Core Practical Guide

GCSE (9-1) Sciences

Pearson Edexcel Level 1/Level 2 GCSE (9-1) Sciences

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Introduction

Purpose of this guide

This guide is designed to support you in delivering the core practicals for Edexcel. The following pages, for *each* core practical, will:

- Give you links to the specification content and highlight key areas to further your students' understanding.
- Contain key questions you can ask to focus your students, and get them thinking about why they are carrying out a particular practical in a certain way.
- Give you a sample question (where possible), with commentary relating to the assessment, which can be used as practice to consolidate students' understanding.

Changes to practical requirements in reformed GCSEs

There will not be any coursework in the GCSE (9–1) Science qualifications. Assessment of practical work is now included as part of the final exam, and a minimum of 15% of the total marks must be allocated to questions related to practical. In our exams, we will have questions on the core practicals in our specifications, as well as other questions on practicals related to the core practicals or techniques that students should be familiar with from their studies.

As well as the practical requirement, there is a list of apparatus and techniques that has been set out by the Department for Education (*Appendix 1*). Specifications must give students opportunities to cover the relevant apparatus and techniques, and this list has been mapped to our core practicals to show you how we are covering all of the requirements. As long as you carry out all of the core practicals, you will automatically cover the apparatus and techniques list. If you want to see how our core practicals map to this list, it is mapped (along with maths skills) in *Appendix 2*.

Approach to core practicals

In order to meet the requirements set out by Ofqual, you need to ensure your centre confirms that reasonable steps have been taken to secure that each learner has completed the practical activities set by us, and has made a contemporaneous record of the practical work and knowledge, skills and understanding derived from those practical activities.

The purpose of this statement is to ensure that practical work remains an important part of GCSE Science. In your day-to-day teaching, this just means that you need to ensure you cover the core practicals outlined by us and that your students are recording the work that they are doing as part of carrying out the core practicals. In practice, this could just be completing worksheets, taking results and doing some analysis or writing notes in their exercise books as a follow up to carrying out the practical. If you prefer, you can use a separate lab book for practical work, but this is not necessary. Indeed, as students will be required to have knowledge of these practical techniques and procedures for the final exam, it may be better to have this practical work sit alongside the relevant theoretical knowledge.

It is important to note that the approach to covering core practicals should be the same approach as you currently take to practical work in your science lessons. If you occasionally cover particular techniques as a carousel, or split students into groups to take readings, there is no reason why you cannot still do this—as long as you have taken reasonable steps to ensure your students all acquire experience of carrying out that particular procedure or technique.

Assessment of practical work

As a centre, you need to confirm that you have taken reasonable steps to ensure that each student has completed the compulsory core practicals and that the evidence for this is recorded. The practical record must include the knowledge, skills and understanding which that student has derived from those practical activities. To confirm that this has been done, centres must complete and submit an *authentication sheet* to confirm that all students have completed these core practicals. This authentication sheet can be found as an appendix in the specifications.

By signing this authentication sheet, you are confirming that reasonable steps have been taken to ensure that all students have been given the opportunity to carry out the core practicals outlined in the specifications. If students are ill or miss core practicals for any reason beyond the school's control, it does not require you to run catch up sessions for those individual students.

In exam papers, practical work will be assessed across the assessment objectives. The sample questions included in this core practical guide outline how you can use that question to consolidate your students' understanding of that particular core practical. The exam papers will assess student's understanding of the practical work, and they will be at an advantage if they have carried out all the core practicals in the course.

Maths skills

Practical activities offer a wide range of opportunities to cover particular mathematical skills. As part of this guide, we have outlined where there are good opportunities to cover mathematical techniques as part of each core practical. There is also a mapping in *Appendix 2* which maps the maths skills outlined by the DfE to the relevant core practical.

Note: There is a Guide to Maths for Scientists which you can download from the Edexcel website. This guide outlines the content that students will have covered in their maths lessons throughout KS3 and KS4. You can use this guide to help you understand how different areas are approached in maths, and therefore support your teaching of mathematical content in science lessons.

Biology

There are six core practicals in the biology section of GCSE Combined Science. GCSE Biology covers the same six practicals as well as an additional two, to make up eight core practicals in total.

This biology section outlines each core practical and gives a brief description of each one. The final part goes through each core practical in turn and outlines key skills as well as an extract of a sample exam question which links to the core practical.

Core practical descriptions

Note: 1.13B and 5.18B are separate GCSE Biology only.

Core practical		Description
1.6	*Investigate biological specimens using microscopes including magnification calculations and labelled scientific drawings from observations*	This practical allows students to develop their skills in using a light microscope, preparing slides, and producing labelled scientific drawings. Students need to be familiar with the set-up and use of a light microscope, as well as to be able to identify structures that they see. Magnification calculations will also be required.
1.10	*Investigate the effect of pH on enzyme activity*	For this core practical students will investigate the effect of pH, however other variables can also be investigated to enhance practical work in this area. This method uses amylase (in solutions of different pH) to break down starch. The reaction can be monitored by using iodine to test the presence of starch in the solution with a continuous sampling method. To maintain the temperature of the solution, a Bunsen burner and water beaker must be used.
1.13B	*Investigate the use of chemical reagents to identify starch, reducing sugars, proteins and fats*	Carry out food tests shown below: 1. identify starch by using iodine solution 2. identify reducing sugars using Benedict's solution (and a water bath) 3. identify protein using the Biuret test (adding potassium hydroxide to a solution of the food, followed by copper sulfate) 4. identify fats and oils (lipids) using the emulsion test to show the formation of a precipitate
1.16	*Investigate osmosis in potatoes*	A known mass of potato must be added to sucrose solution, left for some time, and the final mass recorded to obtain the percentage change in mass. This investigation looks at the exchange of water between the potato and solution and allows the concentration of sucrose in the potato to be determined. The practical provides an opportunity for the appreciation of the need to control variables.

5.18B	*Investigate the effects of antiseptics, antibiotics or plant extracts on microbial cultures*	This practical provides the opportunity for learners to carry out aseptic techniques (Biology statement 5.17). Petri dishes pre-poured with agar must be inoculated with bacteria and discs of antiseptic/antibiotics/plant extracts can be used to determine their effect on bacterial growth. Sterile aseptic technique must include the use of a Bunsen burner.
6.5	*Investigate the effect of light intensity on the rate of photosynthesis*	Algal balls (or similar) must be set up and placed at varying distances from a light source to investigate the effect of light intensity on the rate of photosynthesis. The rate must be measured and compared to the distance away from the light source.
8.11	*Investigate the rate of respiration in living organisms*	Use of a simple respirometer to measure the effect of temperature on the oxygen consumption of some small organisms. A simple respirometer can be made using a tube with soda lime, cotton wool and organisms with a capillary tube to coloured liquid. Students can then track the progress of the liquid up the capillary tube over a set time. This experiment must be carried out using a water bath set at different temperatures. Safety and ethical considerations must also be covered.
9.5	*Investigate the relationship between organisms and their environment using field-work techniques, including quadrats and belt transects*	This investigation involves the use of a belt transect along a gradient (e.g. shaded area to an area with no shade). It involves students thinking about how to sample their chosen area, including the identification and observation of plants/organisms.

Core practical 1: Looking at cells

1.6 Core practical: Investigate biological specimens using microscopes, including magnification calculations and labelled scientific drawings from observations

Links to the specification content

1.3	Explain how changes in microscope technology, including electron microscopy, have enabled us to see cell structures with more clarity and detail than in the past and increased our understanding of the role of sub-cellular structures	
1.4	Demonstrate an understanding of number, size and scale, including the use of estimations and explain when they should be used.	
1.5	Demonstrate an understanding of the relationship between quantitative units in relation to cells, including:	
	a	milli (10^{-3})
	b	micro (10^{-6})
	c	nano (10^{-9})
	d	pico (10^{-12})
	e	**calculations with numbers written in standard form**

Introducing the practical

This core practical provides the opportunity for students to develop their skills in the use of a light microscope, the preparation of slides and the production of labelled scientific drawings from their observations. It then provides a context for the teaching and understanding of the associated maths skills including magnification calculations, the use of estimations and the relationship between quantitative units. For higher tier candidates, there is the opportunity to practice calculations using standard form. A comparison of observations made using a light microscope with images taken using an electron microscope also demonstrates how improvements in microscope technology have increased our understanding of sub-cellular structures.

Although students are likely to have used microscopes at Key Stage 3, it is a technical skill that they find difficult. It might be worth spending time practicing the basic skills needed to focus the microscope before attempting the core practical, either as a starter or in a previous lesson. The core practical suggests a range of cell types which can be used and students only need to look at a plant cell and an animal cell as a minimum. Students should understand the basic principles involved in the preparation of slides for use with a light microscope including the role of staining. Having prepared a slide, they must understand how to use the light microscope to focus in the specimen. They need to understand the total magnification produced by the eyepiece and objective lens and the mathematical relationship between magnification, image size and actual size. The sole use of pre-prepared slides will be insufficient to meet the demand of the core practical, but it does provide the opportunity for students to practice using a microscope and refine their skills for scientific drawings.

Link to GCSE Science 2011: 1.5 'Demonstrate an understanding of how changes in microscope technology have enabled us to see cells with more clarity and detail than in the past, including simple magnification calculations.' From B2 Topic 1 The building blocks of cells.

Investigating biological specimens

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- What sub-cellular structures are likely to be observed using a light microscope?
- Why are some sub-cellular structures not visible using a light microscope?
- What precautions are needed when preparing a microscope slide?
- Why should samples of animal cells be disposed of in disinfectant?
- Why does the layer of specimen cells need to be thin?
- Why do we stain the specimen cells?
- Why does the coverslip have to be carefully applied?
- What is the highest magnification for the light microscope?
- How is the focusing wheel used?
- When should the fine focusing wheel be used?
- What is a field of view and how can its size be measured?
- How is the actual size of a cell structure determined from microscope measurements?
- How can more detail be observed in cells?
- What are the important features of a drawing made from observations?

Skills that are covered in the practical:

- The preparation of microscope slides
- The importance of staining a specimen
- The ability to use a microscope to make observations
- The drawing of observations of specimens from a light microscope
- Magnification calculations from observations

Maths skills:

- Calculations of total magnification
- The mathematical relationship between magnification, image size and actual size
- Make estimations of size
- Understanding of scale and the relationship between different quantitative units (e.g millimetres, micrometres and nanometres)
- Calculations using numbers in standard form for higher tier candidates only

Sample question

These examples are taken from the sample assessment material. It is a mix of questions from 1BI0/1F and 1BI0/1H which illustrate a range of questions applicable to this core practical and the skills associated with it. The commentary below outlines how the skills students will have gained by carrying out the practical may be shown in the final exams.

A student wanted to observe dividing cells under a microscope.

The student squashed the root tip of an onion plant on a microscope slide.

(c) (i) Describe how the student should use a light microscope to view the squashed root tip.

(3)

....

....

....

....

....

....

Question number	Answer	Mark
5(c)(i)	An answer that combines knowledge (1 mark) and understanding (2 marks) to provide a logical description: • place the slide on the stage of the microscope and look through the eyepiece lens (1) Plus two from: • turning the focusing wheel/knob will obtain a clear image (when looking through the eyepiece lens) (1) • start by using the lowest objective lens magnification (1) • increase the magnification of the objective lens and refocus (1)	**(3)**

Part (c)(i) is a question where students have to apply their knowledge on the technique of using a microscope which they obtained by completing the core practical.

(ii) Even though the slide was at the correct magnification, the student could not see the chromosomes in the dividing cells.

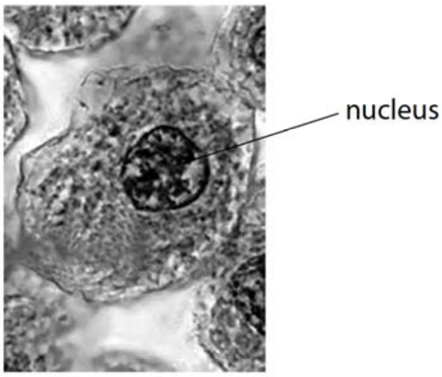
State what could be done to the slide to make the chromosomes more visible.

(1)

Question number	Answer	Mark
(c)(ii)	Use a stain (1)	**(1)**

Part (c)(ii) asks students to recognise the role of staining specimens to make cell structures more visible.

Figure 7 shows an image of an animal cell taken using a microscope with a 10× eyepiece lens and a 40× objective lens.



(Source: © Ed Reschke/Getty Images)

Figure 7

(b) (i) The total magnification of the animal cell is

(1)

☐ **A** ×50

☐ **B** ×140

☐ **C** ×400

☐ **D** ×4000

Question number	Answer	Mark
4(b)(i)	C	**(1)**

Part (b)(i) is a question asking students to use their knowledge of a microscope to calculate the total magnification obtained by the combination of the eyepiece and objective lens.

(ii) The diameter of the cell is 15 μm.

Use Figure 7 to estimate the diameter of the cell nucleus.

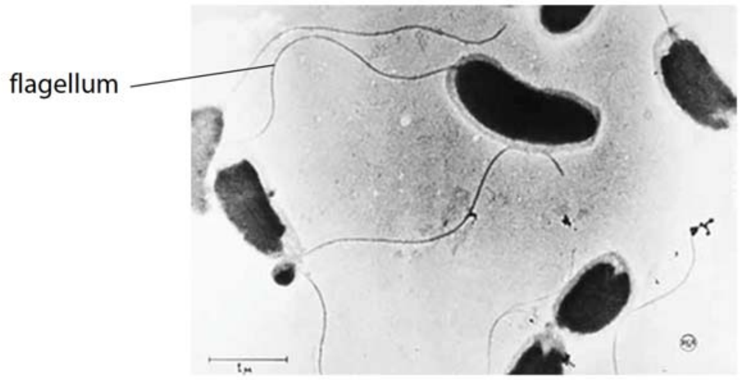
(1)

diameter of nucleus = ... μm

Question number	Answer	Additional guidance	Mark
4(b)(ii)	5 (μm) ± 1.5	approximately a third of the diameter of the cell	**(1)**

Part (b)(ii) is a question that asks students to apply their knowledge on making estimations to an image. It does not require a magnification calculation.

(c) Figure 7 shows some *Vibrio cholerae*, the bacteria that cause cholera.



Magnification ×8000

(Source: Corbis)

Figure 7

The length of one flagellum on Figure 7 is 68 mm.

Calculate the length of the flagellum in μm.

(3)

.... μm

(Total for Question 5 = 9 marks)

Question number	Answer	Additional guidance	Mark
5(c)	• 68 ÷ 8000 (1) • 0.0085 (1) • 8.5 (μm) (1)	award full marks for correct numerical answer without working	**(3)**

Part (c) is a question that combines the maths skills of a magnification calculation with the quantitative relationship between micrometres and millimetres.

Core practical 2: pH and Enzyme activity

1.10 Core practical: Investigate the effect of pH on enzyme activity

Links to the specification content

1.7	Explain the mechanism of enzyme action including the active site and enzyme specificity
1.8	Explain how enzymes can be denatured due to changes in the shape of the active site
1.9	Explain the effects of temperature, substrate concentration and pH on enzyme activity
1.11	Demonstrate an understanding of rate calculations for enzyme activity
1.12	Explain the importance of enzymes as biological catalysts in the synthesis of carbohydrates, proteins and lipids and their breakdown into sugars, amino acids and fatty acids and glycerol

Introducing the practical

There are many factors which affect the activity of enzymes. The core practical focuses on pH, but there is also a suggested practical on the effect of substrate concentration on enzyme activity, which could be used to enhance learning. In addition, there is some information about a demonstration that can be used to demonstrate the calculation of the initial rate of enzyme action.

The core practical which looks at how pH affects the breakdown of starch using amylase has two knowledge aspects to it, enzyme activity and the breakdown of starch into smaller sugars. It also covers the use of iodine to identify the biological molecular starch, which is a biology-only specification point. Candidates may have completed variations on this practical during Key Stage 3, particularly linked to digestion. As part of the GCSE, candidates should focus on the practical details and use of their increased knowledge on enzyme action to interpret and explain their results. The additional practical looks at the effect of increasing the concentration of hydrogen peroxide on the enzyme activity of the enzyme catalase.

Link to GCSE Science 2011: 1.32 'Investigate the factors that affect enzyme activity' is a core practical in GCSE Biology 2011 Unit B2 Topic 1.

The effect of pH (core practical)

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- Why is iodine solution used?
- Why are syringes used to measure the volumes of the solutions?
- Why does the mixture need to be stirred?
- Why are the solutions added in the order stated? (amylase solution, pH solution and starch solution)
- Why is the timer started after the starch solution is added?
- Why must the syringes be used in the same solutions when the investigation is repeated?
- What are the main errors in this procedure?
- How can you improve the procedure?
- What other factors could have affected the results?

- How is the rate of reaction being measured?
- What safety precautions are used in the practical?

Skills that are covered in the practical:

- measuring volumes accurately using syringes
- sampling a reaction at set time intervals, timed by a stop clock
- ability to manipulate apparatus, avoiding cross-contamination and recording observations
- ability to carry out investigation safely

Maths skills:

- mean calculations
- graph drawing

Sample question

This example is taken from the sample assessment material, paper 1BI0/1BH, Q8. The commentary below outlines how the skills students will have gained by carrying out the practical may be shown in the final exams.

8 Phenolphthalein is an indicator. It is pink in alkaline solutions and turns colourless as the pH decreases.

It can be used to measure the activity of the enzyme lipase on the breakdown of lipids.

Samples of milk containing phenolphthalein were incubated with lipase at different temperatures.

The time taken for the phenolphthalein to turn colourless was recorded and used to calculate the rate of enzyme activity.

Figure 10 shows these results.

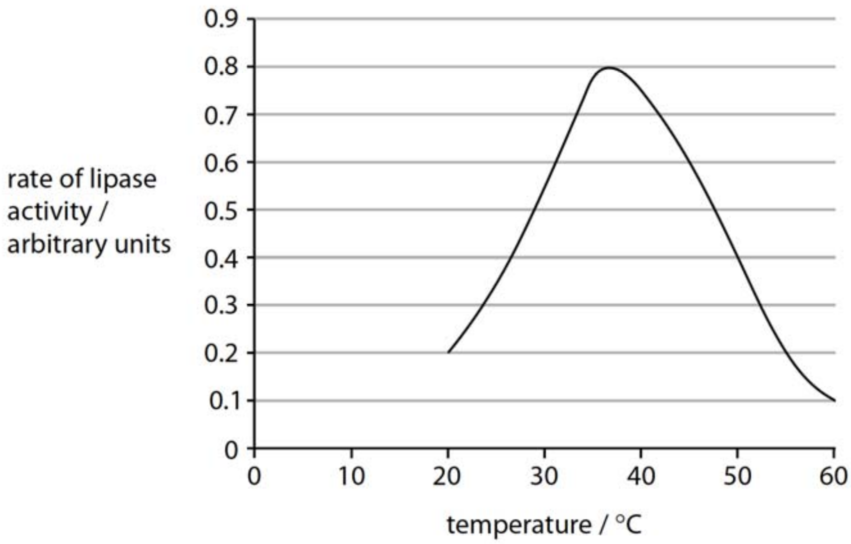


Figure 10

(a) (i) Explain why phenolphthalein turns colourless when lipase breaks down the lipids in milk.

(2)

....

....

....

....

Question number	Answer	Mark
8(a)(i)	An explanation that combines identification – application of knowledge (1 mark) and reasoning/justification – application of understanding (1 mark): • fatty acids are formed when the lipids are broken down by lipase (1) • and fatty acids are acidic (so the pH decreases) (1)	**(2)**

Part (a)(i) is a question where students are asked to apply their knowledge of this core practical to an unfamiliar situation, where it looks at a practical they are not familiar with. They should be able to use their understanding of the core practical they have carried out combined with their theoretical knowledge and the information given in the question to give an answer.

(ii) Describe the effect of temperature on the activity of lipase, as shown in Figure 10.

(2)

Question number	Answer	Mark
8(a)(ii)	An answer that combines up to a maximum of **two** points to provide a logical description: • as the temperature increases from 20 °C to 37 °C the rate of lipase activity increases (from 0.2 to 0.8) (1) • the rate of lipase activity is optimal at 37 °C (1) • above 37 °C the rate of lipase activity decreases (from 0.8 to 0.1) (1)	**(2)**

Part (a)(ii) requires students to interpret the data that they have been presented with to describe the effect of temperature on lipase activity. They should be familiar with the general effect of temperature on the activity of enzymes, and this knowledge can be used to interpret the graph.

(iii) Explain why the activity of lipase changes above a temperature of 40 °C.

(2)

....

....

....

....

