Neil Dixon, David Johnston

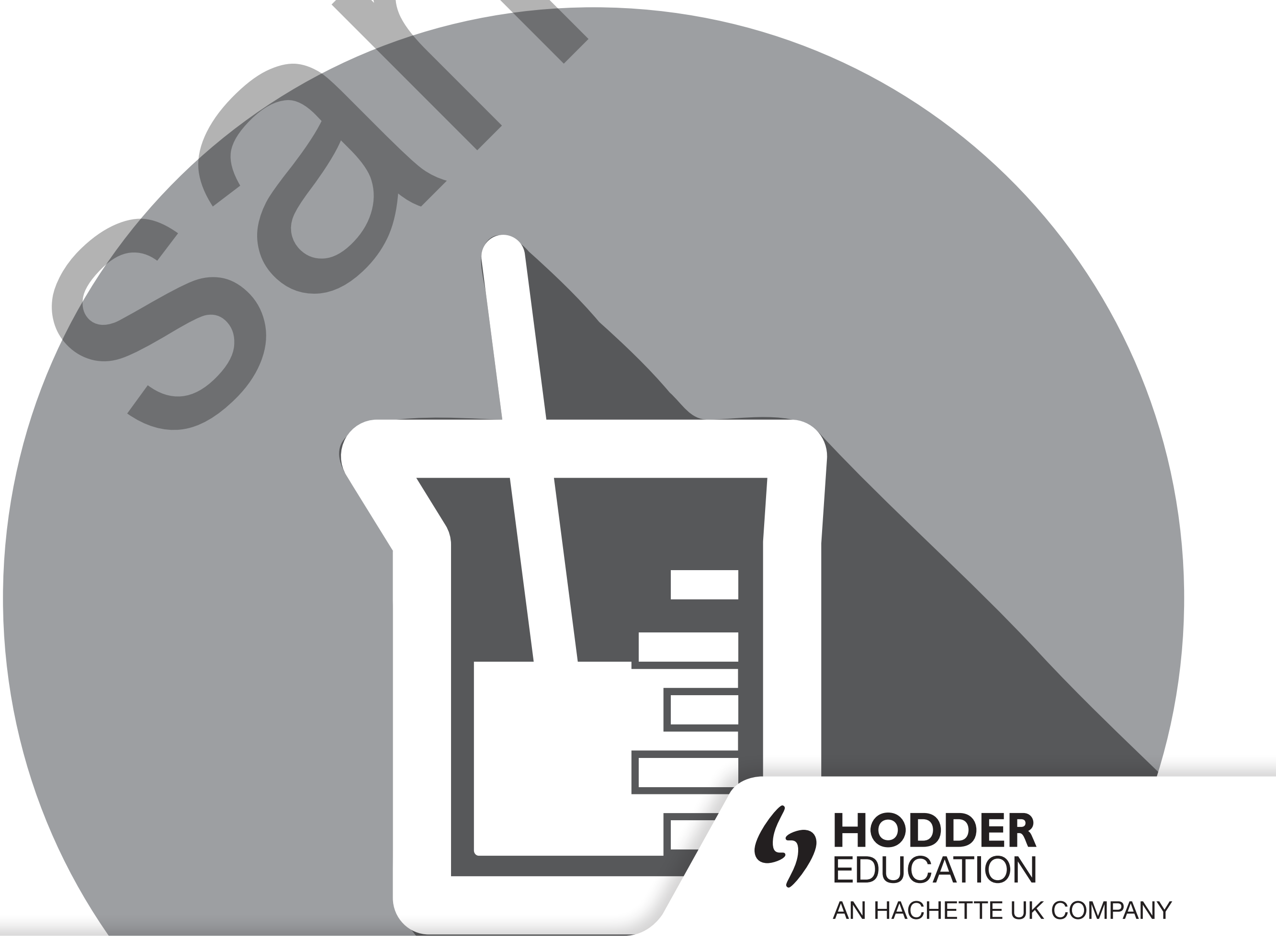
INTERNATIONAL GCSE (9–1)

Chemistry

for Edexcel International GCSE

Core Practicals Teacher Lab Book:

Teacher and technician information



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ISBN: **978 1 5104 5155 1**

First published in 2019 by
Hodder Education,
An Hachette UK Company
Carmelite House
50 Victoria Embankment
London EC4Y 0DZ

www.hoddereducation.co.uk

Impression number 10 9 8 7 6 5 4 3 2 1

Year 2023 2022 2021 2020 2019

Typeset in Integra Software Services Pvt. Ltd., Pondicherry, India

Cover photo © tulpahn - stock.adobe.com

Typeset by Integra, India

Printed in Great Britain by Hobbs the Printers Ltd.

