. There is room for:

- up to .... electrons in the first shell
- up to .... electrons in the second shell
- up to .... electrons in the third shell.

(There are 18 electrons in total when the three shells are completely full.)

The elements in the Periodic Table are organised in the same way as the electrons fill the shells. Shells fill from .... to .... across the .... of the Periodic Table.

- The first shell fills up first from .... to helium.
- The second shell fills next from lithium to ....
- Eight .... go into the third shell from sodium to argon.
- Then the fourth shell starts to fill from potassium.

Exercise C3.2 The first four periods

This exercise is aimed at developing your knowledge of the basic features of the Periodic Table and the properties of an element that relate to its position in the table.

The diagram below shows the upper part of the Periodic Table with certain elements selected.

I	II											III	IV	V	VI	VII	0
				H													He
Li													C	N		F	Ne
Na	Mg											Al		P	S		
	Ca				Cr					Cu						Br	Kr

Using the elements shown above, write down the symbols for the elements which answer the following questions.

a Which **two** elements are stored under oil because they are very reactive?

....

b Which **two** elements are transition metals?

....

c Which element has just two electrons in the full outer shell of its atom?

....

d Which element is a red-brown liquid at room temperature and pressure?

....

e Which element has four electrons in the outer energy level of its atom?

....

f Which element is a yellow solid at room temperature?

....

g Which elements are noble gases?

....

h Which element has compounds that produce blue solutions when they dissolve?

....

i Which element has the electron arrangement 2.8.8.2?

....

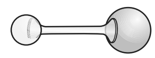
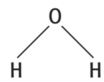
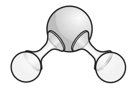
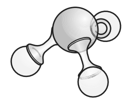
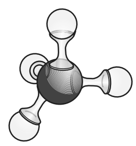
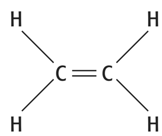
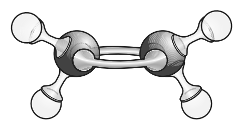
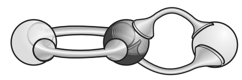
j Which element burns with a brilliant white flame when ignited?

....

Exercise C3.3 The chemical bonding in simple molecules

This exercise will familiarise you with the structures of some simple covalent compounds and the methods we have for representing the structure and shape of their molecules.

a Many covalent compounds exist as simple molecules where the atoms are joined together with single or double bonds. A covalent bond, made up of a shared pair of electrons, is often represented by a short straight line. Complete the table by filling in the blank spaces.

Name of compound	Formula	Drawing of structure	Molecular model
hydrogen chloride	....	H—Cl	
water	H_2O		
ammonia	....		
....	CH_4		
ethene	....		
....	....	O=C=O	

b Graphite is one of the crystalline forms of carbon. Two of the distinctive properties of graphite are:

- it conducts electricity even though it is a non-metal, and
- it can act as a lubricant even though it has a giant covalent structure.

Give a brief explanation of these properties in the light of the structure of graphite.

i Graphite as an electrical conductor

....

....

....

ii Graphite as a lubricant

....

....

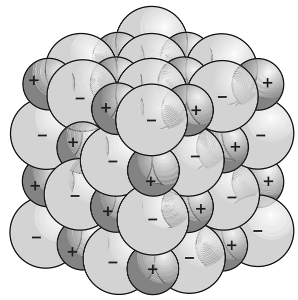
....

Exercise C3.4 The nature of ionic lattices

This exercise will help you relate the structures of ionic compounds to some of their key properties.

The diagram shows a model of the structure of sodium chloride and similar ionic crystals. The ions are arranged in a regular lattice structure – a giant ionic lattice.

The boxes below contain properties of ionic compounds and their explanations. Draw lines to link each pair.