Question number	Answer	Mark
8(a)(iii)	An explanation that combines identification – application of knowledge (1 mark) and reasoning/justification – application of understanding (1 mark): • an increase in temperature above 40 °C causes changes in the shape of the active site of the enzyme (1) • therefore the enzyme becomes denatured and no longer functions (1)	(2)

This part extends the candidates' knowledge to explain the effect of high temperature on the activity of lipase. This is an application mark as it applies their knowledge of the mechanisms of enzymes to practical results that are presented in the question.

(b) A student investigated the time taken for amylase to breakdown a 10% starch solution into glucose at 37 °C. The student repeated the investigation five times.

Figure 11 shows the results.

time taken for amylase to produce glucose (s)				
test 1	test 2	test 3	test 4	test 5
120	125	110	115	118

Figure 11

(i) Calculate the rate of amylase enzyme activity for the 10% starch solution.

(3)

rate = ... s^{-1}

Question number	Answer	Additional guidance	Mark
8(b)(i)	• mean= 588/5 = 117.6 (1) • rate = 1 ÷ 117.6 (1) • 0.0085 (1)	award full marks for correct numerical answer without working accept 1000/*t* accept 10/*t*	**(3)**

This part asks candidates to calculate the rate of enzyme activity by first calculating the mean, and then working out the rate. Candidates have to obtain the correct data from the table and use it to calculate the rate. It focuses on the maths skills required.

Core practical 3: Food tests

1.13B Core practical: Investigate the use of chemical reagents to identify starch, reducing sugars, proteins and fats

Links to the specification content

1.12	Explain the importance of enzymes as biological catalysts in the synthesis of carbohydrates, proteins and lipids and their breakdown into sugars, amino acids and fatty acids and glycerol
1.14B	Explain how the energy contained in food can be measured using calorimetry

Introducing the practical

This core practical is only required for biology and not combined science. It covers techniques and skills that students are likely to have encountered during Key Stage 3. Consequently, the resource to support this core practical suggests that students plan the investigation to test a range of foods for starch, reducing sugars, proteins and fats. This provides students with the opportunity to develop their skills in writing methods, determining what equipment is required and considering safety hazards and how they would deal with these. It may be necessary to split this practical into two lessons, one to plan and one to complete the investigation.

Students will be required to remember the reagents needed to test for starch, reducing sugars, protein and lipids, the methods used for the food tests as well as both positive and negative observed results. They will then be able to link this information to the role of enzymes in the synthesis of carbohydrates, proteins and lipids and their breakdown into sugars, amino acids and fatty acids and glycerol. This core practical is in topic 1 and as such could be linked to relevant theoretical knowledge across both paper 1 and paper 2.

Link to GCSE Science 2011: 3.14 ‘Explain the role of digestive enzymes, including:

a carbohydrases, including amylase, which digest starch to simple sugars

b proteases, including pepsin, which digest proteins to amino acids

c lipase, which digests fats to fatty acids and glycerol’

in GCSE Biology 2011 Unit B2 Topic 3.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- Why should all the food tests be done on each food sample?
- What effect could cross contamination have on the observed results?
- How can cross contamination of samples be avoided?
- What safety hazards will be encountered during the practical work?
- How can safety hazards be minimised or prevented?
- What is the best way to present results that are qualitative?
- How could qualitative food tests be modified to produce semi-quantitative or quantitative data?
- Why might the result for reducing sugars be negative in a food whose food label shows it contains sugar?
- What are the roles of each food group in the body?

- How do the results for each food test link to its potential role as part of a balanced diet?

Skills that are covered in the practical:

- Determining equipment needed for a practical
- Writing a method
- Recognising safety hazards and controlling risks
- Careful labelling and manipulation of apparatus to avoid cross contamination
- Recording of quantitative data in a results table
- Use of scientific ideas to interpret results

Sample question

These examples are taken from the sample assessment material. The question is from 1BI0/1F. The first part of the question requires knowledge gained from the core practical. The second part of the question shows how skills gained from completing core practicals could be applied to new contexts in exam questions. The question links to sugar, the test for which is described in the first part of the question. The commentary below outlines how the skills students will have gained by carrying out the practical may be shown in the final exams.

3 The sugar molecule glucose can be detected by a chemical test.

(a) Use words from the box to complete the sentences.

(2)

blue-black	iodine	brick red
Biuret	lilac	Benedict's

The .... reagent is added to a tube containing a solution of glucose.

The tube is heated and the colour changes to a .... colour.

Question number	Answer	Mark
3(a)	• Benedict's (1) • brick red (1) Answers must be in the correct order	**(2)**

This question requires recall of the reagent used to test for the presence of glucose and the colour change observed with a positive result.

Sugary drinks have been linked to tooth decay.

Tooth decay occurs when the enamel on teeth is dissolved.

A scientist investigates the effect of five different drinks on artificial tooth enamel.

She places 10 g of artificial tooth enamel into 100 ml of each drink. These are left for seven days.

The percentage change of mass for each sample of enamel is calculated.

Figure 5 shows the results.

drink	cola	milk	lemonade	squash	milkshake
percentage change of mass (%)	–3.4	0.0	–2.8	–0.6	–1.6

Figure 5

(b) (i) Which drink is most likely to cause tooth decay?

(1)

☒ **A** cola

☒ **B** lemonade

☒ **C** milkshake

☒ **D** squash

Question number	Answer	Mark
3(b)(i)	A	**(1)**

This question requires the interpretation of a set of results from an investigation that will be unfamiliar to students. The information in the stem of the question is needed to interpret the results given in the table. This would also require students to have an understanding of the maths concept of percentage change in mass.

(ii) Explain why it might be better to drink milk rather than a milkshake.

Use data from Figure 5.

(2)

....

....

....

....

Question number	Answer	Mark
3(b)(ii)	An explanation that combines identification via a judgement (1 mark) to reach a conclusion via justification/reasoning (1 mark): • milk does not change the mass of the enamel/milkshake reduces the mass of the enamel (1) • so therefore milk causes less tooth decay (1)	**(2)**

This question requires students to justify a conclusion by comparing two pieces of data and combine it with information given in the stem of the question as part of the justification.

The scientist is concerned that the conclusions from this experiment might **not** show the real effect of sugary drinks on teeth.

(iii) Give **two** ways in which the scientist could improve the investigation.

(2)

1 ....

....

2 ....

....

Question number	Answer	Mark
3(b)(iii)	Any two of the following points: • use real teeth (1) • clean the teeth (1) • expose the teeth for shorter time periods repeatedly (1)	**(2)**

This question requires students to recognise the limitations of an unfamiliar investigation and suggest possible improvements. Students should work on developing this skill when completing practicals during the course.

Core practical 4: Osmosis in potato strips

1.16 Core practical: Investigate osmosis in potatoes

Links to the specification content

1.15	Explain how substances are transported into and out of cells, including by diffusion, osmosis and active transport
1.17	Calculate percentage gain and loss of mass in osmosis

Introducing the practical

This core practical uses potato strips to demonstrate osmosis. The potato strip will lose or gain mass, due to osmosis, depending on the concentration of solutes in the solution. The practical can be completed within an hour lesson and combining class data allows the opportunity for enhanced analysis of the results. The practical pre-prepares the sucrose solutions and potato strips but it would be helpful to discuss how this was done to control relevant variables. The practical addresses a few areas which candidates find difficult including the idea that a solution with a high concentration of solute molecules contains fewer water molecules and the calculation of percentage change in mass. Graphical analysis of the results gives the opportunity for candidates to determine the isotonic concentration of the potato.

Link to GCSE Science 2011: 2.21 'Investigate osmosis' is a core practical in GCSE Biology 2011 Unit B2 Topic 2.

Osmosis in potato strips

Questions you could ask to enhance learning and focus your students on important aspects of the practical

- What variables can arise with the potato strips?
- Why do the potato strips have to be blotted dry?
- Why are the potato strips the same width and length?
- What precautions must be taken to ensure the mass of the potato is accurately recorded?
- How have the sucrose solutions been prepared?
- Which sucrose solution has the highest number of water/solute molecules?
- Why should the potato strips be left in the solutions for at least 15 minutes?
- What are the main errors in this procedure?
- How can you improve the procedure?
- What safety precautions are used in the practical?
- What is the benefit of combining the class data before the analysis is completed?

Skills that are covered in the practical:

- Using a balance accurately
- Accurate labelling to identify samples in an investigation
- Recording observations (e.g. mass of potato strips)
- Ability to carry out investigation safely

Maths skills:

- Calculating percentage change in mass
- Identifying anomalous results
- Calculating mean values
- Plotting a scatter graph
- Determining the graph intercept point to identify the isotonic value

Sample question

This example is taken from the sample assessment material, paper 1BI0/1BH, Q5(a). The commentary below outlines how the skills students will have gained by carrying out the practical may be shown in the final exams.

5 Diffusion, active transport and osmosis can be used to move substances into and out of cells.

(a) A student was investigating osmosis in potato cubes.

He used the following method:

cut a potato into equal-sized cubes

- record the mass of each potato cube
- place each potato cube into different concentrations of salt solution
- remove the potato cubes after 30 minutes
- dry the potato cubes and record the final mass of each cube.

He plots his results on a graph shown in Figure 6.

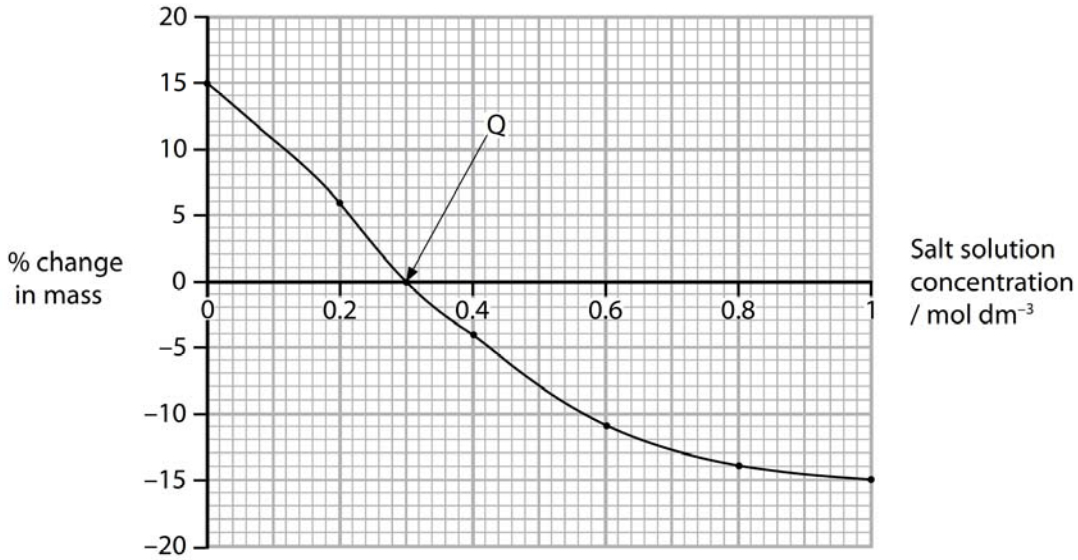


Figure 6

The method controls a number of variables.

(i) Name **one** other variable that needs to be controlled during the student's investigation.

(1)

....

....

Question number	Answer	Mark
5(a)(i)	Any one variable from • temperature • amount of drying • type of potato • age of potato	**(1)**

This question requires candidates to understand the controlled variables in the core practical. The direct link to the core practical makes this a knowledge-based question.

(iii) Explain the conclusion that can be made about point Q on Figure 6.

(2)

....

....

....

....

Question number	Answer	Mark
5(a)(iii)	An explanation that combines identification via a judgement (1 mark) to reach a conclusion via justification/reasoning (1 mark): any **one** identification point from: • there is no change in mass at 0.3 mol dm^{-3} (check once drawn) (1) • this is the isotonic salt concentration in the potato (1) **Plus** reasoning/justification • because there is no net movement of water/no salt concentration gradient (1)	**(2)**

This is an analysis question as it requires candidates to draw a conclusion about the specific data point on the graph. They will need to explain that the value represents the point where there is zero percentage change in mass.

(iv) Give one way that the student could obtain more data to increase the accuracy of point Q.

(1)

....

....

Question number	Answer	Mark
5(a)(iv)	• repeat the test using intermediate concentrations (between 0.2 and 0.4 mol dm^3)	**(1)**

This is also an analysis question requiring candidates to suggest how the investigation could be extended to collect more data to accurately determine the point where there is zero percentage change in mass.

Core practical 5: Microbial cultures

5.18B Core practical: Investigate the effects of antiseptics, antibiotics or plant extracts on microbial cultures

Links to the specification content

5.10B	Describe how plants defend themselves against attack from pests and pathogens by producing chemicals, some of which can be used to treat human diseases or relieve symptoms
5.16	Explain that antibiotics can only be used to treat bacterial infections because they inhibit cell processes in the bacterium but not the host organism
5.17B	Explain the aseptic techniques used in culturing microorganisms in the laboratory, including the use of an autoclave to prepare sterile growth medium and petri dishes, the use of sterile inoculating loops to transfer microorganisms and the need to keep petri dishes and culture vials covered
5.19B	Calculate cross-sectional areas of bacterial cultures and clear agar jelly using πr^2

This core practical provides students with the opportunities to develop their skills handling microorganisms including aseptic techniques. The practical spreads bacteria onto agar in petri dishes. Filter paper discs inoculated with antiseptics, antibiotics or plant extracts are then placed onto the agar before the plate is incubated. As the bacteria grow, the antiseptics, antibiotics or plant extracts kill the bacteria producing a zone of inhibition. The larger the zone of inhibition the more effective the chemical.

The results of the investigation can be analysed and the area of the clear agar jelly surrounding the filter paper discs can be calculated using πr^2. Students should consider ways in which the results of the investigation can be presented and how this type of investigation could be used in a clinical or industrial setting. Students should also be able to explain why the specific aseptic precautions are used.

Link to GCSE Science 2011: 3.15 'Investigate the effects of antiseptics or antibiotics on microbial cultures' is a core practical in GCSE Biology 2011 Unit B1 Topic 3. Also, 1.27 'Demonstrate an understanding of Louis Pasteur's contribution to the development of aseptic techniques' in GCSE Biology 2011 Unit B3 Topic 1.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- Why are aseptic precautions necessary when handling bacteria and other microorganisms?
- Why are bacteria used in this investigation?
- What types of bacteria should be used for this type of investigation?
- Why should a temperature of 30°C be used to culture microorganisms in a school laboratory?
- Why should the plates and cultures only be opened close to a Bunsen flame?
- What are the different variables that need to be controlled during this investigation?
- Why are the chemicals added to the plate on a filter disc?
- What does the agar used for culturing the bacteria contain?

- What is the difference between antiseptics, antibiotics and plant extracts?
- How could investigations similar to this core practical be used in a clinical environment?
- How could investigations similar to this core practical be used in the search for new antibiotics or antiseptics?
- Why do antibiotics only target bacterial cells?

Skills that are covered in the practical:

- Identification of risks associated with handling microorganisms
- Use of different aseptic procedures
- Safe handling of apparatus
- Interpretation and presentation of results
- Identification of anomalous results
- The importance of controls in investigations

Maths skills:

- Measurement of radius
- Calculating the area of a circle
- Calculating mean values from repeats
- Presenting data in a bar graph

Sample question

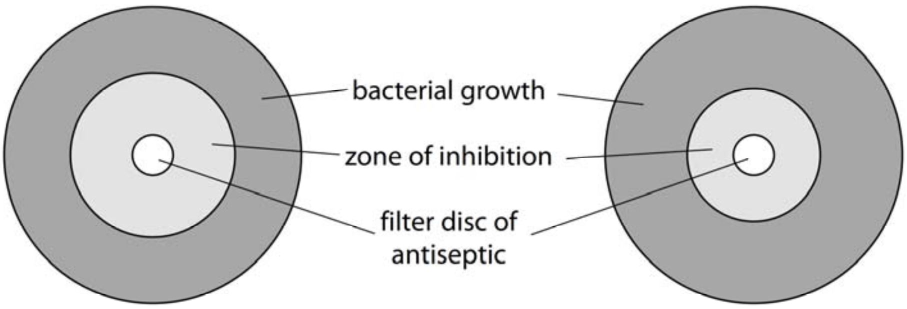
This example is taken from the sample assessment material, paper 1BI0/1BH and 1BIO/1BF. Parts of the question overlap between the higher and foundation tier. The commentary below outlines how the skills students will have gained by carrying out the practical may be shown in the final exams and includes some application of specific maths skills.

2 *Streptococcus pyogenes* is a bacterium that causes communicable infections.

(a) Scientists tested the ability of two antiseptics to kill *Streptococcus pyogenes* bacteria.

They spread *Streptococcus pyogenes* bacteria on two agar jelly plates and placed a small disc of filter paper containing antiseptic in the centre of each dish.

Figure 3 shows the results of the test after 24 hours of incubation.



antiseptic 1 zone of inhibition	
radius (mm)	12
area (mm^2)	452

Figure 3

(i) Calculate the area of the zone of inhibition for antiseptic 2.

Give the answer to 3 significant figures.

($\pi = 3.14$)

(3)

zone of inhibition for antiseptic 2 = ... mm^2

Question number	Answer	Additional guidance	Mark
2(a)(i)	• radius 10 mm ± 1 mm (1) • area = πr^2 (1) • area 314 (mm^2) (1) answer must be to 3 significant figures	if radius outside range but area calculated max 2 marks award full marks for correct numerical answer without working	**(3)**

This question requires students to recall the equation needed to calculate the area of a circle, which is a required maths skill. They need to measure the radius of the zone of inhibition and use this to calculate the total area.

(ii) Explain which antiseptic is the most effective.

(2)

....

....

....

....

Question number	Answer	Additional guidance	Mark
2(a)(ii)	An explanation that combines identification via a judgement (1 mark) to reach a conclusion via justification/reasoning (1 mark): • antiseptic 1 has a larger zone of inhibition (1) • so more of *Streptococcus pyogenes* have been killed (1)	ecf from (a)(i)	**(2)**

For this question, students need to use their answer from part (i) and compare it to the value in the table for antiseptic 1. They need to be able to explain that a larger zone of inhibition indicates that more bacteria have been killed because the antiseptic is more effective.

(iii) After the bacteria were spread on the plates, both plates were incubated for 24 hours at 37 °C.

Give a reason why the plates were incubated at 37 °C.

(1)

....

....

Question number	Answer	Additional guidance	Mark
2(a)(iii)	• to provide optimal growth conditions	*S. pyogenes* grow at body temperature	**(1)**

This question asks for a reason why a particular variable needs to be controlled.

(iii) Both plates were incubated for 24 hours.

State **two** other variables the scientist would need to control during the test.

(2)

1 ....

....

2 ....

....

Question number	Answer	Mark
8(a)(iii)	Any two of the following points: • volume of antiseptic (1) • incubation temperature (1) • same type of agar (1) • amount of bacteria (1)	**(2)**

For this question, students need to identify two other variables that would need to be controlled during the investigation to ensure valid conclusions can be made.

(b) The wire loop used to spread bacteria on an agar plate was heated in a Bunsen burner flame before being used.

(i) Explain why this aseptic precaution was used.

(2)

....

....

....

....

Question number	Answer	Mark
8(b)(i)	An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (1 mark): • the Bunsen burner flame kills all microorganisms on the loop (1) • so only the desired bacteria are transferred to the loop/no unwanted microorganisms spread to the agar plate (1)	**(2)**

This question is based on a knowledge specification point but this knowledge is also likely to have been gained by completing the core practical. Students need to explain why killing any bacteria initially on the wire loop is necessary.

(ii) State **one** additional aseptic technique which would have been used for this investigation.

(1)

....

....

Question number	Answer	Mark
8(b)(ii)	Any one from: • keep the lids on the agar plates after growth (1) • use agar sterilised in an autoclave first (1) • work close to a Bunsen flame to create an uplift (1)	**(1)**

The knowledge needed to answer this question will have been gained while completing the core practical.

Core practical 6: Light intensity and Photosynthesis

6.5 Core practical: Investigate the effect of light intensity on the rate of photosynthesis

Links to the specification content

6.1	Describe photosynthetic organisms as the main producers of food and therefore biomass
6.2	Describe photosynthesis in plants and algae as an endothermic reaction that uses light energy to react carbon dioxide and water to produce glucose and oxygen
6.3	Explain the effect of temperature, light intensity and carbon dioxide concentration as limiting factors on the rate of photosynthesis
6.4	**Explain the interactions of temperature, light intensity and carbon dioxide concentration in limiting the rate of photosynthesis**
6.6	**Explain how the rate of photosynthesis is directly proportional to light intensity and inversely proportional to the distance from a light source, including the use of the inverse square law calculation**

Introducing the practical

This practical allows students to investigate the effect of light intensity on the rate of photosynthesis. Algal balls are placed in hydrogen carbonate indicator at different distances from a light source. The indicator is sensitive to pH and varies depending on the concentration of CO_2 in the solution. The results can be compared with a standard set of solutions to determine the effect of light intensity on the rate of photosynthesis. This core practical allows higher-ability students to investigate the inverse square law for photosynthesis.