A catalogue record for this title is available from the British Library.

FSC www.fsc.org MIX Paper from responsible sources FSC™ C104740

Contents

Asterisks* are used to indicate which practicals are for separate sciences only.

We have carried out a health and safety check of this text and have attempted to identify all recognised hazards and suggest appropriate cautions. However, the Publishers and the authors accept no legal responsibility on any issue arising from this check; whilst every effort has been made to carefully check the instructions for practical work described in this book, it is still the duty and legal obligation of schools to carry out their own risk assessments for each practical in accordance with local health and safety requirements. Suitable blank and model risk assessments are publicly available and can be found readily online.

The text has not been through the Edexcel endorsement process.

For further health and safety information (e.g. Hazcards) please refer to CLEAPSS at www.cleapss.org.uk.

Double Award matching chart

Separate Sciences	Double Award
Core Practical 1: Investigating the solubility of a solid in water	-
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Core Practical 12: Preparing a sample of an ester	-

How to use this book

This book has been designed to help both teachers and technicians ensure full coverage of the core practicals. It covers the following specifications:

- Edexcel International GCSE (9–1) Chemistry
- Edexcel International GCSE Science Double Award (9–1) – Chemistry component only

The mapping chart on page vi provides a guide to how the practicals are covered. Each practical is also flagged with an indication of whether it is 'Double Award' or 'separate sciences only'.

For details on how you may use and share the content within this book (including photocopying and classroom distribution) please see page ii.

Practical structure

Completing the practicals

In both the Student and Teacher Lab Book the **aim** of each practical is laid out first. This is followed by a list of **equipment** needed to complete the practical as suggested. The equipment list will prove invaluable in preparing the practical in advance of the lesson.

The method itself is detailed in the **Student Lab Book**, although you will note that at the end of each practical in this Teacher Book there are **possible alternatives**. These can be used if your school has different equipment available or if you wish to take an alternative approach.

Health and safety notes are provided in both Student and Teacher Lab Books so that everyone is aware of the need to take precautions. See the health and safety feature below for more details.

Questions and answers

Students are led through each practical with scaffolded questions to help them with their observations, conclusions and evaluation. They are then provided with **exam-style questions** that relate to the practical and provide exam practice.

These are followed by **further application** questions that apply the science from the practical to a different context to stretch students and consolidate understanding.

Answers to all of the **Student Lab Book** questions are provided in this Teacher Book, including model data and **unexpected results**. Where applicable, answers are flagged as testing M (maths), QWC (quality of written communication) or EXT (if it goes beyond what most students would be expected to know at GCSE).

As well as the use of QWC in flagging, other common abbreviations used in this book include:

- ECF – error carried forward. This applies to multi-part questions where a student may still pick up marks for calculations, even if they are using incorrect data due to a previous error.
- WTTE – words to that effect. This applies where a student may pick up marks for an answer with similar enough wording to the correct answer. Instances where a particular term or phrasing **must** be used for the mark are also made clear.

The model data sections provide the sorts of data ranges you should expect from the practicals, although actual data will vary based on the equipment used, the environment and so on. You can use this data for checking students' accuracy, and you may wish to provide copies for students to help them evaluate the success of their practicals.

If a student observes results that significantly differ from the model data provided, it is likely that an error in the method has occurred. Each practical has a section for **unexpected results**, which will help you identify the probable error(s) and rectify them.

Related activities

Whilst teachers must teach the core practicals as part of the specification, these practicals should be considered a minimum requirement. The Edexcel International GCSE encourages teachers to provide further opportunities for experimental work throughout the course, to help students improve their ability to work scientifically. To help with this, we have provided **extension questions** and **linked experiments** within this book.

Extension questions provide suggestions for additional work to stretch more able students. These questions relate to the science behind each practical, and range from smaller, more contained questions to mini-research tasks. They can be set as homework or as follow-up work in class, or could possibly be used for revision.

Linked experiments are optional experiments that can either be demonstrated by teachers/technicians or carried out by students. Some of these are other related core practicals; others are extensions, and some are more loosely linked through shared scientific theory. This section can assist you in planning by helping you think about a teaching order, as well as suggesting other experiments that may help to engage students as you move through the course.