Property	Explanation
The solution of an ionic compound in water is a good conductor of electricity – such ionic substances are electrolytes.	The ions in the giant ionic structure are always arranged in the same regular way – see the diagram.
Ionic crystals have a regular shape. All the crystals of each solid ionic compound are the same shape. Whatever the size of the crystal, the angles between the faces of the crystal are always the same.	The giant ionic structure is held together by the strong attraction between the positive and negative ions. It takes a lot of energy to break down the regular arrangement of ions.
Ionic compounds have relatively high melting points.	In a molten ionic compound, the positive and negative ions can move around – they can move to the electrodes when a voltage is applied.
When an ionic compound is heated above its melting point, the molten compound is a good conductor of electricity.	In a solution of an ionic compound, the positive metal ions and the negative non-metal ions can move around – they can move to the electrodes when a voltage is applied.

C4: Stoichiometry

DEFINITIONS TO LEARN

indicator: a substance that changes colour depending on whether it is in an acid or alkali

salt: an ionic substance produced from an acid by neutralisation with a base

neutralisation reaction: a reaction between an acid and a base to produce a salt and water only

relative atomic mass: the average mass of naturally occurring atoms of an element on a scale where the carbon-12 atom has a mass of exactly 12 units

relative formula mass: the sum of all the relative atomic masses of all the atoms or ions in a compound

chemical formula: the formula of an ionic compound shows the ratio of the atoms in a compound in whole numbers; for a simple covalent compound the formula shows the numbers of each atom present in the molecule.

mole: the relative formula mass of a substance in grams

molar gas volume: the volume occupied by one mole of any gas (24 dm^3 at room temperature and pressure)

Exercise C4.1 Formulae of ionic compounds

The writing of chemical formulae is central to chemistry. This exercise will help you understand how to work out the formulae of ionic compounds and what such formulae mean.

The table below shows the valencies and formulae of some common ions.

		Valency		
		1	2	3
Positive ions (cations)	**metals**	sodium (Na^+) potassium (K^+) silver (Ag^+)	magnesium (Mg^{2+}) copper (Cu^{2+}) zinc (Zn^{2+}) iron (Fe^{2+})	aluminium (Al^{3+}) iron (Fe^{3+}) chromium (Cr^{3+})
	compound ions	ammonium (NH_4^+)		
Negative ions (anions)	**non-metals**	chloride (Cl^-) bromide (Br^-) iodide (I^-)	oxide (O^{2-}) sulfide (S^{2-})	nitride (N^{3-})
	compound ions	nitrate (NO_3^-) hydroxide (OH^-)	carbonate (CO_3^{2-}) sulfate (SO_4^{2-})	phosphate (PO_4^{3-})

a Use the information in the table to work out the formulae of the following ionic compounds.

i Copper oxide ....

ii Sodium carbonate ....

iii Zinc sulfate ....

iv Silver nitrate ....

v Magnesium bromide ....

vi Ammonium sulfate ....

vii Magnesium nitride ....

viii Potassium phosphate ....

ix Iron(III) hydroxide ....

x Chromium(III) chloride ....

b Use the information in the table and your answers in **a** above to give the ratio of the different atoms in the following compounds.

i Copper oxide Cu : O ....

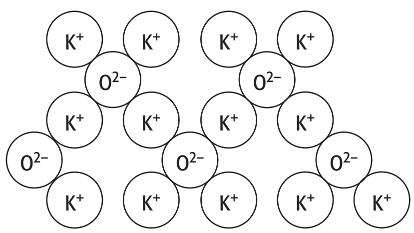
ii Magnesium bromide Mg : Br ....

iii Magnesium nitride Mg : N ....

iv Iron(III) hydroxide Fe : O : H ....

v Ammonium sulfate N : H : S : O ....

c The diagram below shows a representation of the structure of an ionic oxide.

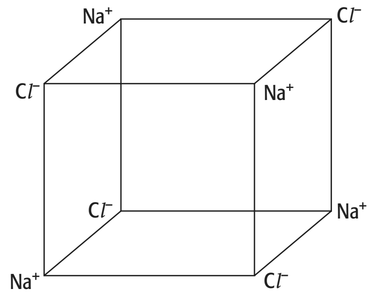


i What is the ratio of K^+ ions to O^{2-} ions? ....