The practical uses algae immobilised in alginate beads, which could be prepared by technicians or by students to increase their practical skills knowledge. There are a number of variables that will need to be identified and controlled by the students during the investigation. A similar method could be used to investigate the effect of other limiting factors on the rate of photosynthesis, e.g. temperature, to enhance the students' understanding of both their theoretical knowledge and the core practical technique.

> Link to GCSE Science 2011: 'Investigate how factors, including the effect of light intensity, CO_2 concentration or temperature, affect the rate of photosynthesis' was a core practical in GCSE Biology 2011 Unit B2 Topic 2.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- How can light intensity be measured?
- How can light intensity be calculated?
- What is the optimum temperature for this investigation?
- When should the algal balls be added to the indicator solution?
- What are the other variables that need to be controlled during the investigation?
- Why does algae work better than pondweed in this type of investigation?
- What are the benefits of using immobilised algae?

- Why does the rate of photosynthesis lead to a colour change in the indicator solution?
- Why is a tube of water placed between the light source and the tubes of indicator containing the algal balls?
- Why is a set of standard solutions used?
- What other methods can be used to measure the rate of photosynthesis?

Skills that are covered in the practical:

- Safe manipulation of apparatus
- Recognition and controlling of risks
- Careful measurements
- Collection and interpretation of quantitative data
- Use of an indicator solution

Maths skills:

- Application of the inverse square law for photosynthesis

Sample question

These examples are taken from the sample assessment material, paper 1BI0/2BF and 1BI0/2BH. The commentary below outlines how the skills students will have gained by carrying out the practical may be shown in the final exams and includes some application of specific maths skills.

A scientist investigates the effect of light intensity on photosynthesis.

He sets up the equipment shown in Figure 1.

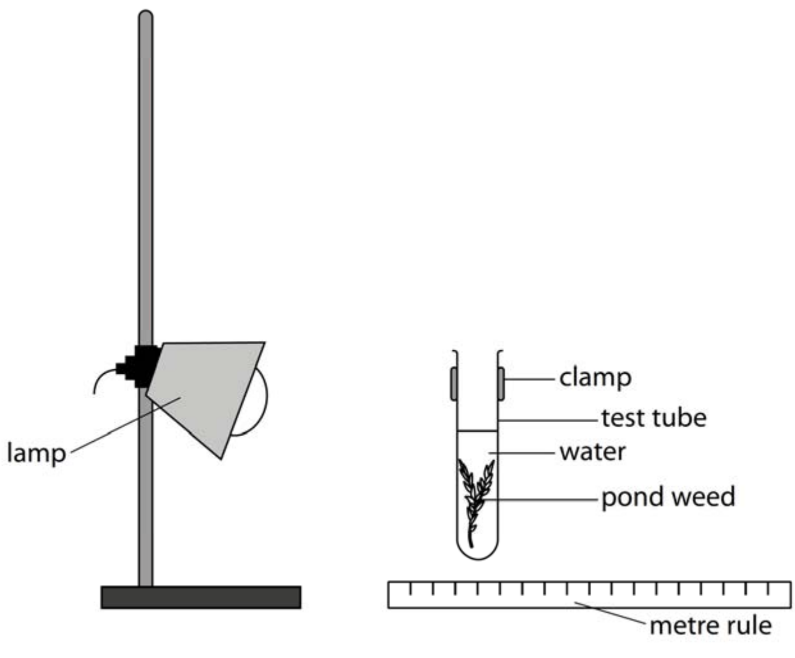


Figure 1

He places the lamp 10 cm from the test tube and records the number of bubbles produced in five minutes.

He repeats the procedure with the lamp at a distance of 20 cm and 30 cm away from the test tube.

The scientist wants to repeat his investigation at each distance.

(b) (i) State **three** variables that should be kept constant to improve the results.

(3)

1 ....

....

2 ....

....

3 ....

....

Question number	Answer	Mark
1(b)(i)	• temperature of water (1) • start each experiment with the same amount of carbon dioxide (1) • start each experiment with the same amount of water (1)	**(3)**

This part of the question uses an alternative practical for measuring the effect of light intensity on the rate of photosynthesis. The students can use the knowledge they have gained while completing the core practical to identify the variables that need to be controlled in this investigation.

The scientist noticed that the temperature of water near the light increased.

(ii) Give **one** improvement the scientist could make to reduce the effect of this increase in temperature.

(1)

....

....

Question number	Answer	Mark
1(b)(ii)	Any one improvement from: • use a heat shield (1) • use a water bath (1)	**(1)**

This part of the question requires students to recognise the importance of a heat shield during investigations that measure the effect of light intensity on the rate of photosynthesis.

(c) Figure 2 shows the results of the investigation.

distance (cm)	number of bubbles counted			
	test 1	test 2	test 3	mean
10	42	37	44	41
20	23	24	22	
30	10	11	12	11

Figure 2

(i) Calculate the mean result for a distance of 20 cm.

(1)

....

Question number	Answer	Additional guidance	Mark
1(c)(i)	• $\frac{23+24+22}{3}$ (1) • 69 ÷ 3 = 23 (1)	award full marks for correct numerical answer without working	**(1)**

This part of the question is a simple mean calculation using data from the table.

The number of bubbles counted for test 2 at 10 cm was anomalous.

(ii) State how the scientist could deal with this anomaly.

(1)

....

....

Question number	Answer	Mark
1(c)(ii)	repeat the reading to get concordant results/calculate the mean without the anomalous result	**(1)**

This part of the question draws on skills for the analysis of data that students will gain from completing many of the core practicals.

(iii) Give a conclusion about the effect of light intensity on photosynthesis.

(1)

....

....

(Total for Question 1 = 8 marks)

Question number	Answer	Mark
1(c)(iii)	{as light intensity decreases/distance from the lamp increases} the rate of photosynthesis decreases	**(1)**

This part of the question requires students to interpret the data in the table to produce a simple conclusion.

5 A scientist investigated the effect of light intensity on the rate of photosynthesis of the aquatic *Cabomba* plant.

A lamp was used as a source of light. The lamp was placed at different distances (d) from the *Cabomba* plant, and the number of bubbles produced in 60 seconds was counted.

The number of bubbles produced in 60 seconds was used to calculate the rate of photosynthesis.

The light intensity was then calculated using the inverse square law $\left(\frac{1}{d^2}\right)$.

Figure 10 shows the scientist's results.

distance (d) of lamp from *Cabomba* (cm)	light intensity (arbitrary units)	bubbles produced in 60 seconds
5	0.0400	79
10	0.0100	21
15	0.0044	12
20	0.0025	7
25		5
30	0.0011	4

Figure 10

(a) (i) Calculate the light intensity when the lamp is 25 cm from the *Cabomba* plant.

(2)

light intensity = ... arbitrary units

Question number	Answer	Additional guidance	Mark
5(a)(i)	25 × 25 = 625 (1) 1 ÷ 625 = 0.0016 (1)	award full marks for correct numerical answer without working	**(2)**

This part of the question requires students to use the equation given in the stem of the question to calculate the light intensity.

(ii) Use information from Figure 10 to describe the effect of light intensity on the rate of photosynthesis.

(2)

....

....

....

....

Question number	Answer	Mark
5(a)(ii)	An answer that combines points of interpretation/evaluation to provide a logical description: • as light intensity decreases the rate of photosynthesis also decreases (1) • after 20 cm away when light intensity appears to have little effect on the rate of photosynthesis (1)	**(2)**

The students need to interpret the data given in the table to describe the effect of light intensity on the rate of photosynthesis. They need to recognise two features from the data, the initial decrease in the rate of photosynthesis and then a levelling off of the rate as light intensity decreases.

(iii) Give another method of measuring light intensity rather than calculating it.

(1)

....

....

Question number	Answer	Mark
5(a)(iii)	use a light meter/lux meter	**(1)**

The knowledge required to answer this part of the question could have been gained during a discussion of different techniques that could be used during the core practical.

(iv) The scientist counted the number of bubbles produced by the *Cabomba* plant.

Another scientist stated that this was not the best method of measuring the volume of gas produced.

Explain how you could improve the method to measure the volume of gas released more accurately.

(2)

....

....

....

....

Question number	Answer	Additional guidance	Mark
5(a)(iv)	An explanation that combines identification – improvement of the experimental procedure (1 mark) and justification/reasoning which must be linked to the improvement (1 mark): • collect the gas/oxygen produced in a graduated gas syringe (1) • to reduce the errors generated when counting bubbles which maybe of different sizes (1)	accept alternative gas collection method with measuring cylinder and beehive shelf accept leave the apparatus for a longer amount of time	**(2)**

This part of the question draws on the skills students will have gained by completing core practicals. They should be able to analyse given methods and suggest improvements.

(b) Explain what would happen to the levels of gas produced if the light intensity decreased to 0.0001 arbitrary units.

(2)

....

....

....

....

Question number	Answer	Mark
5(b)	An explanation that combines identification via a judgment (1 mark) to reach a conclusion via justification/reasoning (1 mark): • the volume of gas produced would decrease to below four bubbles (1) • because light is needed for photosynthesis (1)	**(2)**

This part of the question requires students to analyse data they have been given and make a prediction as to the outcome if the data is extrapolated.

Core practical 7: Respiration rates

8.11 Core practical: Investigate the rate of respiration in living organisms

Links to the specification content

8.9	Describe cellular respiration as an exothermic reaction which occurs continuously in living cells to release energy for metabolic processes, including aerobic and anaerobic respiration
8.10	Compare the process of aerobic respiration with the process of anaerobic respiration

Introducing the practical

There are many factors which can effect respiration rate. This core practical uses a respirometer to investigate the effect of temperature on the rate of respiration in small organisms. There are a number of different organisms that can be used in the respirometer. In addition, this could also be done using germinating peas. The respirometer measures the rate of oxygen uptake and uses soda lime to absorb the carbon dioxide released. The apparatus needs to be carefully assembled and care must be taken at all times to ensure that the living organisms are treated appropriately.

The core practical offers many opportunities for students to develop their practical skills and knowledge. There are a number of variables which need to be controlled and a control tube is needed as a comparison. The investigation measures the distance moved by a coloured liquid along a capillary tube and this information can be used to calculate a rate of oxygen uptake by the organisms at different temperatures. The practical also provides the opportunity to discuss the ethics of using living organisms in scientific investigations.

Link to GCSE Science 2011: 2.1 'Recall that respiration is a process used by all living organisms that releases the energy in organic molecules' and 2.4 'Demonstrate an understanding of how aerobic respiration uses oxygen to release energy from glucose and how this process can be modelled using the word equation for aerobic respiration' in GCSE Biology 2011 Unit B2 Topic 2.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- Why is soda lime used in the investigation?
- Why must soda lime be handled carefully?
- What variables need to be controlled during the investigation?
- What are the ethical and safety issues that arise from using living organisms in investigations?
- Why do the tubes containing the organisms need to be left in a water bath for 5 minutes before the rate of oxygen consumption is measured?
- How can the distance that the coloured liquid moves be used to determine the rate of oxygen uptake?
- What temperatures are appropriate to use during the investigation?
- Why is a control tube included in the investigation?
- Why should measurements be repeated at each temperature?
- What are the benefits of using thermostatically controlled water baths?
- How should anomalous results in the data be dealt with?
- How can the final data be presented?

Skills that are covered in the practical:

- Safe handling and manipulation of living organisms
- The ability to manipulate apparatus and use a respirometer
- Measuring and recording information carefully
- Careful use of a water bath
- Safe handling of chemical reagents

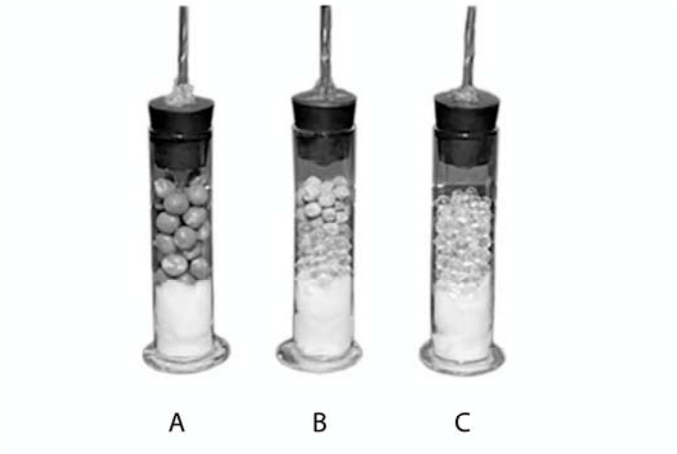
Maths skills:

- Mean calculations
- Calculating rates of oxygen uptake
- Identification of anomalous results
- Plotting a scatter graph

Sample question

This example is taken from the sample assessment material, paper 1BI0/2BH and. The commentary below outlines how the skills students will have gained by carrying out the practical may be shown in the final exams and includes some application of specific maths skills.

6 Figure 11 shows the equipment used for measuring respiration in peas.



(Source: Martin Shields/Science Photo Library)

Figure 11

- Respirometer A contains germinating peas.
- Respirometer B contains peas that are not germinating.
- Respirometer C contains glass beads.

All three respirometers are placed in a water bath at 25 °C for 30 minutes.
The reduction in oxygen levels in each respirometer is measured using a data logger.

(a) Explain why the respirometers are placed in a water bath at 25 °C.

(2)

....

....

....

....

Question number	Answer	Mark
6(a)	An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (1 mark): • same temperature to act as control (1) • to provide the optimum temperature for enzyme action in the peas (1)	**(2)**

This question requires an explanation as to why temperature needs to be controlled in this investigation. The students need to link controlling temperature to enzyme activity.

(b) A student recorded the change in oxygen levels in the germinating peas over a 30-minute period.

The results are shown below.

A 10 mins (–0.8) ml, 20 mins (–1.6) ml, 30 mins (–2.4) ml

B 10 mins (–0.1) ml, 20 mins (–0.1) ml, 30 mins (–0.1) ml

C No change

(i) Complete the table for these results.

(2)

<table>
<tr><th>Question number</th><th>Answer</th><th>Additional guidance</th><th>Mark</th></tr>
<tr><td>6(b)(i)</td><td>
headed table with units (1)
accurately completed table (1)
<table>
<tr><th></th><th>A</th><th>B</th><th>C</th></tr>
<tr><td>O_2 used /ml at 10 mins</td><td>0.8</td><td>0.1</td><td>0.0</td></tr>
<tr><td>O_2 used /ml at 20 mins</td><td>1.6</td><td>0.1</td><td>0.0</td></tr>
<tr><td>O_2 used /ml at 30 mins</td><td>2.4</td><td>0.1</td><td>0.0</td></tr>
</table>
</td><td>negative values do not need to be shown if table heading states oxygen used/lost

accept time in row 1 as an alternative</td><td>(2)</td></tr>
</table>

This question requires students to understand how scientific data should be presented in a results table including the use of units in the header.

(ii) Calculate the rate of oxygen consumption per second for the results in respirometer A.

(2)

.... ml/second

Question number	Answer	Additional guidance	Mark
6(b)(ii)	2.4 ÷ (30 × 60) (1) = 0.0013 (ml/second) (1)	accept 1.6 ÷ (20 × 60) accept 0.8 ÷ (10 × 60) award full marks for correct numerical answer without working maximum one mark if no unit conversion	(2)

This question requires students to calculate the rate of oxygen consumption per second by using data from the investigation. It requires the conversion of minutes to seconds in the rate calculation.

(iii) Explain why respirometer A has the highest rate of oxygen consumption.

(2)

....

....

....

....

Question number	Answer	Mark
6(b)(iii)	An explanation that combines identification – application of knowledge (1 mark) and reasoning/justification – application of understanding (1 mark): • the peas in respirometer A are germinating so using up oxygen (1) • during the process of respiration to release energy for growth (1)	(2)

This question requires students to use their knowledge on respiration to explain the results of the investigation. They should recognise that germination is an active process and therefore requires energy which is released during respiration.

(c) Some respirometers read the movement of a bubble along capillary tubing.

Carbon dioxide can affect the measuring of oxygen used in this type of respirometer.

State a chemical that could be placed in the respirometer that would stop carbon dioxide affecting the experiment.

(1)

....

....

Question number	Answer	Additional guidance	Mark
6(c)	Any one improvement from: soda lime (1) • cotton wool soaked with potassium hydroxide (1)	accept other relevant chemical that would remove carbon dioxide	**(1)**

This question requires students to demonstrate their knowledge of the core practical method by knowing that soda lime is used to absorb carbon dioxide.

Core practical 8: Quadrats and transects

9.5 Core practical: Investigate the relationship between organisms and their environment using field-work techniques, including quadrats and belt transects

Links to the specification content

9.6	Explain how to determine the number of organisms in a given area using raw data from field-work techniques, including quadrats and belt transects

Introducing the practical

The core practical investigates the effect of shade on the abundance of low growing plants. It uses a belt transect to measure the abundance of plants and also requires students to measure light intensity. Students should start measuring the abundance of plants and light intensity in open ground and finish their measurements in in the shade of a tree. It would also be possible to repeat this investigation measuring the effect of a different abiotic factor, such as water, to enhance understanding of the techniques involved. The practical will teach students how a quadrat is used. It will also make them consider other factors such as how frequently a measurement should be taken along a transect and methods for recording and presenting data.

Link to GCSE Science 2011: 2.22 'Investigate the relationship between organisms and their environment using fieldwork techniques' and 2.23 'Investigate the distribution of organisms in an ecosystem, using sampling techniques including a pooters, b sweep nets/pond nets, c pitfall traps, d quadrats, and measure environmental factors including e temperature, f light intensity, g pH' were core practicals in GCSE Biology 2011 Unit B2 Topic 2.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- What variables need to be considered when measuring light intensity?
- How many plants species should be measured?
- How long should the belt transect be?
- How frequently along the transect should a measurement be taken?
- How does a belt transect differ from a line transect?
- Which plants on the edges of the quadrat should be included in the count?
- How can the results be recorded and presented?
- What factors, other than light intensity, could affect the distribution of organisms along the belt transect?
- How might the results differ at different times of the day?
- How might the results differ at different times of the year?
- How would the method be modified to measure the abundance of a particular species across a large area?

Skills that are covered in the practical:

- The use of a quadrat and belt transect
- Consideration of variables
- Recording and presentation of quantitative data
- Consideration of the environment during fieldwork

Maths skills:

- Presentation of multiple sets of quantitative data

Sample question

This example is taken from the sample assessment material, paper 1BI0/2BF. The commentary below outlines how the skills students will have gained by carrying out the practical may be shown in the final exams

6 (a) A scientist wanted to estimate the number of earthworms in a field using a quadrat.

The scientist placed the quadrats at random on the surface of the area being sampled and then watered the area with a very dilute solution of mustard.

This causes the earthworms to come to the surface to be counted.

(i) Give a reason why the quadrats were placed at random.

(1)

....

....

Question number	Answer	Mark
6(a)(i)	To obtain a representative sample of the field (1)	**(1)**

This question looks at the use of a quadrat to measure abundance of organisms across an area and requires students to know why random sampling is required.

(b) A student wants to estimate the number of daisy plants in a 500 m^2 field.

She uses a 1 m^2 quadrat to sample the field.

Figure 9 shows the results for the number of daisy plants counted in six areas sampled with the quadrat.

sample number	number of daisy plants	mean diameter of daisy plants / cm
1	5	7
2	2	2
3	6	9
4	3	3
5	4	5
6	4	6

Figure 9

(i) Calculate the mean number of daisy plants for the six samples.

(1)

mean number of daisy plants = ...

Question number	Answer	Mark
6(b)(i)	$\frac{5+2+6+3+4+4}{6}$ = 4 (1)	**(1)**

This question requires the calculation of a mean, which is one of the required maths skills.

(ii) Describe how the student could use this calculated mean to estimate the total number of daisy plants in this field.

(2)

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Question number	Answer	Mark
6(b)(ii)	An answer that combines the following points of understanding to provide a logical description: • divide the field area by the quadrat size (1) • multiply by the mean number of daisies (1)	**(2)**

This question is based on the specification statement and requires students to know how to determine the number of organisms in a given area using raw data from field-work techniques. Students will be required to write plans for possible practical work in the exams.

Sample 2 was taken in an area where there were many overhanging trees.

(iii) Explain how these trees may have affected the distribution of daisy plants growing in this area.

(2)

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Question number	Answer	Mark
6(b)(iii)	An explanation that combines identification – application of knowledge (1 mark) and reasoning/justification – application of understanding (1 mark): • less daisy plants are likely to be growing in this area (1) • because the trees would cause lower light levels for photosynthesis/lower mineral levels for growth/less water available for photosynthesis (1)	**(2)**

This question is based on the knowledge the students will have acquired by doing the core practical activity. It needs the candidates to extract the data about sample 2 from the table and then explain why there are fewer daisies growing in the shade.