Where page references are provided for the Student Book (as opposed to the **Student Lab Book**), these refer to our accompanying **Edexcel International GCSE (9–1) Chemistry Student Book**. Please note that purchasing our student books is not required, and all of the content within the Teacher and Student Lab Books is self-contained and valuable in and of itself.

Features to help you teach

Health and safety

Each practical includes health and safety guidance to help you carry out the experiment safely. However, it is still the duty and legal obligation of schools to carry out their own risk assessments for each practical in accordance with local health and safety requirements.

Maths opportunities

Opportunities to cover the recommended mathematical skills are flagged in these boxes. These will usually only list the mathematical skills most relevant to the practical, and additional minor skills may also be covered. A more comprehensive mapping of mathematical skills to practicals is provided on page v.

Common mistakes

As well as containing the answers to every question in the **Student Lab Book**, this Teacher Book also flags where students are likely to make mistakes. These provide valuable teaching opportunities to address common misconceptions.

Note

These are used to highlight additional practical notes that needed flagging. For example, if there is a particular recommended way to carry out a practical, or if there are multiple ways a student could answer a question to get the mark.

How students are assessed

In Edexcel International GCSE (9–1) Science, students are expected to complete all core practicals as part of the wider science course, so they may get questions on any of them in the exam. It is important to note that the exams are **not** restricted to asking questions on these specific practicals, and instead are designed to focus on investigative skills. This means the exam board may test students on how well they can apply the practical knowledge to unfamiliar contexts.

The **Student Lab Book** allows students to keep a record of the practicals they have completed, as well as their results and conclusions. This will provide them with a useful resource when it comes to revising the practicals prior to the exams.

Core Practical 5: Determine the approximate percentage by volume of oxygen in air

Teacher/technician notes

Aim

Determine the approximate percentage by volume of oxygen in air using a metal.

Equipment and reagents (per student)

- Test tube
- Glass rod
- 250 cm^3 beaker
- Iron or steel wool (a piece about half the size of your finger)
- Ruler

Alternatives to this practical are suggested on page 23.

Results

Expected results

The following expected results are based on the practical method and quantities as recommended. It is likely that the values obtained by students will show a decrease in the height of the air over one week of approximately one-sixth to one-fifth of the original height of air.

Height of air in test tube at the start in mm (A)	120
Height of air in test tube after one week in mm (B)	98

Unexpected results

If the calculated percentage of oxygen in the air is **less** than 21%, this may be due to the following reasons:

- Iron wool not wet enough.
- Experiment not left for long enough.
- Not enough iron wool was used.

If the calculated percentage of oxygen in the air is **more** than 21%, this may be due to the following reasons:

- Some of the air in the test tube has escaped between the two height measurements.
- A decrease in air temperature has caused contraction of the air in the test tube.

Further information can be found in the **Edexcel International GCSE (9–1) Chemistry Student Book** on pages:

- 119–122: The air
- 116: Oxidation
- 136–137: Rusting

Note

Students need to be familiar with the method for using a non-metal (e.g. white phosphorus) but it is not recommended that students use phosphorus for safety reasons. You may decide to demonstrate the method using phosphorus, but appropriate safety advice should be sought and a specific risk assessment should be performed. The questions in the **Student Lab Book** cover this method.

Health and safety

Wear eye protection.

Maths opportunities

- Recognising and using numbers in decimal form
- Using ratios and fractions
- Using an appropriate number of significant figures

Answers

Observations

1 Results will vary, but example observations are provided in the model data. Students should see a decrease in the height of the air over one week of approximately one-sixth to one-fifth of the original height.

Conclusions

2 Using the results in the model data, the decrease in height of air was: 120 – 98 = 22 mm

3 percentage decrease in volume of air

$$= \frac{\text{decrease in height of air}}{\text{starting height of air}} \times 100$$

$$= \frac{22}{120} \times 100 = 18\%$$

The actual percentage of oxygen in air is 21% but students are unlikely to achieve this result. The reasons for this are described in ***unexpected results****.*

Evaluation

4 Comparison with results from other students will enable students to evaluate the uncertainty and range for this experiment. If the calculated answers differ significantly, this suggests random experimental errors. In this case, anomalous results could be ignored from the data set and a new mean value could be calculated. If the results are similar to each other, but differ from the expected answer of 21%, this suggests a systematic error in the method.

5 The mean value should in theory be approximately 21% when anomalies are ignored. In reality, values of slightly less than 20% should still be seen as a successful outcome.