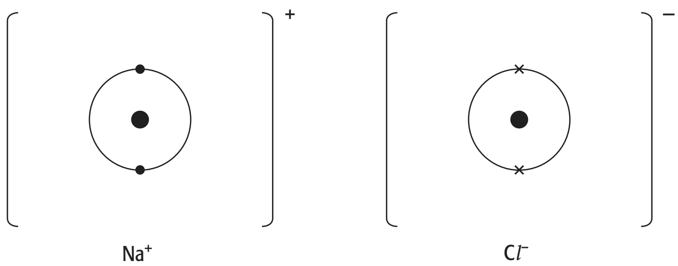
ii What is the formula of this compound? ....

d The following diagram shows the structure of common salt.

i Extend the structure to the right, by adding **four** more ions.



ii Complete the diagrams below for the ions in the structure to show their electron arrangement. Draw in any missing electron shells, showing clearly the origin of the electrons involved.



iii Draw an ionic diagram similar to the one above for the structure of magnesium chloride.

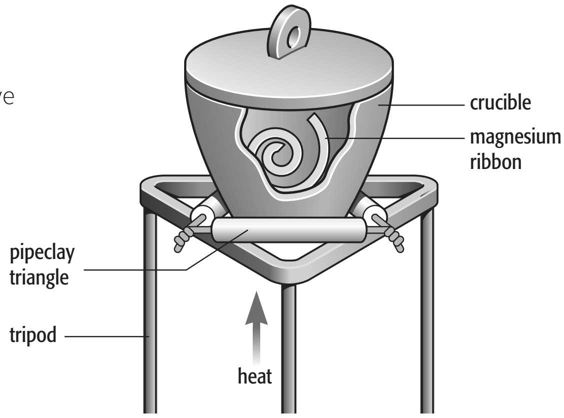
Exercise C4.2 Making magnesium oxide – a quantitative investigation

This exercise will develop your skills in processing and interpreting results from practical work.

Magnesium oxide is made when magnesium is burnt in air. How does the mass of magnesium oxide made depend on the mass of magnesium burnt? The practical method is described below.

Method

- Weigh an empty crucible and lid.
- Roll some magnesium ribbon around a pencil, then remove the coiled ribbon and place it in the crucible and re-weigh (not forgetting the lid).
- Place the crucible in a pipeclay triangle sitting safely on a tripod. (The lid should be on the crucible.)
- Heat the crucible and contents strongly, occasionally lifting the lid to allow more air in.
- When the reaction has eased, take off the lid.
- Heat strongly for another three minutes.
- Let the crucible cool down and then weigh it.
- Repeat the heating until the mass is constant.

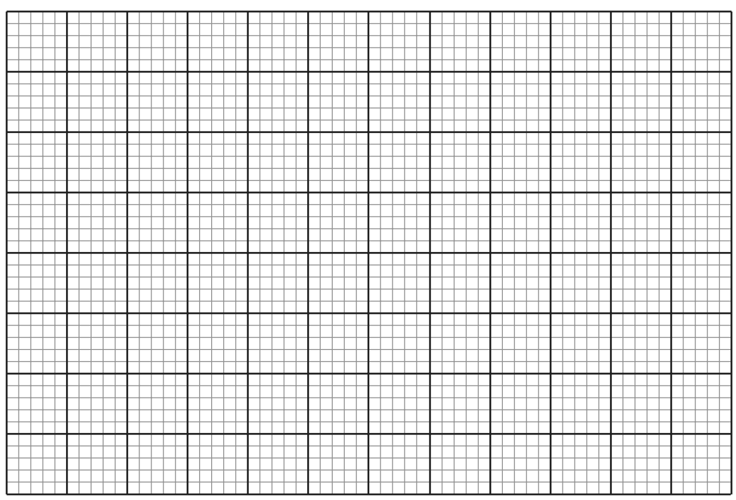


Results

The table shows a set of class results calculated from the weights each student group obtained using this method.