(iv) Give **two** abiotic factors that could affect the distribution and size of daisies growing in this field.

(2)

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(Total for Question 6 = 11 marks)

Question number	Answer	Mark
6(b)(iv)	Any two of the following: Temperature (1) pH (1) pollutants (1) water (1)	**(2)**

To answer this question, candidates need to know two abiotic factors which affect the growth of plants.

Chemistry

There are five core practicals in the chemistry section of GCSE Combined Science. GCSE Chemistry covers the same five practicals as well as an additional three, to make up eight core practicals in total.

This chemistry section outlines each core practical and gives a brief description of each one. The final part goes through each core practical in turn and outlines key skills as well as an extract of a sample exam question that links to the core practical.

Chemistry core practical descriptions

Note: 5.9C, 9.6C and 9.28C are separate GCSE Chemistry only.

Core practical		Description
2.11	*Investigate the composition of inks using simple distillation and paper chromatography*	This core practical is in two parts; a simple chromatography practical to obtain a chromatogram of dyes in ink and using simple distillation apparatus to separate pure water from ink. It needs to cover usage of a Bunsen burner, methods used in chromatography and distillation and safety of handling liquids.
3.6	*Investigate the change in pH on adding powdered calcium hydroxide or calcium oxide to a fixed volume of dilute hydrochloric acid*	This practical focuses on recording the pH at intervals when calcium hydroxide or calcium oxide reacts with dilute hydrochloric acid. An initial mass of the solid must be added to a fixed volume of the acid, and the pH recorded each time more of the solid is added to the acid. The pH can be recorded using a pH meter, or universal indicator paper with a glass rod used to take a pH measurement at each interval.
3.17	*Investigate the preparation of pure, dry hydrated copper sulfate crystals starting from copper oxide including the use of a water bath*	Excess copper oxide must be added to warm dilute sulfuric acid (warmed using a water bath), which will react to produce a blue solution of the salt copper(II) sulfate. The solution then needs to be filtered using filter paper and evaporated using an evaporating basin and Bunsen burner, followed by final drying using a watch glass to allow all the water to evaporate.
3.31	*Investigate the electrolysis of copper sulfate solution with inert electrodes and copper electrodes*	This involves setting up an electrolysis to investigate the effect of changing the current on the mass of the copper electrodes used in the electrolysis of copper sulfate solution. The second part of this investigation covers the products formed during the electrolysis of copper sulfate solution using inert (graphite) electrodes. Quantitative analysis when using copper electrodes will be expected.

5.9C	*Carry out an accurate acid-alkali titration, using burette, pipette and a suitable indicator*	A titration is carried out to determine the volume of hydrochloric acid required to neutralise a solution of unknown concentration of sodium hydroxide. An indicator must be used to determine the end point. Standard procedure for a titration must be carried out, such as the use of a white tile and swirling the conical flask to obtain an accurate end point. The data must then be used to determine the concentration of the unknown solution.
7.1	*Investigate the effects of changing the conditions of a reaction on the rates of chemical reactions by:* *a measuring the production of a gas (in the reaction between hydrochloric acid and marble chips)* *b observing a colour change (in the reaction between sodium thiosulfate and hydrochloric acid)*	This investigation is in two parts. Both parts require the reaction to be observed with respect to time to obtain the rate. In the first part, marble chips must be added to hydrochloric acid, and the volume of gas collected and measured over time. This will lead to graphical analysis to calculate rate, as well as an appreciation for how the rate may change with varying concentration of acid/temperature/surface area of marble chips. The second part involves sodium thiosulfate reacting with dilute hydrochloric acid to produce a precipitate using the idea of a 'disappearing cross' to observe the change in the appearance of the reaction mixture as a precipitate of sulfur is formed. This must be carried out at different temperatures by warming the thiosulfate solution. A graph must be drawn to show the time taken for the reaction to take place at different temperatures.
9.6C	*Identify the ions in unknown salts, using the tests for the specified cations and anions in 9.2C, 9.3C, 9.4C, 9.5C*	Tests must be carried out to determine the ions present as described in specification points 9.2C, 9.3C, 9.4C and 9.5C. This will include gas tests, flame tests and precipitation reactions.
9.28C	*Investigate the temperature rise produced in a known mass of water by the combustion of the alcohols ethanol, propanol, butanol and pentanol*	Apparatus set up to measure the increase in temperature when the different fuels given are burnt. This must lead to a comparison of the results for the four alcohols.

Core practical 1: Investigating the composition of inks

2.11 Core practical: Investigate the composition of inks using simple distillation and paper chromatography

Links to the specification content

2.7	Explain the experimental techniques for separation of mixtures by:
	a simple distillation
	e paper chromatography
2.9	Describe paper chromatography as the separation of mixtures of soluble substances by running a solvent (mobile phase) through the mixture on the paper (the paper contains the stationary phase), which causes the substances to move at different rates over the paper
2.10	Interpret a paper chromatogram:
	a to distinguish between pure and impure substances
	b to identify substances by comparison with known substances
	c to identify substances by calculation and use of R_f values

Introducing the practical

This practical is in two sections – simple distillation and paper chromatography of inks. You can carry out the practical in one session or two, depending on the length of your lesson. Many of your students will have carried out these practicals as part of their Key Stage 3 course so this activity can be used to revise the techniques as well as introduce the additional theory required for chromatography.

> Link to GCSE Science 2011: 'Using paper chromatography to separate inks, food dyes etc' is a suggested practical in GCSE Chemistry 2011 Unit C2 Topic 3.

Chromatography

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- Why is it important to draw the lines and write labels on the chromatography paper in pencil and not in ink?
- Why should the spots of ink be above the level of the solvent in the beaker?
- What is meant by the term 'solvent front'?
- What would happen if you used permanent ink instead of water soluble ink? How could you overcome this problem?
- Which is the mobile phase? Which is the stationary phase?
- Which ink(s), if any, contain one dye? Which ink(s) are mixtures of dyes? Which inks contain the same dye?

Skills that are covered in the practical:

- Measuring distance travelled by solvent
- Measuring height of dye above start line (estimate to centre of spot)
- Ability to manipulate apparatus for chromatography, recording observations (e.g. number of dyes in each ink, distance travelled by solvent, height of each dye above start line)
- Ability to carry out investigation safely

Maths skills:

- Interpreting a chromatogram
- Recording measurements accurately (1 dp)
- Substituting values correctly into expression for R_f, calculating the R_f value for the different dyes, giving answer to an appropriate number of significant figures

Distillation

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- Why do you need to heat the tube of ink gently?
- What is the temperature on the thermometer when the water is distilling off?
- Why does the collection tube need to be surrounded by crushed ice?
- What are the main errors in this procedure?
- How can you improve the procedure?

Skills that are covered in the practical:

- Measuring the temperature
- Ability to heat gently and safely
- Ability to manipulate apparatus for simple distillation
- Recording observations (e.g. colour of distillate)
- Ability to carry out investigation safely

Maths skills – not relevant here.

Sample question

This example is taken from the sample assessment material, paper 1CH0/1H, Q1. The commentary below outlines how the skills students will have gained by carrying out the practical may be shown in the final exams.

1 Mixtures of coloured substances can be separated by paper chromatography.

(a) Paper chromatography was used to separate a mixture of blue and red inks.
A spot of the mixture was placed on chromatography paper as shown in Figure 1.

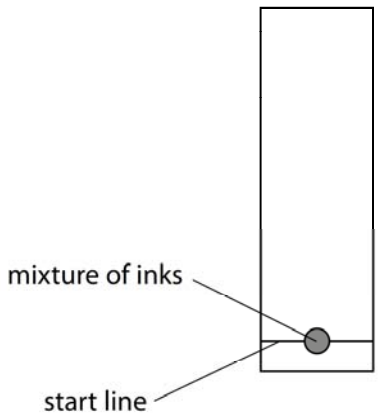


Figure 1

(i) Give a reason why the start line is drawn in pencil rather than in ink.

(1)

....

....

Question number	Answer	Mark
1(a)(i)	Pencil is insoluble in the solvent (but chromatography would separate the ink in an ink line).	(1)

Here, students are expected to know a practical detail about chromatography. They will have carried out a method such as this when looking at inks, so this links directly to a core practical they should have experienced as part of the course. It focuses on their understanding of the method, and why certain parts of the method are done in a certain way, such as using pencil instead of pen.

(ii) The chromatography paper, with the spot of mixture on it, was placed in a beaker with the bottom of the paper in water.

On Figure 2, complete the diagram showing the position of the chromatography paper with the spot of mixture at the start of the experiment.

(1)

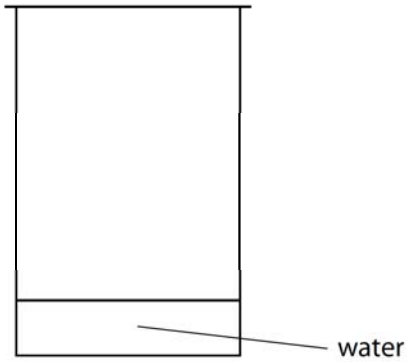
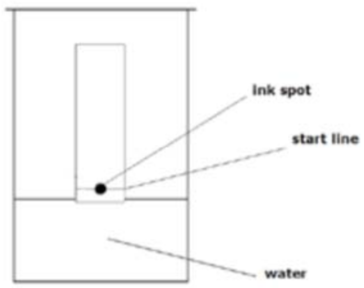


Figure 2

Question number	Answer	Mark
1(a)(ii)	Correct position of chromatography paper with start line and ink spot above surface of water. 	**(1)**

Again, students are expected to know a practical detail about chromatography. It focuses on students being aware of how to place the chromatography paper into a beaker of water, why it is important to make sure the ink spot is above the surface of water, and how the initial ink spot should be set up on the pencil line.

(iii) The chromatography was carried out and the result is shown in Figure 3.

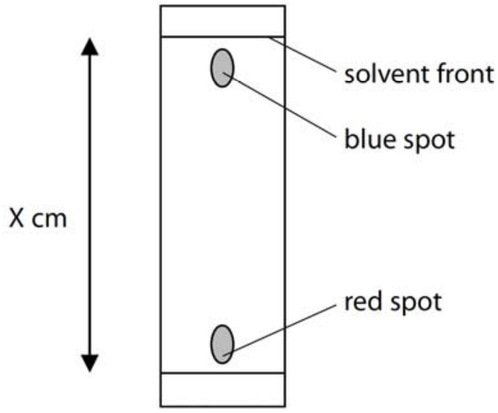


Figure 3

The blue spot had moved 14.5 cm and the solvent front had moved 15.3 cm.

Calculate the R_f value of the substance in the blue spot, giving your answer to 2 significant figures.

$$R_f \text{ value} = \frac{\text{distance travelled by a dye}}{\text{distance travelled by solvent front}}$$

(2)

R_f value = ...

Question number	Answer	Additional guidance	Mark
1(a)(iii)	• R_f = 14.5 / 15.3= 0.9477 (1) • = 0.95 (answer to 2 significant figures) (1)	Award full marks for correct numerical answer without working.	**(2)**

Students should be able to calculate an R_f value and understand the meaning of 2 significant figures. This brings out the mathematical requirement in chemistry, and exemplifies the sort of question that could be asked to focus on the maths requirements.

(b) **P**, **Q**, **R** and **S** are mixtures of food colourings.
They are investigated using paper chromatography.
Figure 4 shows the chromatogram at the end of the experiment.

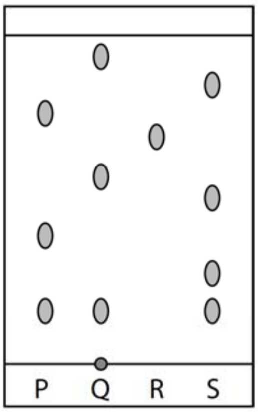


Figure 4

(i) Which mixture contains an insoluble food colouring?

(1)

☒ **A** mixture **P**

☒ **B** mixture **Q**

☒ **C** mixture **R**

☒ **D** mixture **S**

Question number	**Answer**	**Mark**
1(b)(i)	B	**(1)**

Students should understand that an insoluble substance will not move up the chromatography paper.

(ii) Give a change that could be made to the experiment to obtain an R_f value for the insoluble colouring.

(1)

....

....

Question number	**Answer**	**Mark**
1(b)(ii)	use a different solvent.	**(1)**

This question tests the understanding that different solvents can be used for chromatography. It applies their knowledge of chromatography as a method of separating mixtures.

(iii) Explain, by referring to Figure 4, which mixture is separated into the greatest number of soluble food colourings by this chromatography experiment.

(2)

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....

(Total for Question 1 = 8 marks)

Question number	Answer	Mark
1(b)(iii)	An explanation that combines identification via a judgement (1 mark) to reach a conclusion via justification/reasoning (1 mark): • mixture S (1) • because it gives the greatest number of spots/gives four spots (1)	**(2)**

Students should be able to interpret chromatograms. Here, it is not necessarily the chromatogram they will have looked at, but it focuses on applying their understanding of how to interpret the chromatogram and understanding the meaning of features such as why there may be more spots in some mixtures.

Core practical 2: Investigating pH

3.6 Core practical: Investigate the change in pH on adding powdered calcium hydroxide or calcium oxide to a fixed volume of dilute hydrochloric acid

Links to the specification content

3.1	Recall that acids in solution are sources of hydrogen ions and alkalis in solution are sources of hydroxide ions
3.2	Recall that a neutral solution has a pH of 7 and that acidic solutions have lower pH values and alkaline solutions higher pH values
3.4	**Recall that the higher the concentration of hydrogen ions in an acidic solution, the lower the pH; and the higher the concentration of hydroxide ions in an alkaline solution, the higher the pH**

Introducing the practical

This practical involves adding different masses of calcium oxide or hydroxide to a fixed volume of hydrochloric acid and measuring the pH after each addition until the base is in excess.

You may wish the students to use universal indicator paper for this experiment. They can place small pieces of the paper on a white tile and use a glass rod to transfer a drop of solution after each addition of calcium hydroxide or calcium oxide to the paper. They then compare the colour with a pH chart and record the pH value. It is helpful if you can demonstrate the use of a digital pH probe for this experiment.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- What is the best piece of apparatus to measure the volume of hydrochloric acid?
- Why is that the best piece of apparatus?
- How do you use universal indicator paper to measure the pH of the solution?
- Why is it necessary to stir the mixture when the calcium hydroxide powder is added?
- What are the main errors in this experiment?
- How could you improve the method?
- How do you know when the hydrochloric acid is exactly neutralised?

Skills that are covered in the practical:

- measuring mass of calcium hydroxide
- measuring volume of hydrochloric acid
- measuring pH using universal indicator or a pH probe
- making observations of colour changes with universal indicator
- safe use and careful handling of calcium hydroxide and hydrochloric acid

Maths skills:

- plot a graph of pH against mass of calcium hydroxide or calcium oxide added
- translate information between graphical and numeric form, for example, use the graph to estimate the mass of calcium hydroxide or calcium oxide needed to neutralise the hydrochloric acid

Sample question

This example is taken from the sample assessment material, paper 1CH0/1F, Q2. The commentary below outlines how the skills students will have gained by carrying out the practical may be shown in the final exams.

2 Ammonium phosphate and ammonium sulfate are made from ammonia.

These compounds can be used as fertilisers.

(a) Ammonia solution is alkaline.

Which of the following could be used to show that ammonia solution is alkaline?

(1)

☐ **A** conical flask

☐ **B** pH meter

☐ **C** pipette

☐ **D** thermometer

Question number	Answer	Mark
2(a)	B	**(1)**

This multiple-choice question expects students to know that a pH meter is used to show that a solution is alkaline.

This example is taken from the sample assessment material, paper 1CH0/1H, Q9. The commentary below outlines how the skills students will have gained by carrying out the practical may be shown in the final exams.

(ii) Give a reason why adding hydroxide ions to an acid solution leads to an increase in pH.

(1)

....

....

Question number	Answer	Mark
9(a)(ii)	hydroxide ions react with hydrogen ions and reduce the hydrogen ion concentration therefore increase pH (1)	**(1)**

This question occurs towards the end of a higher tier paper and expects students to know that hydroxide ions react with hydrogen ions to form water. The lower the concentration of hydrogen ions, the higher the pH of the solution.

Core practical 3: Preparing copper sulfate

3.17 Core practical: Investigate the preparation of pure, dry hydrated copper sulfate crystals starting from copper oxide including the use of a water bath

Links to the specification content

3.9	Recall that a base is any substance that reacts with an acid to form a salt and water only
3.11	Explain the general reactions of aqueous solutions of acids with: b metal oxides to form salts
3.13	Describe a neutralisation reaction as a reaction between an acid and a base
3.15	Explain why, if soluble salts are prepared from an acid and an insoluble reactant: a excess of the reactant is added b the excess reactant is removed c the solution remaining is only salt and water

Introducing the practical

Many students will have carried out this experiment or a similar salt preparation in Key Stage 3. It is important here to emphasise why each step is carried out.

It is important to use a water bath to evaporate some of the water from the copper sulfate solution in this experiment as that is one of the essential practical skills required. The students can use their own water baths by supporting the evaporating basin of copper sulfate solution on top of a beaker half-filled with water, which is heated by a Bunsen burner. You can demonstrate the use of an electric boiling water bath if there is one available.

> Link to GCSE Science 2011: 'Carry out simple neutralisation reactions of acids, using metal oxides, hydroxides and/or carbonates' is a suggested practical in C1 Topic 3.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- What safety precautions should you take when carrying out this experiment and why?
- Why was it necessary to warm the sulfuric acid?
- What colour was the copper sulfate solution that formed?
- Why was it necessary to add copper oxide until it was present in excess?
- How did you know when the copper oxide was present in excess?
- How did you separate the excess copper oxide from the copper sulfate solution?
- What is meant by the filtrate?
- What is meant by the residue?
- What is the filtrate in this experiment?
- What is the residue in this experiment?
- Why is a water bath used to evaporate the water from the copper sulfate solution instead of heating the evaporating basin directly with a Bunsen burner?
- Why should you not evaporate all of the water from the copper sulfate solution?

Skills that are covered in the practical:

- Measuring the volume of sulfuric acid
- Safe use of a Bunsen burner for warming the sulfuric acid
- Safe use of a water bath or electric heater for evaporating some of the water from the copper sulfate solution
- Safe use of filtration to separate unreacted copper oxide from copper sulfate solution
- Safe use of evaporation to evaporate some of the water from the copper sulfate solution
- Safe use and careful handling of sulfuric acid, copper oxide and copper sulfate

Sample question

This example is taken from the sample assessment material, paper 1CH0/1F, Q2. The commentary below outlines how the skills students will have gained by carrying out the practical may be shown in the final exams.

(iii) Some ammonium phosphate solution was made.

Describe how pure, dry crystals of ammonium phosphate are obtained from the ammonium phosphate solution.

(2)

Question number	Answer	Mark
2(c)(iii)	An answer that combines the following points of application of knowledge and understanding to provide a logical description: • first heat the solution/leave water to evaporate (1) • and then filter off/dry crystals formed (1)	**(2)**

This question tests whether students know how to obtain pure, dry crystals of a soluble salt from a solution.

This example is taken from the sample assessment material, paper 1CH0/1H, Q9.

(b) The salt zinc nitrate can be made by reacting zinc oxide, ZnO, with dilute nitric acid, HNO_3.

Write the balanced equation for this reaction.

(2)

....

Question number	Answer	Mark
9(b)	$ZnO + 2HNO_3 \rightarrow Zn(NO_3)_2 + 2H_2O$ • zinc nitrate formula (1) • full, balanced equation (1)	(2)

This question tests whether students can write a balanced equation for a similar reaction to that in the core practical.

This example is taken from the sample assessment material, paper 1CH0/1H, Q9.

*(d) Salts of metals can be made by reacting one of the metal's compounds with the appropriate acid.

Plan an experiment to prepare pure, dry crystals of magnesium sulfate, $MgSO_4$, by reacting a suitable magnesium compound with a suitable acid.

You may use equations if you wish.

(6)

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Question Number	Indicative content
9(d)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **AO2 (3 marks)** • suitable acid: sulfuric acid • suitable substance : magnesium oxide / magnesium carbonate / magnesium hydroxide / magnesium • equation for reaction: $MgO + H_2SO_4 \rightarrow MgSO_4 + H_2O$/ $Mg(OH)_2 + H_2SO_4 \rightarrow MgSO_4 + 2H_2O$/ $MgCO_3 + H_2SO_4 \rightarrow MgSO_4 + H_2O + CO_2$/ $Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$ **AO3 (3 marks)** • add solid to warmed acid until in excess solid remains (oxide and hydroxide) / add solid a little at a time until no more bubbles (carbonate/metal) • filter off the excess solid, pour remaining solution into an evaporating basin • {heat solution / leave the water to evaporate} • until pure salt crystals form and then dry salt crystals with absorbent paper/leave to dry.