6 It is essential for the tube to be placed on an angle so that the water can move freely in and out of the tube.

7 An amount of iron wool that was too small would not use up all the oxygen in the air. This would give a percentage of oxygen that was too low.

Exam-style questions

1 **a)** copper + oxygen → copper oxide
Correct reactants **[1]***; correct product* **[1]**

b) i) The volume of oxygen removed from air is calculated by subtracting the volume at the end from the volume at the start:
98 – 75 = 23 cm^3 **[1]**
percentage decrease in volume of air

$$= \frac{23}{98} \times 100 \textbf{ [1]} = 23\% \textbf{ [1]}$$

Common mistake

Sometimes students divide the volume of air at the end by the volume of air at the start and then multiply by 100. They need to divide the **change** in the volume of air by the starting volume of air, and then multiply by 100.

ii) Not all of the 23 cm^3 decrease in the volume of air was caused by the reaction between copper and oxygen **[1]**. If the correct value had been smaller, e.g. 20 cm^3, then the calculated percentage would have been smaller **[1]** *(E.g. (20 / 98) × 100 = 20%).*

c) Hot gas would take up more volume **[1]** so the subtracted value for volume of oxygen used would be smaller **[1]** and the calculated percentage would therefore be smaller **[1]**.

2 **a)** Volume of oxygen removed from air:
82 – 43 = 39 cm^3
The total volume of air at the start of the experiment is calculated by adding up the volume of the air in the flask, tubing and gas syringe: 100 + 10 + 82 = 192 cm^3 **[1]**

Common mistake

Students are likely to ignore the air in the conical flask and tubing when calculating the total volume of air at the start of the experiment.

percentage decrease in volume of air

$$= \frac{39}{192} \times 100 \textbf{ [1]} = 20.3\% \textbf{ [1]} \textit{ (accept 20\%)}$$

b) Iron nails have a lower surface area to volume ratio **[1]**. Therefore the reaction is slower and may not have gone to completion **[1]**.

c) i) Effect on the volume of oxygen in the air: no effect **[1]**

ii) Effect on the rate of reaction: faster **[1]**

Further application

1 a) $P_4(s) + 5O_2(g) \rightarrow 2P_2O_5(s)$
[1] *for correct balancing;* **[1]** *for state symbols.*

M b) The height decrease is calculated by subtracting the height of the air at the end from the height of the air at the start: 12.5 – 10.3 = 2.2 cm **[1]**

percentage decrease in height of air

$$= \frac{2.2}{12.5} \times 100 \text{ [1]} = 18\% \text{ to 2 s.f. [1]}$$

c) The cross-sectional area of the conical flask is not uniform **[1]**. Therefore, the height decrease of the air in the flask would not be proportional to the volume of the air **[1]**.

2 a) **[1]** *for each value correctly completed in the table:*

Mass of iron wool used in g	Height of air in test tube at start in mm	Height of air in test tube at end in mm	Decrease in air height in mm	% of oxygen in air
0.1	86	79	7	8.1
0.4	78	60	18	23.1
0.5	72	57	**15**	**20.8**
0.2	91	80	**11**	**12.9**
0.7	96	75	21	21.9
0.6	90	72	18	20.0

b) **[1]** *for ignoring the % values of 8.1 and 12.9. Mean is calculated from the four remaining values* **[1]**:

$$\text{mean} = \frac{23.1 + 20.8 + 21.9 + 20.0}{4}$$

= 21.45% **[1]** *Accept answer rounded to 1 d.p. to give 21.5%.*

Common mistake

Students often struggle to identify the anomalous results. They are likely to identify 8.1 as anomalous but may not notice 12.9 because it is of the same order of magnitude as the other (more consistent) results.

c) The two anomalous results were when very small masses of iron wool were used **[1]**, so it is likely that the iron was the limiting reactant **[1]**. Therefore not all the oxygen in the air was used up **[1]**.