Mass of magnesium / g	0.06	0.05	0.04	0.18	0.16	0.10	0.11	0.14	0.15	0.14	0.08	0.10	0.13
Mass of magnesium oxide / g	0.10	0.08	0.06	0.28	0.25	0.15	0.15	0.21	0.24	0.23	0.13	0.17	0.21

Use these results to plot a graph on the grid below relating mass of magnesium oxide made to mass of magnesium used. Remember there is one point on this graph that you can be certain of – what point is that? Include it on your graph.



Use the checklist below to give yourself a mark for your graph. For each point, award yourself:

- **2 marks if you did it really well**
- **1 mark if you made a good attempt at it, and partly succeeded**
- **0 marks if you did not try to do it, or did not succeed.**

Self-assessment checklist for graphs:

Check point	Marks awarded	
	You	Your teacher
You have drawn the axes with a ruler, using most of the width and height of the grid.		
You have used a good scale for the *x*-axis and the *y*-axis, going up in 0.01 s, 0.05 s or 0.10 s.		
You have labelled the axes correctly, giving the correct units for the scales on both axes.		
You have plotted each point precisely and correctly.		
You have used a small, neat cross for each point.		
You have drawn a single, clear best-fit line through the points – using a ruler for a straight line.		
You have ignored any anomalous results when drawing the line.		
Total (out of 14)		

12–14 Excellent.

10–11 Good.

7–9 A good start, but you need to improve quite a bit.

5–6 Poor. Try this same graph again, using a new sheet of graph paper.

1–4 Very poor. Read through all the criteria again, and then try the same graph again.

a How does the mass of magnesium oxide relate to the starting mass of magnesium?

....

b Work out from the graph the mass of magnesium oxide that you would get from 0.12 g of magnesium (show the lines you use for this on your graph). .... g

c What mass of oxygen combines with 0.12 g of magnesium? .... g

d What mass of oxygen combines with 24 g of magnesium? .... g

e What is the formula of magnesium oxide, worked out on the basis of these results?
(Relative atomic masses: Mg = 24, O = 16.)

....

....

Exercise C4.3 The analysis of titration results

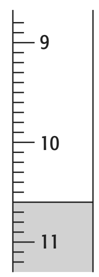
This exercise will develop your understanding of some of the practical skills involved in acid–base titrations and the processing and evaluation of experimental results.

A student investigated an aqueous solution of sodium hydroxide and its reaction with hydrochloric acid. He carried out two experiments.

Experiment 1

Using a measuring cylinder, 10 cm^3 of the sodium hydroxide solution was placed in a conical flask. Methyl orange indicator was added to the flask. A burette was filled to the 0.0 cm^3 mark with hydrochloric acid (solution **P**).

The student added solution **P** slowly to the alkali in the flask until the colour just changed. Use the burette diagram to record the volume in the results table and then complete the column for experiment **1**.

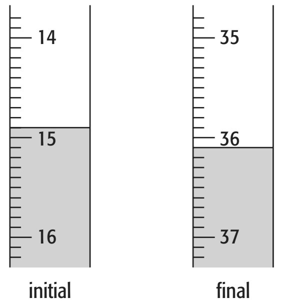


Experiment 1 final reading

Experiment 2

Experiment **1** was repeated using a different solution of hydrochloric acid (solution **Q**).

Use the burette diagrams to record the volumes in the results table and complete the column.



Experiment 2 readings

Table of results

Burette readings / cm^3	Experiment 1	Experiment 2
final reading	....	....
initial reading	0.0	....
difference	....	....

a What type of chemical reaction occurs when hydrochloric acid reacts with sodium hydroxide?

....

b Write a word equation for the reaction.

....

c What was the colour change of the indicator observed?

....

d Which of the experiments used the greater volume of hydrochloric acid?

....

e Compare the volumes of acid used in experiments **1** and **2** and suggest an explanation for the difference between the volumes.

....

....