This extended writing question tests whether students can plan the preparation of a salt. Although the core practical is based on the preparation of copper sulfate from copper oxide, students should be able to apply their knowledge to the preparation of other similar salts. Magnesium oxide, magnesium carbonate or magnesium hydroxide would be suitable starting materials for this experiment. Students who have carried out the core practical should find questions like this fairly straightforward to do.

Core practical 4: Electrolysis of copper sulfate solution

3.31 Core practical: Investigate the electrolysis of copper sulfate solution with inert electrodes and copper electrodes

Links to the specification content

3.22	Recall that electrolytes are ionic compounds in the molten state or dissolved in water
3.23	Describe electrolysis as a process in which electrical energy, from a direct current supply, decomposes electrolytes
3.24	Explain the movement of ions during electrolysis, in which:
	a positively charged cations migrate to the negatively charged cathode
	b negatively charged anions migrate to the positively charged anode
3.25	Explain the formation of products in the electrolysis, using inert electrodes, of some electrolytes, including:
	a copper chloride solution
	c sodium sulfate solution
3.27	**Write half equations for reactions occurring at the anode and cathode in electrolysis**
3.30	Explain the formation of products in the electrolysis of copper sulfate solution, using copper electrodes, and how this can be used to purify copper

Introducing the practical

This practical is in two sections – the electrolysis of copper sulfate solution with inert (graphite) electrodes and the electrolysis of copper sulfate solution with copper electrodes. You can carry out the practical in one session or two, depending on the length of your lesson.

When inert electrodes are used, the students are just expected to identify and explain the formation of the products. The ability to write half equations for the reactions at the electrodes and classify them as oxidation or reduction will only be tested in the higher tier paper. The experiment with copper electrodes is quantitative and students can measure the mass changes at the electrodes when, for example, the current or the time is varied.

Link to GCSE Science 2011: 'Investigate the mass changes at the electrodes during the electrolysis of copper sulfate solution using copper electrodes' is a core practical in C3 Topic 3.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

Electrolysis of copper sulfate solution using inert electrodes

- What safety precautions should you take when carrying out this experiment and why?
- What did you observe at the anode?
- How do you explain the formation of the product at the anode?

- **Write the half equation for the formation of the product at the anode and explain whether it is oxidation or reduction.**
- What did you observe at the cathode?
- How do you explain the formation of the product at the cathode?
- **Write the half equation for the formation of the product at the cathode and explain whether it is oxidation or reduction.**
- What happens to the colour of the solution during the electrolysis?
- If the electrolysis is continued for a long time, what will be left in the solution?

Electrolysis of copper sulfate solution using copper electrodes

- What safety precautions should you take when carrying out this experiment and why?
- Why is it necessary to clean the copper electrodes with emery paper before using them?
- Why do you use an ammeter in the circuit?
- Why do you use a variable resistor in the circuit?
- Why is it necessary to measure the time taken for the electrolysis?
- Which factors should be kept the same during the electrolysis?
- How do you wash and dry the electrodes at the end of the electrolysis?
- Why is it necessary to dry the electrodes?

Skills that are covered in the practical:

- Measure the mass of the copper electrodes
- Measure time
- Set up an electrical circuit for electrolysis
- Use an electrical circuit to carry out electrolysis
- Safe use and careful handling of copper sulfate solution and propanone (for drying the electrodes)
- Draw a circuit diagram for electrolysis

Maths skills:

- Use numbers in decimal form when calculating mass changes at the electrodes
- Plot graphs of mass changes against time or current
- Understand that $y = mx + c$ represents a linear relationship between the variables
- Translate information between graphical and numeric form, for example, predict the mass change when the current is a given value or vice versa

Sample question

This example is taken from the sample assessment material, paper 1CH0/1F, Q4. The commentary below outlines how the skills students will have gained by carrying out the practical may be shown in the final exams.

(b) Copper sulfate solution was electrolysed for five minutes using copper electrodes.

Figure 5 shows the mass of the anode and of the cathode before electrolysis and after electrolysis.

	anode	**cathode**
mass of electrode before electrolysis / g	1.16	1.28
mass of electrode after electrolysis / g	0.85	1.57

Figure 5

Calculate the mass of copper deposited.

(2)

mass of copper deposited = ... g

Question number	**Answer**	**Additional guidance**	**Mark**
4(b)	• copper is deposited on the cathode, therefore mass deposited = 1.57 – 1.28 (1) • = 0.29 (g) (1)	Award full marks for correct numerical answer without working.	**(2)**

This question tests whether students understand that copper is deposited on the cathode and they can calculate the increase in mass.

This example is taken from the sample assessment material, paper 1CH0/1H, Q6.

(c) When a solution of sodium sulfate, Na_2SO_4, is electrolysed, the products formed at the electrodes are hydrogen and oxygen.

Explain the formation of the products at the electrodes.

(4)

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Question number	Answer	Mark
6(c)	An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (3 marks): • hydrogen (H^+) and sodium (Na^+) ions attracted to cathode, hydroxide (OH^-) ions and sulfate (SO_4^{2-}) ions attracted to anode (1) • because the ions are attracted to the oppositely charged electrode (1) • 2 hydrogen ions/2 H^+ accept 2 e to form hydrogen molecule/H_2 (1) • 4 hydroxide ions/4 OH^- lose 4 e to form oxygen molecule/O_2 (1)	**(4)**

This question tests whether students can explain the formation of products at the electrodes. The formation of oxygen at the anode during the electrolysis of copper sulfate solution using inert electrodes can be explained in the same way as the reaction at the anode during the electrolysis of sodium sulfate.

This example is taken from the sample assessment material, paper 1CH0/1H, Q6.

(d) Copper is purified by the electrolysis of copper sulfate solution using an impure copper anode and a pure copper cathode.

Write the half-equation for the formation of a copper atom from a copper ion.

(2)

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Question number	Answer	Mark
6(d)	$Cu^{2+} + 2e^{-} \rightarrow Cu$ • all species (1) • balancing (1)	**(2)**

Only higher tier candidates are expected to be able to write half equations for the reactions at the electrodes.

Core practical 5: Acid-alkali titration

5.9C Core practical: Carry out an accurate acid-alkali titration, using burette, pipette and a suitable indicator

Links to the specification content

3.3	Recall the effect of acids and alkalis on indicators, including litmus, methyl orange and phenolphthalein
3.13	Describe a neutralisation reaction as a reaction between an acid and a base
3.14	Explain an acid-alkali neutralisation as a reaction in which hydrogen ions (H^+) from the acid react with hydroxide ions (OH^-) from the alkali to form water
3.16	Explain why, if soluble salts are prepared from an acid and a soluble reactant: a titration must be used b the acid and the soluble reactant are then mixed in the correct proportions c the solution remaining, after reaction, is only salt and water
3.18	Describe how to carry out an acid-alkali titration, using burette, pipette and a suitable indicator, to prepare a pure, dry salt
5.10C	**Carry out simple calculations using the results of titrations to calculate an unknown concentration of a solution or an unknown volume of solution required**

Introducing the practical

All students can carry out an acid-alkali titration to determine the exact volume of an acid needed to neutralise a given volume of alkali or vice versa. Students are expected to know the colour changes for methyl orange and phenolphthalein in dilute solutions of strong acids and strong alkalis, however, they are not expected to know which indicator is suitable if a weak acid or alkali is used.

There is then the opportunity to continue the experiment in two different ways. The students who will be taking the foundation tier paper can use the result of the titration to prepare a pure, dry sample of a salt whereas those taking the higher tier paper can calculate the concentration of one of the solutions.

> Link to GCSE Science 2011: 'Carry out an acid-base titration to prepare a salt from a soluble base' was a core practical in C3 Topic 2. 'Carry out titration reactions to find an unknown concentration of an acid or alkali in solution' was a suggested practical in C3 Topic 2.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- What safety precautions should you take when carrying out this experiment and why?
- Why is a burette used to measure the volume of one of the solutions instead of a measuring cylinder?
- Why is it necessary to rinse the burette and pipette with the solutions they will contain before filling them?
- Why is it necessary to use an indicator in the titration?

- What are the colours of methyl orange in acid, neutral and alkaline solutions?
- What are the colours of phenolphthalein in acid, neutral and alkaline solutions?
- Why is universal indicator not suitable to use in a titration?
- Why is a white tile used?
- Why is it important to swirl the conical flask during the titration?
- What is meant by the end point?
- Why do you repeat the titration?
- What are concordant results?
- Which results are included in the calculation when you determine the mean or average titre?

Skills that are covered in the practical:

- Measure volume of solution using a volumetric pipette
- Measure volume of solution using a burette
- Use a suitable indicator to find the end point during an acid-alkali titration
- Make and record observations of colour change during an acid-alkali titration with an indicator
- Safe use and careful handling of acids and alkalis during an acid-alkali titration
- **Determine the concentrations of strong acids and strong alkalis from the results of a titration experiment**

Maths skills:

- Use expressions in decimal form when calculating a mean titre
- Use mole ratio when calculating an unknown concentration
- Give answers to calculations to an appropriate number of significant figures
- Calculate the number of moles of a solute from the volume and concentration of a solution
- Calculate the concentration of a solute from the number of moles and the volume

Sample question

This example is taken from the sample assessment material, paper 1CH0/1F, Q8. The commentary below outlines how the skills students will have gained by carrying out the practical may be shown in the final exams.

8 A titration is to be carried out to find the concentration of a solution of sodium hydroxide.

The sodium hydroxide solution is titrated with dilute sulfuric acid.

The available apparatus includes a burette, a pipette, a funnel, a conical flask and an indicator.

(a) State one safety precaution that must be taken when using sodium hydroxide solution and dilute sulfuric acid.

(1)

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Question number	Answer	Mark
8(a)	any **one** precaution from: • wear gloves to prevent contact with skin/safety (1) • spectacles to prevent contact with eyes (1)	**(1)**

This question tests whether students are aware of appropriate safety precautions to take when performing a titration.

(c) Write the balanced equation for the reaction of dilute sulfuric acid, H_2SO_4, with sodium hydroxide.

(2)

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Question number	Answer	Additional guidance	Mark
8(c)	$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$ • correct formulae (1) • balancing (1)	Do not award 2 if incorrect balancing added.	**(2)**

Students should be able to write balanced equations for common acids and alkalis reacting in titration experiments.

(d) The results of titrations to determine how much of an acid is required to neutralise a given volume of an alkaline solution are shown in Figure 14.

	titration 1	titration 2	titration 3	titration 4
final burette reading (cm^3)	27	27.40	29.20	29.30
initial burette reading (cm^3)	0	2.10	4.00	3.50
volume of acid used (cm^3)	27	25.30	25.20	25.80

Figure 14

Two of the titrations in Figure 14 should **not** be used to calculate the mean volume of acid required.

Identify each titration and give a reason why it should not be used in the calculation of the mean.

(2)

Question number	Answer	Mark
8(d)	• {titration 1/27 cm^3} should not be used because burette readings {not precise/not accurate/not read to 2 d.p.} (1) • {titration 4/25.80 cm^3} should not be used because volume of used (25.80 cm^3) not concordant with other two (1)	**(2)**

Students should understand which titration results should be used in calculating the mean.

*(e) Describe the experimental procedure to carry out a titration to find the exact volume of sulfuric acid needed to neutralise 25.0 cm^3 of sodium hydroxide solution and obtain pure, dry crystals of sodium sulfate.

(6)

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Question number	Indicative content
*8(e)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material that is indicated as relevant. Additional content included in the response must be scientific and relevant. **AO1 (6 marks)** • rinse pipette with alkali and burette with acid • measure alkali using a pipette into suitable container e.g. flask/beaker and place flask on a white tile • add a few drops of indicator/suitable named indicator (eg methyl orange/phenolphthalein) • fill burette with acid and read volume of acid in burette • add acid from burette to the flask slowly swirling the flask until {indicator just changes colour/correct colour change for named indicator (eg methyl orange yellow to peach/orange, phenolphthalein pink to colourless)/solution is neutral} • read volume of acid in burette at end of titration • repeat experiment until concordant results • mix the same volume of alkali with the volume of acid determined from the titration but do not add indicator • pour solution into an evaporating basin then {heat solution/leave the water to evaporate} until pure salt crystals are left • dry crystals using absorbent paper

This extended writing question expects students to give the detailed method of a titration experiment and how to obtain pure, dry crystals of a salt. Students who have carried out this type of experiment themselves will find it much easier to score a high mark.

Core practical 6: Investigating reaction rates

7.1 Core practical: Investigate the effects of changing the conditions of a reaction on the rates of chemical reactions by:

a measuring the production of a gas (in the reaction between hydrochloric acid and marble chips)

b observing a colour change (in the reaction between sodium thiosulfate and hydrochloric acid)

Links to the specification content

7.2	Suggest practical methods for determining the rate of a given reaction
7.3	Explain how reactions occur when particles collide and that rates of reaction are increased when the frequency and/or energy of collisions is increased
7.4	Explain the effects on rates of reaction of changes in temperature, concentration, surface area to volume ratio of a solid and pressure (on reactions involving gases) in terms of frequency and/or energy of collisions between particles
7.5	Interpret graphs of mass, volume or concentration of reactant or product against time

Introducing the practical

There are two investigations to carry out and they are likely to take a lesson each. Students could investigate the effect of changing the concentration of hydrochloric acid or the size of marble chips on the rate of reaction between hydrochloric acid and marble chips. They could investigate the effect of changing the concentration of sodium thiosulfate solution or the temperature on the rate of reaction between sodium thiosulfate and hydrochloric acid.

The volume of gas can be measured by collecting it in an upturned measuring cylinder over water or in a gas syringe. It would be helpful to demonstrate the method that the students do not use so they are familiar with both methods.

Some students are sensitive to the sulfur dioxide produced in the sodium thiosulfate experiment so it is important to have a well-ventilated room and make an appropriate risk assessment.

Students should plot appropriate graphs using their results, for example, volume of gas produced against time. They can then draw a tangent to the curve and calculate the gradient to determine the rate of reaction at a particular time.

Link to GCSE Science 2011: 'Investigate the effect of temperature, concentration and surface area of a solid on the rate of a reaction such as hydrochloric acid and marble chips' was a core practical in C2 Topic 5. 'Investigate the rate of reactions, such as magnesium and hydrochloric acid, or sodium thiosulfate and hydrochloric acid' was a suggested practical in C2 Topic 5.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

Reaction between hydrochloric acid and marble chips

- What is the balanced equation for the reaction?
- What are the state symbols for the reactants and products?
- What is the best practical method to determine the rate of this reaction and why?

- What are two different methods of collecting and measuring the volume of gas produced?
- What is the biggest error in this experiment?
- How could you reduce this error?
- How do you decrease the size of the marble chips?
- What specific safety precaution should you take when decreasing the size of the marble chips?
- How does this affect the surface area of the marble chips?
- What effect does this have on the rate of reaction?
- How can you explain this effect from graphs of volume of gas plotted against time for two different sizes of marble chips?
- How can you calculate the rate of reaction from these graphs?
- What needs to be kept the same when you repeat the first experiment but use different size marble chips?
- How could you decrease the concentration of the hydrochloric acid?
- What effect will decreasing the concentration of hydrochloric acid have on the rate of reaction?
- How do you explain this effect in terms of particles and collisions?

Reaction between sodium thiosulfate and hydrochloric acid

- What is the balanced equation for this reaction?
- What are the state symbols for the reactants and products?
- What is seen when sodium thiosulfate solution reacts with dilute hydrochloric acid?
- What safety precautions should you take in this investigation?
- What is the best practical method to determine the rate of this reaction and why?
- How do you change the temperature of the solutions?
- What happens to the time taken for the reaction to occur as the temperature increases?
- How do you explain this change in terms of the energy of the particles and collisions?

Skills that are covered in the practical:

- Use appropriate apparatus to make and record measurements of mass, volume of solutions, time, temperature and volume of gas
- Safe use of a water bath to investigate the effect of temperature on the rate of a reaction
- Use appropriate apparatus and techniques for monitoring chemical reactions, for example, a gas syringe or collecting gas over water in an upturned measuring cylinder
- Make and record observations and measurements of rate of reaction when a gas is produced or there is a colour change
- Safe use and careful handling of hydrochloric acid, marble chips and sodium thiosulfate solution

Maths skills:

- Use expressions in decimal form when calculating gradients
- Use ratios in balanced equations
- Use an appropriate number of significant figures when calculating rate
- Determine the mean of experimental data
- Compare experimental data to see which has the greater rate
- Plot a graph involving two variables from experimental data
- Draw and use the slope of a tangent to a curve as a measure of rate of reaction
- Translate information between graphical and numeric form

Sample question

This example is taken from the sample assessment material, paper 1CH0/2F, Q5. The commentary below outlines how the skills students will have gained by carrying out the practical may be shown in the final exams.

5 A student used the equipment in Figure 6 to investigate the rate of reaction between zinc and excess dilute hydrochloric acid.

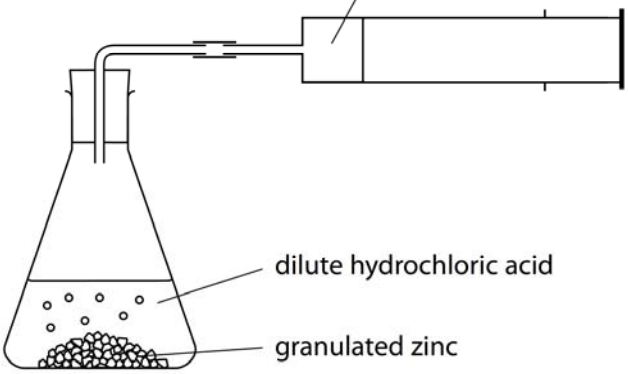


Figure 6

The student uses the following method:

- place a known mass of granulated zinc into the conical flask
- pour 25 cm^3 of dilute hydrochloric acid (an excess) into the conical flask and fit the bung quickly into the neck of the flask
- measure the volume of gas produced every 20 seconds until after the reaction finishes.

Figure 7 shows the results.

time / s	volume of hydrogen / cm^3
0	0
20	42
40	66
60	75
80	80
100	82
120	82
140	82

Figure 7

(a) Give the name of a piece of equipment that can be used to measure 25 cm^3 of dilute hydrochloric acid accurately.

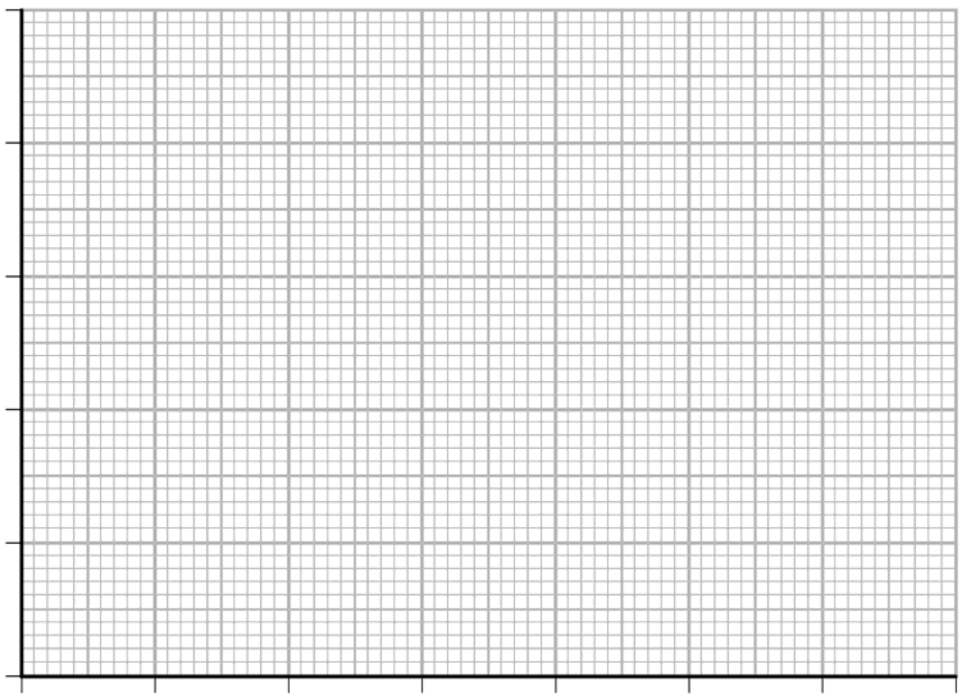
(1)

Question number	Answer	Mark
5(a)	Measuring cylinder/burette/pipette	**(1)**

This question expects students to know that a (25 cm^3) measuring cylinder is suitable for measuring the volume of hydrochloric acid.

(b) Draw a graph of the volume of hydrogen gas produced against time using the grid.