Possible alternatives

- Using an inverted measuring cylinder instead of the test tube will give a more accurate reading for the volume of air before and after the reaction, as it has a uniform cross-sectional area and removes the need for measuring the height of the air column. However, the rusted iron wool may stain plastic measuring cylinders. Glass measuring cylinders are easier to clean than plastic ones.
- The percentage of oxygen in the air can also be demonstrated (or deduced by student experiment) using a pair of gas syringes, as described in Figure 5.2 on page 119 of the **Edexcel International GCSE (9–1) Chemistry Student Book**. This method is likely to produce more accurate results than the method involving wire wool described above, but it requires two gas syringes per experiment. If using this method, it is important for the apparatus to be airtight, and also to allow the apparatus to cool before measuring the final volume.
- Upon completion of a suitable risk assessment, due to the significant risks associated with using white phosphorus, teachers might decide to demonstrate how a non-metal can be used to measure the percentage of oxygen in the air. A diagram of the method can be found on page 121 (Figure 5.4) of the **Edexcel International GCSE (9–1) Chemistry Student Book**.

Extension questions

Students could research other possible substances (metals and non-metals) that could be used in this experiment. Challenge students to deduce what they must all have in common (*namely that they must all produce a solid oxide*). You could give students a list of elements and ask them to deduce whether or not they could be used to calculate the percentage of oxygen in the air, giving a reason for each one. For example:

Element	Could it be used?	Reason
Mg	*Yes*	*Magnesium is a reactive metal and burns to form a solid oxide, reducing the volume of air as the oxygen is removed.*
C	*No*	*Carbon burns to form a gaseous oxide (CO_2) so it does not reduce the volume of oxygen in air.*
H_2	*No*	*Hydrogen burns to form a gaseous oxide (H_2O) but it does then condense, so it will reduce the volume of oxygen in air. However, the limitation is more that it is difficult to measure the volume or mass of the hydrogen at the start of the experiment, and it is also difficult to ignite the hydrogen safely without it exploding!*
Si	*No*	*Silicon will react with oxygen to form a solid oxide, but in practice it is very hard to do this at temperatures that are achievable in the lab. Even when heated using a strong Bunsen flame, the silicon will not react with oxygen in the air.*
Ca	*Yes*	*Calcium is a reactive metal and burns to form a solid oxide, reducing the volume of air as the oxygen is removed.*
S	*No*	*Sulfur burns to form a gaseous oxide (SO_2) so it does not reduce the volume of oxygen in air.*

Linked experiments

The conditions needed for the oxidation of iron during rusting can be investigated. Set up a test tube rack with six test tubes, each one containing an iron or steel nail. The table shows the conditions required:

Tube	Contents	Conditions
1	Tap water	Water and oxygen
2	Freshly boiled tap water to the very top, then a bung inserted so no air is present	Water but no oxygen (in theory – we have tried to remove the oxygen dissolved in the water by boiling it)
3	A spatula of silica gel, with a bung	Oxygen but no water
4	A spatula of silica gel and a spatula of salt, with a bung	Oxygen, salt, but no water
5	Sodium chloride solution	Oxygen, water and salt
6	Dilute hydrochloric acid solution	Oxygen, water and acid

Because rusting requires both oxygen and water, the nails in tubes 1, 5 and 6 will rust. The nail in tube 2 should not rust, but in reality it is difficult to completely remove the oxygen from the water. The nails in tubes 3 and 4 will not rust due to there being no water present. The nails in 5 and 6 should be the most rusty because rusting is speeded up by any ions present, e.g. acid or salt.

The acid-base characteristics of metal oxides and non-metal oxides can be investigated. Some metal oxides can easily be made by students (e.g. MgO, CuO). Observations can be made when metal oxides and non-metal oxides are added to 50 cm^3 water in a beaker that has had universal indicator added to it. The expected results are shown in the table.

Oxide	**Teacher demo or student activity**	**Observations**	**Expected pH**
Calcium oxide	Student (very small quantities)	Exothermic reaction, causes steam; solid dissolves. Rapid colour change.	12–14
Magnesium oxide	Student	No visible change. Most of the solid remains undissolved. Very slow colour change.	8–9
Carbon dioxide	Teacher/student	Colour change of indicator.	3–5
Sulfur dioxide	Teacher (fume cupboard)	Rapid colour change of indicator.	1–3
Silicon(IV) oxide	Student	No visible change. The solid is insoluble.	7
Phosphorus(V) oxide	Teacher (very small quantities)	Exothermic reaction, causes steam; solid dissolves. Rapid colour change.	0–1
Aluminium oxide	Student	No visible change. The solid is insoluble.	7
Copper(II) oxide	Student	No visible change. Black powder remains undissolved.	7

We can conclude that metal oxides are alkalis if they dissolve, although some are insoluble, such as aluminium oxide. Non-metal oxides are acidic and most of them dissolve, but some are insoluble, such as silicon(IV) oxide.