(3)



Question number	Answer	Additional guidance	Mark
5(b)	• axes with linear scale that use more than half of each edge of the grid and labelled with units from the table (1). • all points correctly plotted to ± half a square (1). • single straight line passing through all points and the origin (1).	7 points plotted correctly (i.e. one error) (1) allow ecf from plotting error.	**(3)**

Students should be able to plot a graph of the data provided. They will normally be expected to draw their own axes, select a suitable scale and label the axes, including units, where appropriate. They should plot the points accurately and join them with a best-fit straight line or curve, as appropriate for the data.

(c) The average rate of reaction in the first 20 seconds in cm^3 of hydrogen produced per second is

(1)

☒ **A** 2.1

☒ **B** 8.4

☒ **C** 21

☒ **D** 84

Question number	Answer	Mark
5(c)	A	**(1)**

Students are not expected to draw a tangent and calculate the gradient for this multiple choice question, but they should see from the data that the volume of hydrogen collected in 20 seconds is 42 cm^3 so be able to deduce the average rate of reaction.

(d) The student repeated the experiment keeping all conditions the same but using the same mass of powdered zinc instead of granulated zinc.

On the grid above sketch the graph you would expect when the experiment is repeated using powdered zinc.
Label your line **A**.

(2)

Question number	Answer	Mark
5(d)	Line A on graph: • steeper curve/curve drawn to left of original (1) • levelling off at 82 cm^3 (1)	**(2)**

Students are expected to sketch, with reasonable accuracy, the graph they would expect when one of the conditions is change. They should consider the steepness of the initial part of the curve and where the graph ends.

(e) Sodium thiosulfate solution, $Na_2S_2O_3$, reacts with dilute hydrochloric acid as shown in the equation.

$$Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow 2NaCl(s) + H_2O(l) + S(s) + SO_2(g)$$

The rate of this reaction can be investigated by mixing the reactants and finding the time taken for a precipitate of sulfur to become visible.

A student wants to investigate the effect of changing the temperature on the rate of this reaction.

Devise a method the student could use to find out how the time taken for the precipitate of sulfur to become visible changes with temperature.

(3)

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Question number	**Answer**	**Mark**
5(e)	An answer that combines the following points to provide a method: • suitable method of warming the solutions, e.g. water bath, Bunsen burner with tripod and gauze and measure the temperature of each solution using a thermometer (1) • use the same volumes of the solutions in each experiment (1) • measure the time for the precipitate to form (and obscure a cross placed under the reaction vessel) using a stop watch/clock (1)	**(3)**

Students who have carried out this core practical should score high marks on this question.

Core practical 7: Identifying ions

9.6C Core practical: Identify the ions in unknown salts, using the tests for the specified cations and anions in 9.2C, 9.3C, 9.4C, 9.5C

Links to the specification content

9.2C	Describe flame tests to identify the following ions in solids: a lithium ion, Li^+ (red) b sodium ion, Na^+ (yellow) c potassium ion, K^+ (lilac) d calcium ion, Ca^{2+} (orange-red) e copper ion, Cu^{2+} (blue-green)
9.3C	Describe tests to identify the following ions in solids or solutions as appropriate: a aluminium ion, Al^{3+} b calcium ion, Ca^{2+} c copper ion, Cu^{2+} d iron(II) ion, Fe^{2+} e iron(III) ion, Fe^{3+} f ammonium ion, NH_4^+ using sodium hydroxide solution
9.4C	Describe the chemical test for ammonia
9.5C	Describe tests to identify the following ions in solids or solutions as appropriate: a carbonate ion, CO_3^{2-}, using dilute acid and identifying the carbon dioxide evolved b sulfate ion, SO_4^{2-}, using dilute hydrochloric acid and barium chloride solution c chloride ion, Cl^-, bromide ion, Br^-, iodide ion, I^-, using dilute nitric acid and silver nitrate solution
3.12	Describe the chemical test for b carbon dioxide (using limewater)
9.7C	Identify the ions in unknown salts, using results of the tests above

Introducing the practical

Students could carry out a series of tests with known substances so they become familiar with the technique used for each test and the observation for a positive result. You could then give them some unknown substances and they carry out tests to identify the ions present. All students should be able to combine the symbols of the ions to produce the formula of the unknown compound.

Students taking the higher tier paper can write ionic equations, with state symbols, for the precipitation reactions in the tests.

Link to GCSE Science 2011: 'Identify the ions in unknown salts, using the tests in C3 Topic 1 and C2 Topic 2' was a core practical in C3 Topic 1.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- How do you carry out a flame test?
- A flame test was carried out and a lilac flame was seen. Which ions are present?
- Which ion in solution gives a blue precipitate when sodium hydroxide solution is added?
- Which two ions in solution give the same colour precipitate when sodium hydroxide solution is added to them?
- What further test can be done to distinguish between those two ions?
- What is the test, and its result, for ammonia gas?
- What is the test for a sulfate ion?
- Which ion gives carbon dioxide gas when hydrochloric acid is added to it?
- A yellow precipitate was formed when nitric acid and silver nitrate were added to a solution. Which ion is in the solution?
- Why is nitric acid added to the solution before silver nitrate solution?

Skills that are covered in the practical:

- use appropriate reagents for measuring the pH of solutions
- safe use and careful handling of gases, liquids and solids in unknown substances and reagents used to identify the ions they contain
- use appropriate qualitative reagents and techniques to analyse and identify unknown samples or products including gas tests, flame tests and precipitation reactions

Sample question

This example is taken from the sample assessment material, paper 1CH0/2F, Q10. The commentary below outlines how the skills students will have gained by carrying out the practical may be shown in the final exams.

10 Qualitative tests can be used to identify ions in substances.

(a) Sodium hydroxide solution is warmed with a solution of ammonium ions. Ammonia gas is given off.

Describe the test to show the gas is ammonia.

(2)

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Question number	Answer	Additional guidance	Mark
10(a)	An answer that provides a description by making reference to: • test gas with moist (red) litmus paper (1) • turns blue (1)	Allow universal indicator paper/pH paper (1) and yellow to blue/purple (1).	**(2)**

Students should learn the test for the gases in the specification and should always include the description of the test and the result.

(b) Two tests were carried out on copper sulfate solution.

(i) Sodium hydroxide solution was added to a small amount of copper sulfate solution.
A blue precipitate of copper hydroxide formed.

Complete the word equation for the reaction.
Include state symbols.

(2)

copper sulfate (aq) + sodium hydroxide (aq) → .... (.........) + ... (.........)

Question number	Answer	Additional guidance	Mark
10(b)(i)	(copper sulfate(aq) + sodium hydroxide(aq) →) copper hydroxide(s) + sodium sulfate(aq) • sodium sulfate identified as a product (1) • (sodium sulfate)(aq) **and** copper hydroxide(s) both state symbols matched to the correct product (1)	allow Na_2SO_4 allow copper(II) hydroxide/ $Cu(OH)_2$	**(2)**

(ii) Dilute hydrochloric acid was added to a different sample of copper sulfate solution. Barium chloride solution was then added.

State what would be **seen**.

(1)

....

Question number	Answer	Mark
10(b)(ii)	white precipitate/ppt/solid	**(1)**

Students should be able to write equations for the reactions in the qualitative analysis tests, although ionic equations will only be expected in the higher tier paper. Students should be familiar with all the observations from these tests.

*(c) A technician found some colourless crystals in an unlabelled beaker in a laboratory.

The technician knew that the substance was potassium chloride, potassium carbonate, sodium chloride or sodium iodide.

Plan a series of tests the technician could carry out to identify the colourless crystals.

(6)

Question number	Indicative content
***10(c)**	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **AO3 (6 marks)** Any logical description of tests which result in identification of all four substances. Plans may include: • flame test • description of carrying out a flame test • if the flame is yellow/not lilac, sodium ions present • if the flame is lilac/not yellow, potassium ions present • add dilute {hydrochloric/nitric} acid to the solid • if bubbles of gas form then carbonate ions present • bubble gas through limewater • if limewater turns milky/cloudy, carbon dioxide present • make a solution of the crystals in water • add dilute nitric acid • (if no reaction with acid) add silver nitrate solution • if there is a white precipitate, chloride ions present • if there is a yellow precipitate, iodide ions present. Alternative test for halide ions: • make a solution of the crystals in water • add chlorine water • then cyclohexane • if the cyclohexane/top layer turns purple, iodide ions present.

This extended writing question expects students to be familiar with the tests in the specification and to be able to plan a series of tests to identify unknown substances. Their answer should follow a logical sequence.

Core practical 8: Combustion of alcohols

9.28C Core practical: Investigate the temperature rise produced in a known mass of water by the combustion of the alcohols ethanol, propanol, butanol and pentanol

Links to the specification content

9.26C	Recall the formulae of molecules of the alcohols, methanol, ethanol, propanol (propan-1-ol only) and butanol (butan-1-ol only), and draw the structures of these molecules, showing all covalent bonds
9.27C	Recall that the functional group in alcohols is -OH
9.32C	Recall members of a given homologous series have similar reactions because their molecules contain the same functional group and use this to predict the products of other members of these series

Introducing the practical

Students burn the alcohols in spirit burners and heat water in a beaker or copper can. They can heat the water for a given amount of time and measure the temperature rise of water and the mass of alcohol that was burned.

Students should notice many possible errors in the experiment, including: heat loss to the surroundings, difficulty in having the same height of flame from each spirit burner, incomplete combustion, evaporation of alcohols during weighing.

There is an opportunity for students taking the higher tier to process their experimental data before plotting a graph, for example, they could calculate the temperature rise of water per gram of alcohol burned.

Link to GCSE Science 2011: 'Compare the temperature rise produced when the same volume of water is heated by different fuels' was a core practical in C1 Topic 5.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- What safety precautions should you take in this investigation and why?
- Which variables should be controlled?
- How will you control these variables?
- What measurements will you take?
- What measuring instruments will you use?
- What are the formulae of methanol, ethanol, propanol, butanol and pentanol?
- What are the main errors in this investigation?
- How could you improve the investigation to reduce the errors?
- How is the temperature rise of water related to the number of carbon atoms in the alcohol molecules?

Skills that are covered in the practical:

- Measure mass of alcohol
- Measure volume of water
- Measure temperature rise of water
- Measure time
- Monitor these reactions by measuring the temperature rise of water
- Make and record measurements for these reactions
- Safe use and careful handling of alcohols

Maths skills:

- Use expressions in decimal form when calculating the mass of alcohol burnt
- Use ratios in the formulae of the alcohols
- Use an appropriate number of significant figures in calculations
- Calculate mean values from experimental data
- Construct bar charts or graphs of the experimental results

Sample question

This example is taken from the sample assessment material, paper 1CH0/2F, Q6. The commentary below outlines how the skills students will have gained by carrying out the practical may be shown in the final exams.

(d) The temperature rise in water when liquid fuels burn can be found using the equipment shown in Figure 9.

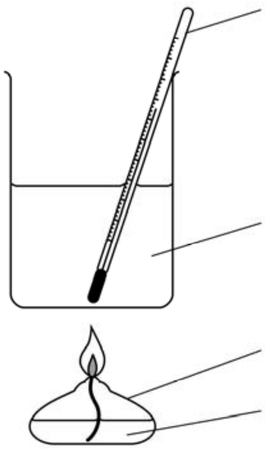

Figure 9

(i) A student compares the temperature rise produced in the water when propanol burns with the temperature rise produced when ethanol burns.

State **two** factors that the student must keep the same in both experiments in order to have a fair comparison.

(2)

1 ....

....

2 ....

....

Question number	Answer	Mark
6(d)(i)	Any two from: • mass/volume of water (1) • height of container above wick (1) • length of wick/height of flame (1) • the container needs to be the same {shape/size/material} (1) • same number of moles of alcohol (1)	**(2)**

Students should be able to identify factors that need to be kept the same in a fair test.

(ii) The results for the two alcohols are shown in Figure 10.

alcohol	mass of alcohol burned / g	temperature rise / °C
ethanol	0.33	20
propanol	0.28	20

Figure 10

Explain, using only the information in Figure 10, why propanol might be the better fuel.

(2)

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....

....

Question number	Answer	Mark
6(d)(ii)	An explanation that combines identification via a judgement (1 mark) to reach a conclusion via justification/reasoning (1 mark): • the same temperature rise is achieved (1) • using a lower mass of alcohol/propanol (1)	**(2)**

Students may be given results to interpret, as in this question.

Physics

There are six core practicals in the physics section of GCSE Combined Science. GCSE Physics covers the same six practicals as well as an additional two, to make up eight core practicals in total.

Core practical descriptions

Note: 5.19P is separate GCSE Physics only.

Core practical		Description
2.19	*Investigate the relationship between force, mass and acceleration by varying the masses added to trolleys*	Different masses must be used to investigate the effect of varying masses on the acceleration of a trolley down a ramp. Appropriate methods must be used to measure the force and time taken for the trolley to travel down the ramp, and data analysis must include calculating the acceleration.
4.17	*Investigate the suitability of equipment to measure the speed, frequency and wavelength of a wave in a solid and a fluid*	This investigation involves looking at the characteristics of waves and using the equation: $v = f \times \lambda$ It is expected that students will have looked at waves in a liquid using a ripple tank, and waves in a solid using a metal rod and a method of measuring the frequency. Suitability of apparatus to take these measurements must also be considered.
5.9	*Investigate refraction in rectangular glass blocks in terms of the interaction of electromagnetic waves with matter*	A light source with grating must be used to produce a beam of light, which must then be used to investigate the effect of refraction using a glass block. An appreciation of the interaction of the light ray with the glass block and the effect of changing medium on the light ray (moving towards and away from the normal) must be included.
5.19P	*Investigate how the nature of a surface affects the amount of thermal energy radiated or absorbed*	A minimum of four different beakers or test tubes must be covered in different materials (different colours, or shiny/dull surfaces). The same volume of hot water must then be poured into each container, and covered with a lid. Using a thermometer the temperature can be monitored and recorded at fixed times using a stopwatch.

10.17	*Construct electrical circuits to:* *a investigate the relationship between potential difference, current and resistance for a resistor and a filament lamp* *b test series and parallel circuits using resistors and filament lamps*	This investigation involves constructing a circuit to investigate potential difference, current and resistance for a resistor and a filament lamp. The behaviour of parallel and series circuits must also be included, and this must be done using filament lamps. A series circuit should be set up initially with a resistor, ammeter and voltmeter. The current must be recorded at different voltages. This must then be repeated using a filament lamp instead of a resistor. To investigate series and parallel circuits, a parallel circuit must be set up with ammeters, voltmeters, and filament lamps. Readings from this circuit must then be compared with series circuits used initially. Analysis must include use of the equation $V = I \times R$
14.3	*Investigate the densities of solid and liquids*	The density of a solid object must be determined by measuring the mass and volume of the object, and then using the equation: $\rho = \frac{m}{v}$ The volume must be determined by putting the object into water, and measuring the volume of water that has been displaced. The density of a liquid can be calculated by weighing the liquid using a balance, and determining the volume. The equation: $\rho = \frac{m}{v}$ must then be used to calculate the density.
14.11	*Investigate the properties of water by determining the specific heat capacity of water and obtaining a temperature-time graph for melting ice*	The temperature of crushed ice must be recorded using a thermometer. This must then be melted using a Bunsen burner and beaker of water as a water bath. The temperature must be monitored as the ice melts. To determine specific heat capacity of water, the temperature of water using a thermometer must be monitored while heating it using a heat supply connected to a joulemeter. This must then be used to calculate the specific heat capacity.
15.6	*Investigate the extension and work done when applying forces to a spring*	The stretching of a spring must be investigated by measuring the length of a spring with no weights, followed by adding varying masses and measuring the new length. This must include calculating the work done and an appreciation of the forces involved.

Core practical 1: Investigating force, mass and acceleration

2.19 Core practical: *Investigate the relationship between force, mass and acceleration by varying the masses added to trolleys*

Links to the specification content

2.8	Recall and use the equation: acceleration (metre per second squared, m/s^2) = change in velocity (metre per second, m/s) ÷ time taken (second, s) $a = \frac{(v-u)}{t}$
2.11	Describe a range of laboratory methods for determining the speeds of objects such as the use of light gates
2.15	Recall and use Newton’s second law as: force (newton, N) = mass (kilogram, kg) × acceleration (metre per second squared, m/s^2) $F = m \times a$
2.22	**Explain that inertial mass is a measure of how difficult it is to change the velocity of an object (including from rest) and know that it is defined as the ratio of force over acceleration**

Introducing the practical

This practical can be done in one session. Students should already be familiar with the use of light gates and dataloggers for measuring times and velocity. Dataloggers can be set to measure acceleration directly but calculating acceleration from velocity and time measurements can lead to a deeper understanding of the concepts involved. The practical can be adapted to the situation where dataloggers are not available.

Link to GCSE Science 2011: ‘Investigate the relationship between force, mass and acceleration’ is a practical embedded in the specification, Unit P2, Topic 3, 3.15.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- Why is one end of the ramp propped up?
- How would you calculate the force pulling the trolley?
- Why do you use the same force pulling the trolley each time?
- Why do you need two light gates?
- What effect does the mass on the end of the string have on the total mass in the table of results?
- What are the main errors involved in this procedure?
- How can you improve the procedure?
- This practical investigates the relationship between mass and acceleration. How could you use the same equipment to investigate the relationship between force and acceleration?

Skills that are covered in the practical:

- Using a digital balance to measure the mass of the trolley
- Using light gates

- Using data logging software to measure velocity and time
- Recording measurements systematically in a complex table

Maths skills

- Substituting measured values into the equation for acceleration
- Plotting a graph of acceleration against mass
- Drawing a smooth curve
- Interpreting a graph showing an inverse relationship
- Extending this to plot a graph of acceleration against 1/mass to produce a straight line
- Interpreting the straight line graph

Sample question

This example is taken from the sample assessment material, paper 1PH0/1H, Q7, part (a) Although this is not about core practical 1 directly, the commentary below outlines how the skills students will have gained by carrying out the practical may be shown in the final exams.

7 A student investigates how the average speed of the trolley varies with starting height.

Figure 9 shows the trolley and runway.

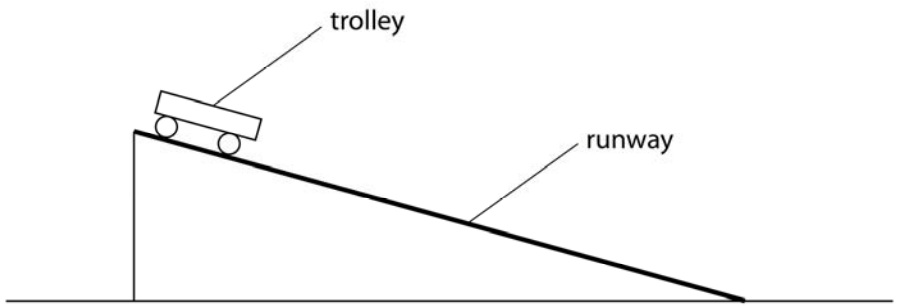

Figure 9

(a) Describe how the student can determine the average speed of the trolley.

(4)

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Question number	Answer	Additional guidance	Mark
7(a)	An answer that combines the following points of understanding to provide a logical description: • measurement of time between(or at) two positions using suitable timing equipment (1) • measurement of suitable distance along the runway with metre rule (1) • measurement of vertical height to starting position (1) • repeats AND averages AND use of a correct equation (1)	allow stopwatch, light gates minimum is 0.5 m metal tape measure average speed = distance/time OR average speed = (speed at A – speed at B)/2	**(4)**

Part (a) requires students to demonstrate knowledge and understanding of scientific ideas and procedures related to this particular practical. They will have carried out a practical similar to this, using a similar method, but varied the mass of the trolley. This practical varies the height, but the principle is the same. Therefore students should be able to use their understanding of the core practical they have carried out to outline how the practical should be carried out.

Core practical 2: Measuring waves in solids and liquids

4.17 Core practical: Investigate the suitability of equipment to measure the speed, frequency and wavelength of a wave in a solid and a fluid

Links to the specification content

4.3	Define and use the terms frequency and wavelength as applied to waves
4.4	Use the terms amplitude, period, wave velocity and wavefront as applied to waves
4.6	Recall and use both the equations below for all waves: wave speed (metre/second, m/s) = frequency (hertz, Hz) × wavelength (metre, m) $v = f \times \lambda$ wave speed (metre/second, m/s) = distance (metre, m) ÷ time (second, s) $v = \frac{x}{t}$
4.7	Describe how to measure the velocity of sound in air and ripples on water surfaces

Introducing the practical

The emphasis in this practical should be on the different methods needed to measure these quantities for the different waves. For water waves, the speed, frequency and wavelength can all be measured separately, but the speed of sound in a solid is too fast to be measured by simply measuring distance and time. Here, the speed is calculated using the measurements made of frequency and wavelength.

Link to GCSE Science 2011: 'Use the terms frequency, wavelength, amplitude and speed to describe waves' and 'Use the equations $v = f \times \lambda$ and $v = x/t$' appear in Unit 1 Topic 1, 1.13 and 1.15.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- Waves can be transverse or longitudinal. What type of wave is
  (a) a water wave on the surface of the water in a ripple tank?
  (b) a sound wave in a metal rod?
- How would you measure the speed of sound in air?
- How would you measure the speed of water waves in a ripple tank?
- Why can you not measure the speed of sound waves in a metal rod in the same way?
- Is it possible to measure the speed of light?

Skills that are covered in the practical:

- Adjusting the components of a ripple tank to give parallel water waves of measurable wavelength
- Measuring the wavelength of a water wave in a ripple tank
- Measuring the speed of a wavefront (wave crest)

Maths skills:

- Substituting measured values into the equation relating speed, distance and time

- Substituting measured values into the equation relating speed, wavelength and frequency
- Changing the subject of an equation

Sample question

This example is taken from the sample assessment material, paper 1PH0/1H, Q1, parts (a) and b(i) and (ii). It is directly related to core practical 2. The commentary below outlines how the skills students will have gained by carrying out the practical may be shown in the final exams.

1 There are many different types of waves.

(a) Waves on the surface of water are transverse waves.

Sound waves are longitudinal waves.

Describe the difference between transverse waves and longitudinal waves.

(2)

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Question number	Answer	Mark
1(a)	An answer that provides a description by making reference to: • transverse waves have oscillations perpendicular to direction of travel of the wave (1) • whereas longitudinal waves have oscillations in the same direction as the direction of travel of the wave (1)	**(2)**

Part (a) requires students to demonstrate knowledge and understanding of scientific ideas related to core practical 2.

(b) Figure 1 shows a ripple tank.

This is used to study the behaviour of water waves.

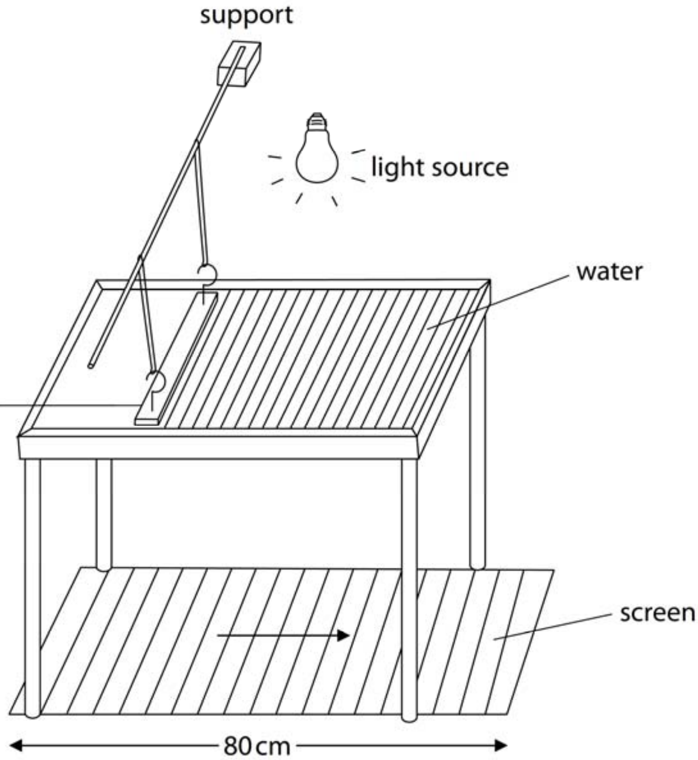

Figure 1

Water waves are produced in the tank.

The shadow of the waves is projected onto the screen below the tank.

The waves appear to move in the direction of the arrow.

(i) Describe how to determine the frequency of the waves.

(2)

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Question number	**Answer**	**Mark**
1(b)(i)	An answer that combines the following points of understanding to provide a logical description: • take time T for waves to pass a fixed point (1) • and frequency = $\frac{\text{number of waves}}{\text{time taken}}$ (1)	**(2)**

(ii) The screen is 80 cm long.

What is the approximate wavelength of the waves as seen on the screen?

(1)

- ☒ **A** 4 cm
- ☒ **B** 8 cm
- ☒ **C** 40 cm
- ☒ **D** 80 cm

Question number	Answer	Mark
1(b)(ii)	A	**(1)**

Parts (b)(i) and (ii) require students to demonstrate knowledge and understanding of scientific techniques and procedures related to core practical 2.

Core practical 3: Investigating refraction

5.9 Core practical: Investigate refraction in rectangular glass blocks in terms of the interaction of electromagnetic waves with matter

Links to the specification content

4.9P	Describe the effects of a reflection b refraction c transmission d absorption of waves at material interfaces
4.10	Explain how waves will be refracted at a boundary in terms of the change of direction **and speed**
5.1P	Explain, with the aid of ray diagrams, reflection, refraction and total internal reflection (TIR), including the law of reflection and critical angle

Introducing the practical

This practical investigates the effect of changing medium on the path of a wave by looking at a light ray entering a glass (or clear plastic) block and tracing the ray as it passes through. Although the relationship between the angle of incidence and the angle of refraction can be treated graphically, recall of Snell's law or refractive index is not required.

Link to GCSE Science 2011: Unit P1, Topic 1, 1.10 'Recall that waves are reflected and refracted at boundaries between different materials'; 1.11 **'explain how waves will be refracted at a boundary in terms of the change of speed and direction'** Unit P3 Topic 1, 1.15 'Explain, with the aid of ray diagrams, reflection, refraction and total internal reflection (TIR), including the law of reflection and critical angle'.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- Why does a swimming pool appear to be less deep than it actually is?
- What do lenses do to light?
- What causes mirages?
- How can you produce a ray of light on a sheet of paper?

Skills that are covered in the practical:

- Producing and tracing rays (thin beams) of light using a ray box and a single slit.
- Accurate measurement of angles using a protractor
- Systematic recording of measurements

Maths skills:

- Graph plotting

Sample question

This example is taken from the sample assessment material, paper 1PH0/1F, Q4, part (a). Although this is not about core practical 3 directly, the commentary below outlines how the skills students will have gained by carrying out the practical may be shown in the final exams.

4 A student investigates how light behaves as it leaves a clear plastic block.

Figure 4 shows some of her equipment and the path of a ray of light through the block.

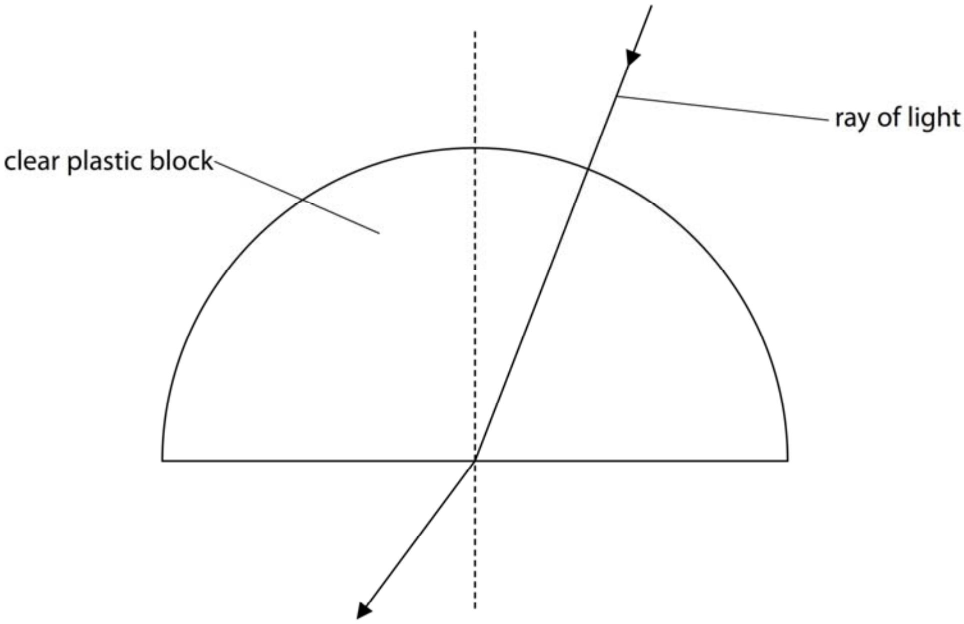

Figure 4

(a) Describe how the student can make sure the light does not change direction as it enters the block.

(2)

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Question number	Answer	Additional guidance	Mark
4(a)	An answer that combines the following points of understanding to provide a logical description: • shine the light along a radius (1) • by marking it on the paper before putting the block down (1)	allow shine the ray at the centre of the straight edge before putting the block down	**(2)**

Part (a) requires students to demonstrate knowledge and understanding of scientific techniques and procedures similar to those used in core practical 2.

Core practical 4: Investigating thermal energy

5.19P Core practical: Investigate how the nature of a surface affects the amount of thermal energy radiated or absorbed

Links to the specification content

5.15P	Explain that all bodies emit radiation, that the intensity and wavelength distribution of any emission depends on their temperature
5.16P	**Explain that for a body to be at a constant temperature it needs to radiate the same average power that it absorbs**

Introducing the practical

This investigation is a good opportunity to demonstrate the need for controlling variables. In this case, the only difference between vessels used as radiators (or absorbers) should be the nature of the surfaces concerned. All other factors should be the same. It also provides an opportunity to use dataloggers and temperature sensors, producing real-time graphs.

Link to GCSE Science 2011: Unit P1, Topic 6, 6.6 'Demonstrate an understanding that for a system to be at a constant temperature it needs to radiate the same average power that it absorbs.'; 6.7 'Investigate how the nature of a surface affects the amount of thermal energy radiated or absorbed'.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- Why are buildings in hot countries often painted white?
- Why are the surfaces of solar water heaters often painted black?
- To test the effect of the nature of the surface for several absorbers or radiators, what other factors do you have to control?

Skills that are covered in the practical:

- Controlling variables
- Measuring temperature
- Systematic recording of measurements

Maths skills:

- Plotting temperature-time graphs.

Sample question

This example is taken from the sample assessment material, paper 1PH0/1F, Q6, part (a). Although this is not about core practical 4 directly, the commentary below outlines how the knowledge and understanding students will have gained by carrying out the practical may be shown in the final exams.

6 (a) A student investigates how the surface of an object affects the radiation it emits.

Figure 7 shows the equipment he uses.

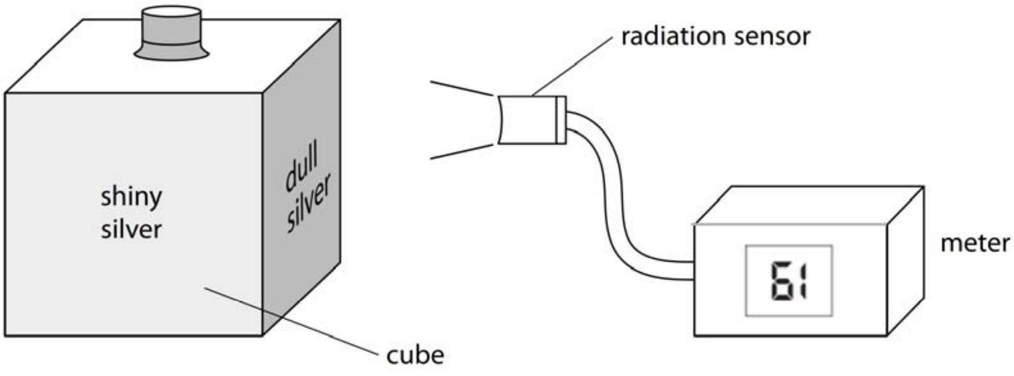


Figure 7

The cube has four different surfaces.

He fills the cube with boiling water so that the temperature of each surface is the same.

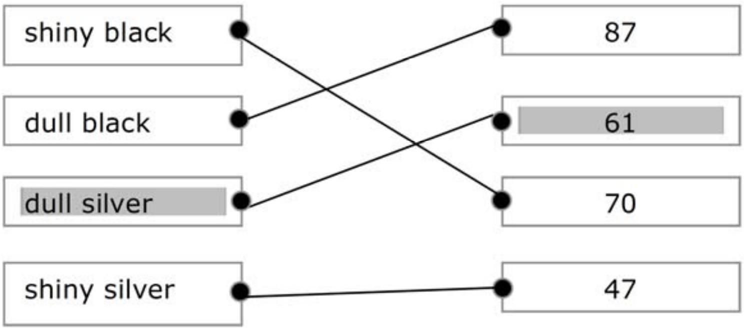
He uses the radiation sensor to measure the radiation emitted from each surface.

(i) His readings are shown.

Draw a line from each surface colour to its correct meter reading.
One has been done for you.

(2)

surface colour	meter reading
shiny black	87
dull black	61
dull silver	70
shiny silver	47

Question number	Answer	Mark
6(a)(i)	All three correct (2) One or two correct (1) 	**(2)**

(ii) The temperature of each surface is the same.

Give a reason why the radiation sensor gives a different reading for each surface.

(1)

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....

Question number	Answer	Additional guidance	Mark
6(a)(ii)	Different surfaces emit (thermal) radiation at different rates	allow reference to surfaces in question	**(1)**

Parts (a)(i) and (ii) require students to apply their knowledge and understanding of scientific ideas gained from core practical in this new situation.

Core practical 5: Investigating resistance

10.17 Core practical: Construct electrical circuits to:

a *investigate the relationship between potential difference, current and resistance for a resistor and a filament lamp*

b *test series and parallel circuits using resistors and filament lamps*

Links to the specification content

10.2	Draw and use electric circuit diagrams representing them with the conventions of positive and negative terminals, and the symbols that represent cells, including batteries, switches, voltmeters, ammeters, resistors, variable resistors, lamps, motors, diodes, thermistors, LDRs and LEDs
10.3	Describe the differences between series and parallel circuits
10.4	Recall that a voltmeter is connected in parallel with a component to measure the potential difference (voltage), in volt, across it
10.7	Recall that an ammeter is connected in series with a component to measure the current, in amp, in the component
10.11	Recall that current is conserved at a junction in a circuit
10.13	Recall and use the equation: potential difference (volt, V) = current (ampere, A) × resistance (ohm, Ω) $V = I \times R$
10.14	Explain why, if two resistors are in series, the net resistance is increased, whereas with two in parallel the net resistance is decreased
10.15	Calculate the currents, potential differences and resistances in series circuits
10.16	Explain the design and construction of series circuits for testing and measuring
10.18	Explain how current varies with potential difference for the following devices and how this relates to resistance a filament lamps c fixed resistors
10.21	Explain how the design and use of circuits can be used to explore the variation of resistance in the following devices a filament lamps

Introducing the practical

These investigations build on Key Stage 3 work on circuits. The work is more quantitative and will give students direct experience as they develop their understanding of difficult concepts such as potential difference

Link to GCSE Science 2011: 'Controlling and using electric current' is Unit P2 topic P2.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- What are the circuit symbols for the following components?
  battery, switch, resistor, variable resistor, filament lamp, ammeter, voltmeter
- How is an ammeter connected into a circuit?
- How is a voltmeter connected into circuit?
- How could you vary the current and potential difference in a circuit?

Skills that are covered in the practical:

- Constructing electrical circuits
- Varying the current and potential difference in an electrical circuit
- Reading ammeters and voltmeters

Maths skills:

- Substituting measured values into the equation relating potential difference, current and resistance
- Changing the subject of an equation
- Plotting graphs of current against potential difference
- Drawing best fit straight lines
- Drawing smooth curves
- Interpreting graphs (straight lines and curves)

Sample question

This example is taken from the sample assessment material, paper 1PH0/2H, Q3. It is not directly related to core practical 5 as it tests a thermistor, but the circuit used is similar. The commentary below outlines how the skills students will have gained by carrying out core practical 5 may be shown in the final exams.

3 A student investigates how the resistance of a thermistor varies with temperature.

(a) The student sets up the circuit shown in Figure 5 to measure current and voltage.

He finds that it does not work.

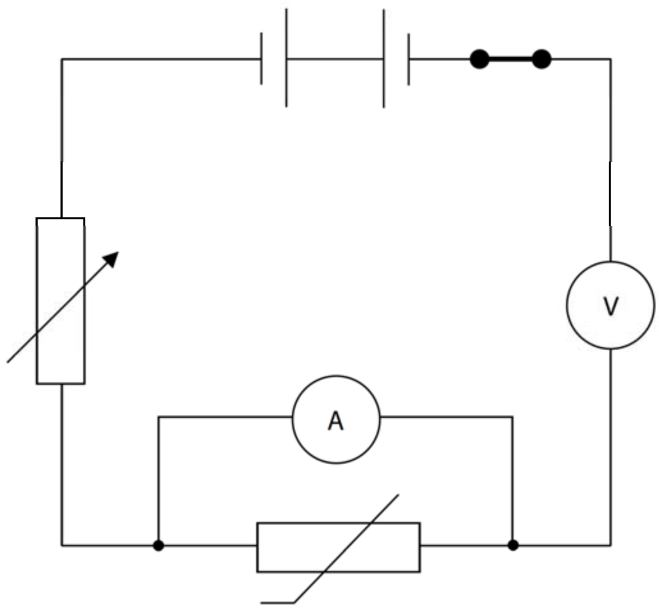

Figure 5

Give **three** modifications the student should make to the circuit so that the circuit works correctly.

(3)

1 ....

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2 ....

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3 ....

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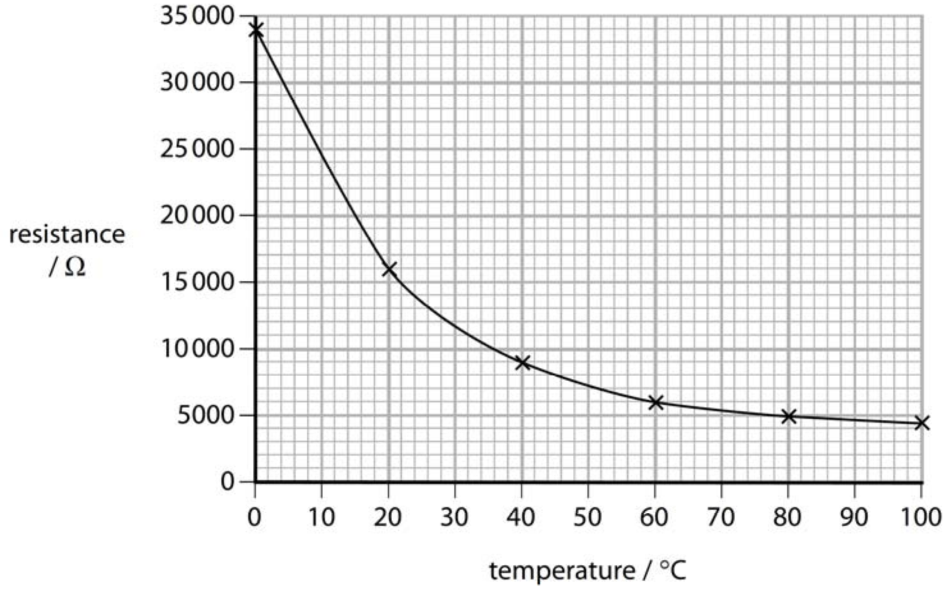
Question number	Answer	Additional guidance	Mark
3(a)	• connect ammeter in series (with thermistor) (1) • connect voltmeter in parallel (with thermistor) (1) • reverse (connections for) one of the cells (1)	allow idea that meters should be swapped for two marks (equivalent to first two points)	**(3)**

Part (a) requires students to demonstrate knowledge and understanding of scientific techniques and procedures to do with constructing circuits that they will have used in core practical 5.

(c) The student takes measurements for two other components, **A** and **B**.

The results for both these components are shown in Figure 7.

Component A



Component B

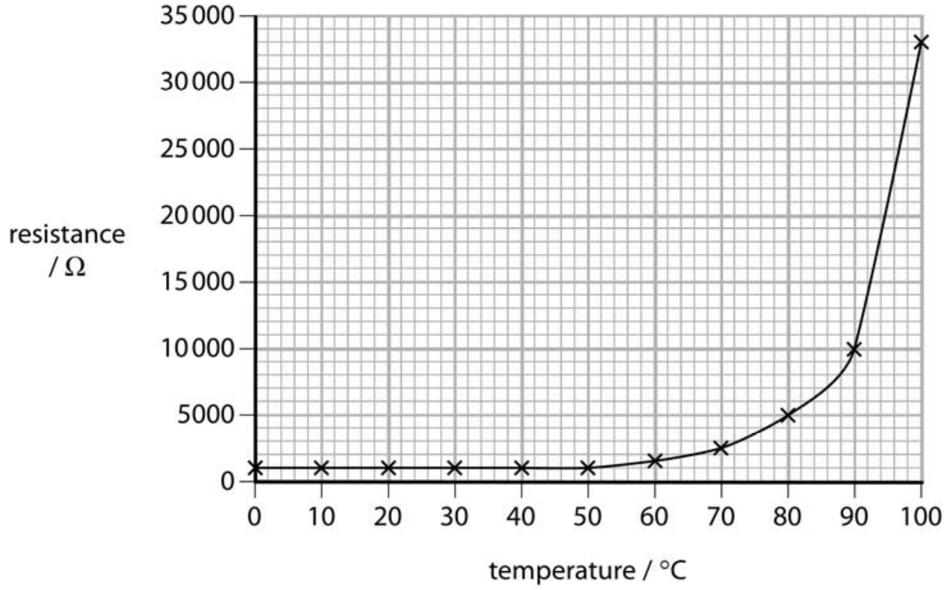


Figure 7

(i) Compare and contrast how the resistances of component **A** and component **B** vary with temperature.

(3)

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....

Question number	Answer	Additional guidance	Mark
3(c)(i)	A comparison and contrast that must include at least **one** similarity and **one** difference from the following points to a maximum of three marks: Similarities • resistance of both changes with temperature (1) • both graphs show a non-linear relationship (1) • data comparison, e.g. both have the same resistance at 80°C (1)		**(3)**

Part (c)(i) requires students to analyse, interpret and evaluate information from the graphs to compare the two components.

Core practical 6: Investigating densities

14.3 Core practical: Investigate the densities of solid and liquids

Links to the specification content

14.2	Recall and use the equation: density (kilogram per cubic metre, kg/m^3) = mass (kilogram, kg) ÷ volume (cubic metre, m^3) $\rho = \frac{m}{V}$
14.4	Explain the differences in density between the different states of matter in terms of the arrangements of the atoms or molecules

Introducing the practical

These are straightforward investigations that provide a starting point for more complex work on pressure and upthrust in fluids. They also present opportunities to practice using balances and measuring cylinders.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- Think of examples of heavy objects that float on water.
- Think of some light objects that sink in water.
- Is the mass of an object the only factor that determines whether or not it will float on water?

Skills that are covered in the practical:

- Using a balance
- Using a measuring cylinder
- Using a displacement can

Maths skills:

- Substituting measured values into the equation relating density, mass and volume
- Changing the subject of an equation
- Calculating volume
- Changing units between kg/m^3 and g/cm^3

Sample question

This example is taken from the first question in a foundation tier paper in the sample assessment material, paper 1PH0/2F,, Q1 which reflects the straightforward nature of the core practical.

(b) A student investigates the density of a copper block and the density of a small stone, as shown in Figure 2.

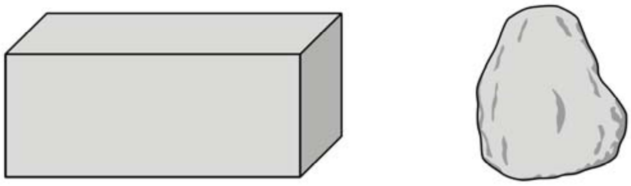

Figure 2

(i) The student calculates the volume of the block as 13 cm^3.

She finds that the mass of the block is 100 g.

Calculate the density of the block.

Use the equation

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

(2)

density = ... g/cm^3

Question number	Answer	Additional guidance	Mark
1(b)(i)	substitution (1) 100 ÷ 13 answer (1) 7.7 (g/cm^3)	award full marks for correct numerical answer without working allow 7.692 (g/cm^3)	**(2)**

Part (b)(i) requires students to apply their knowledge and understanding of scientific ideas by calculating density from given data and the equation as they will have done in core practical 6. It is worth noting that, further on in a paper, candidates could have been asked to <u>recall</u> and use the equation.

(ii) The student found the volume of the copper block by multiplying the area of its base by its height.

The small stone does not have straight sides.

Describe how the student could measure the volume of the small stone. You may use a diagram if it helps your answer.

(3)

Question number	Answer	Additional guidance	Mark
1(b)(ii)	An answer that provides a description by making reference to: • part fill a measuring cylinder with water and record the starting volume (1) • completely immerse the stone in the water and record the final volume of water and stone (1) • volume of stone = final volume – initial volume (1)	accept valid alternative methods, e.g. fill a displacement can until some water overflows/flows out of spout completely immerse the stone in the displacement can and collect the displaced water in a measuring cylinder volume of water displaced = volume of stone	**(3)**

Parts (b)(ii) require students to demonstrate knowledge and understanding of scientific techniques and procedures related directly to core practical 6.

Core practical 7: Investigating water

14.11 Core practical: Investigate the properties of water by determining the specific heat capacity of water and obtaining a temperature-time graph for melting ice

Links to the specification content

14.5	Describe that when substances melt, freeze, evaporate, boil, condense or sublimate mass is conserved and that these physical changes differ from some chemical changes because the material recovers its original properties if the change is reversed
14.6	Explain how heating a system will change the energy stored within the system and raise its temperature or produce changes of state
14.7	Define the terms specific heat capacity and specific latent heat and explain the differences between them
14.8	Use the equation: change in thermal energy (joule, J) = mass (kilogram, kg) × specific heat capacity (joule per kilogram degree Celsius, J/kg °C) × change in temperature (degree Celsius, °C) $\Delta Q = m \times c \times \Delta\theta$
14.9	Use the equation: thermal energy for a change of state (joule , J) = mass (kilogram, kg) × specific latent heat (joule per kilogram, J/kg) $Q = m \times L$
14.10	Explain ways of reducing unwanted energy transfer through thermal insulation

Introducing the practical

This material was not in the Science 2011 specification but has been in previous specifications. If a joulemeter is not available, a voltmeter, ammeter and stopwatch can be used to measure the energy supplied in the specific heat capacity investigation. The investigation could be extended by doing it first without insulation and then with insulation to support work on specification point 14.10.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- What two things might happen to water if you heat it?
- How would you measure the temperature of ice?
- What happens to the temperature of ice when it is melting?
- What quantities will you need to measure before you can calculate specific heat capacity?
- If you heat water in a beaker, some of the thermal energy supplied is lost to the surroundings. How can you reduce this energy loss?

Skills that are covered in the practical:

- Using a Bunsen burner and a water bath to melt ice
- Reading a thermometer
- Positioning a thermometer to get an accurate reading
- Reading a thermometer at regular time intervals and recording the readings systematically
- Using a balance

Maths skills:

- Substituting measured values into the equation relating change in thermal energy, mass, specific heat capacity and change in temperature
- Changing the subject of an equation
- Plotting a temperature-time graph for melting ice
- Drawing an unfamiliar curve
- Interpreting a temperature-time graph for melting ice

Sample question

These examples are taken from the sample assessment material, paper 1PH0/2F, Q3(b) and question 8(c). Although 3(b) is a slight variation on core practical 7, the commentary below the question outlines how the skills students will have gained by carrying out the practical may be shown in the final exams. 8(c) is an example of an extended open response (6 mark) question directly related to core practical 7.

3 An electric heater is used to heat some water.

Figure 8 shows the experimental setup used.

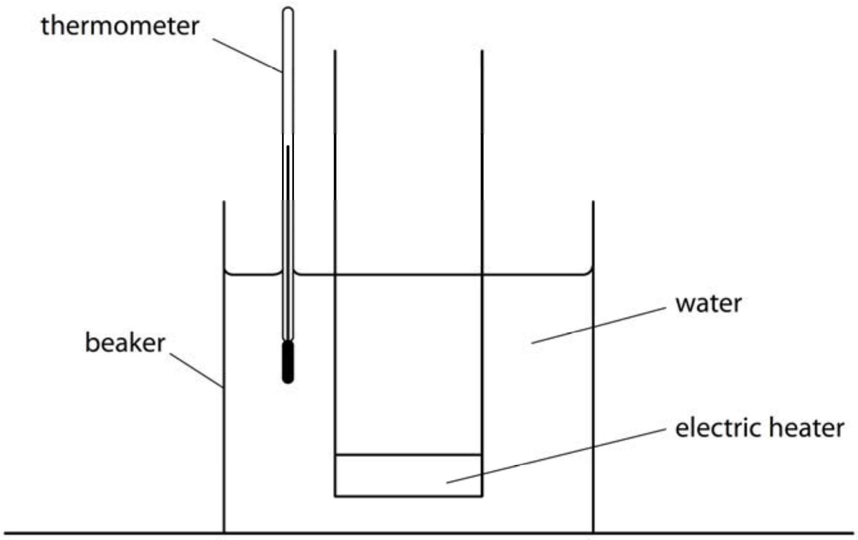

Figure 8

(b) Explain **one** way the experiment can be improved to reduce the amount of wasted energy.

(2)

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Question number	Answer	Additional guidance	Mark
3(b)	An explanation that combines identification – improvement of the experimental procedure (1 mark) and justification/reasoning which must be linked to the improvement (1 mark): • place the beaker on an insulator (1) • so this (material) will reduce rate of energy transfer (1) or • wrap the beaker in an insulator (1) • so this (material) will reduce the rate of energy transfer (1) or • reduce the surface areas of the water (1) • to give less evaporation (1)	allow named insulator, e.g. cork mat put a lid on the beaker/make the beaker taller and narrower	**(2)**

3(b) requires students to analyse information and ideas to improve experimental procedures.

*(c) Describe how the student should carry out an experiment to determine the specific heat capacity of water.

(6)

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Question number	Indicative content	Mark
*8(c)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **AO1 (6 marks)** • Use of top pan balance to measure mass • Insulate beaker to reduce heat loss • Ammeter connected in series with heater • Voltmeter connected in parallel with heater • Use of $E = I \times V \times t$ to determine energy supplied to the water • Accept use of joule-meter to measure energy supplied • Use of $\Delta E = m \times c \times \Delta\theta$ to determine the specific heat capacity of the water • Measure p.d. across heater • Use stopwatch to measure time liquid is heating • Measure current in heater • Determine mass of water as mass of (beaker and water) – mass of beaker • Measure temperature before and after heating	**(6)**

8(c) requires students to demonstrate their understanding of scientific techniques and procedures.

Core practical 8: Investigating springs

15.6 Core practical: Investigate the extension and work done when applying forces to a spring

Links to the specification content

15.1	Explain, using springs and other elastic objects, that stretching, bending or compressing an object requires more than one force
15.2	Describe the difference between elastic and inelastic distortion
15.3	Recall and use the equation for linear elastic distortion including calculating the spring constant: force exerted on a spring (newton, N) = spring constant (newton per metre, N/m) × extension (metre, m) $F = k \times x$
15.4	Use the equation to calculate the work done in stretching a spring: energy transferred in stretching (joules, J) = 0.5 × spring constant (newton per metre, N/m) × (extension (metre, m))^2 $E = \frac{1}{2} \times k \times x^2$
15.5	Describe the difference between linear and non-linear relationships between force and extension

Introducing the practical

These practicals build on Key Stage 3 work. The work did not appear in the Science 2011 Specification.

Questions you could ask to enhance learning and focus your students on important aspects of the practical:

- Why is it difficult to measure the unstretched length of a spring?
- How would you measure the extension of a spring?
- What do the words 'elastic' and 'inelastic' mean when used in connection with stretching materials?
- In what circumstances can you use the equation $F = k \times x$ when stretching materials?
- Think of some examples where the energy stored in stretched spring might be used.

Skills that are covered in the practical:

- Setting up a safe system for stretching materials
- Measuring the length of unstretched materials
- Using reference points when measuring extensions

Maths skills:

- Substituting measured values into the equation relating force exerted on a spring, spring constant and extension
- Substituting measured values into the equation relating work done in stretching a spring, spring constant and extension
- Changing the subject of an equation
- Plotting force-extension graphs
- Relating work done in stretching a spring to the area under the line for a force-extension graph

Sample question

This example is taken from the sample assessment material, paper 1PH0/2H, Q5 (b)(ii) and (c). 5(b)(ii) relates directly to the core practical and (c) is an extension of this, The commentaries below the questions outline how the skills students will have gained by carrying out the practical may be shown in the final exams.

(b) The student investigates the stretching of a spring with the equipment shown in Figure 22.

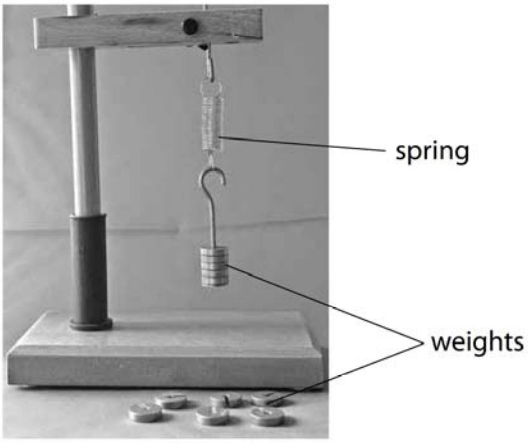

Figure 22

The student investigates the extension of the spring using six different weights.

The results are shown in Figure 23.

weight (N)	extension (mm)
0.20	4.0
0.40	8.0
0.60	12.0
0.80	16.0
1.00	20.0
1.20	24.0

Figure 23

(ii) The student writes this conclusion:

'The extension of the spring is directly proportional to the weight stretching the spring.'

Comment on the student's conclusion.

(3)

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Question number	Answer	Additional guidance	Mark
5(b)(ii)	A comment that makes reference to the following points: (using table) • idea that equal increments of force/weight/mass cause equal increments of extension (1) • correct reference to figures in the table (1) OR (using graph) • the graph line is straight (1) • the graph line passes through the origin (1) AND therefore the student's conclusion is correct (1)	last marking point can only be achieved if at least one of the other two marks is awarded	**(3)**

5(b)(ii) requires students to analyse information and ideas to make judgements and draw conclusions. They will have done this with their own graphs in the core practical.

(c) The student extends the investigation by finding information about the stretching of wires.

The student finds the graph shown in Figure 24 for the stretching of a wire.

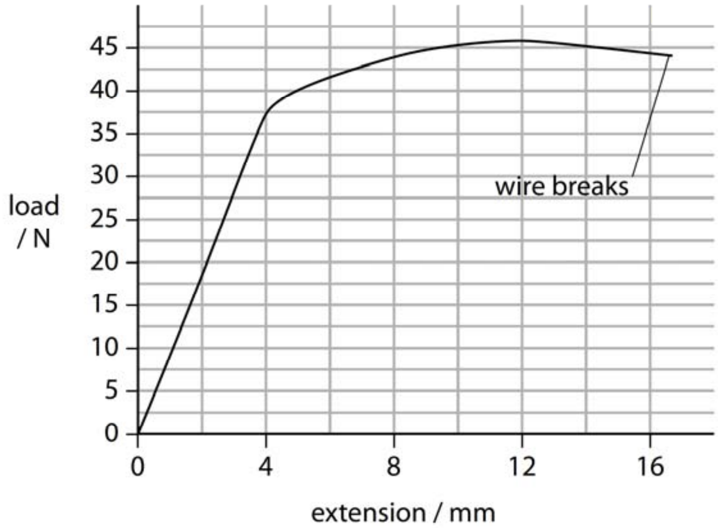

Figure 24

Describe the non-linear stretching of the wire shown in Figure 24.

(3)

Question number	Answer	Additional guidance	Mark
5(c)	An answer that combines points of interpretation/evaluation to provide a logical description: • above 37.5 N/4 mm there are large increases of extension for small increases in load (1) • the maximum extension of the wire is about 16.5 mm before it breaks (1) • above 12 mm the wire keeps on extending when the load is reduced below 46 N (1)	accept extension is (much) greater for each 1 N increase in load above 37.5 N	**(3)**

5(b)(ii) requires students to analyse information and ideas to interpret and evaluate the graph of a new situation. Having done the core practical will assist them here.

Appendix 1

Department for Education: apparatus and techniques list

	BIOLOGY	CHEMISTRY	PHYSICS
1	Use of appropriate apparatus to make and record a range of measurements accurately, including length, area, mass, time, temperature, volume of liquids and gases, and pH	Use of appropriate apparatus to make and record a range of measurements accurately, including mass, time, temperature, and volume of liquids and gases	Use of appropriate apparatus to make and record a range of measurements accurately, including length, area, mass, time, volume and temperature. Use of such measurements to determine densities of solid and liquid objects.
2	Safe use of appropriate heating devices and techniques including use of a Bunsen burner and a water bath or electric heater	Safe use of appropriate heating devices and techniques including use of a Bunsen burner and a water bath or electric heater	Use of appropriate apparatus to measure and observe the effects of forces including the extension of springs
3	Use of appropriate apparatus and techniques for the observation and measurement of biological changes and/or processes	Use of appropriate apparatus and techniques for conducting and monitoring chemical reactions, including appropriate reagents and/or techniques for the measurement of pH in different situations	Use of appropriate apparatus and techniques for measuring motion, including determination of speed and rate of change of speed (acceleration/deceleration)
4	Safe and ethical use of living organisms (plants or animals) to measure physiological functions and responses to the environment	Safe use of a range of equipment to purify and/or separate chemical mixtures including evaporation, filtration, crystallisation, chromatography and distillation	Making observations of waves in fluids and solids to identify the suitability of apparatus to measure speed/frequency/wavelength. Making observations of the effects of the interaction of electromagnetic waves with matter.
5	Measurement of rates of reaction by a variety of methods including production of gas, uptake of water and colour change of indicator	Making and recording of appropriate observations during chemical reactions including changes in temperature and the measurement of rates of reaction by a variety of methods such	Safe use of appropriate apparatus in a range of contexts to measure energy changes/transfers and associated values such as work done

		as production of gas and colour change	
6	Application of appropriate sampling techniques to investigate the distribution and abundance of organisms in an ecosystem via direct use in the field	Safe use and careful handling of gases, liquids and solids, including careful mixing of reagents under controlled conditions, using appropriate apparatus to explore chemical changes and/or products	Use of appropriate apparatus to measure current, potential difference (voltage) and resistance, and to explore the characteristics of a variety of circuit elements
7	Use of appropriate apparatus, techniques and magnification, including microscopes, to make observations of biological specimens and produce labelled scientific drawings	Use of appropriate apparatus and techniques to draw, set up and use electrochemical cells for separation and production of elements and compounds	Use of circuit diagrams to construct and check series and parallel circuits including a variety of common circuit elements
Separate science only			
8	Use of appropriate techniques and qualitative reagents to identify biological molecules and processes in more complex and problem-solving contexts, including continuous sampling in an investigation.	Use of appropriate qualitative reagents and techniques to analyse and identify unknown samples or products including gas tests, flame tests, precipitation reactions, and the determination of concentrations of strong acids and strong alkalis	Making observations of waves in fluids and solids to identify the suitability of apparatus to measure the effects of the interaction of waves with matter.

Appendix 2

Core practical mapping

The tables on the following pages show how each core practical in biology, chemistry and physics offers opportunities for students to develop some of the mathematical skills and how the practicals map to the practical techniques in Appendix 1.

Biology

Biology Core Practical	Practical technique								Mathematical skills
	1	2	3	4	5	6	7	8	
1. Investigate biological specimens using microscopes, including magnification calculations and labelled scientific drawings from observations (1.6)	✓		✓				✓		1d Make estimates of the results of simple calculations 2a Use an appropriate number of significant figures 2h Make order of magnitude calculations 3b Change the subject of an equation
2. Investigate the effect of pH on enzyme activity (1.10)	✓		✓		✓			✓	1a Recognise and use expressions in decimal form 1c Use ratios, fractions and percentages 2a Use an appropriate number of significant figures 2b Find arithmetic means 2g Use a scatter diagram to identify a correlation between two variables 4a Translate information between graphical and numeric form 4d Determine the slope and intercept of a linear graph 4e Draw and use the slope of a tangent to a curve as a measure of rate of change

Biology Core Practical	Practical technique 1	2	3	4	5	6	7	8	Mathematical skills
3. Investigate the use of chemical reagents to identify starch, reducing sugars, proteins and fats (1.13B)		✓	✓		✓			✓	None
4. Investigate osmosis in potatoes (1.16)	✓		✓		✓				1a Recognise and use expressions in decimal form 1c Use ratios, fractions and percentages 2b Find arithmetic means 2g Use a scatter diagram to identify a correlation between two variables 4a Translate information between graphical and numeric form
5. Investigate the effects of antiseptics or antibiotics or plant extracts on microbial cultures (5.18B)	✓	✓	✓				✓		1a Recognise and use expressions in decimal form 1c Use ratios, fractions and percentages 2a Use an appropriate number of significant figures 2c Construct and interpret frequency tables and diagrams, bar charts and histograms 3a Understand and use the symbols: =, <, <<, >>, >, ∝, ~ 3c Substitute numerical values into algebraic equations using appropriate units for physical quantities 4a Translate information between graphical and numeric form 5c Calculate areas of triangles and rectangles, surface areas and volumes of cubes.
6. Investigate the effect of light intensity on the rate of photosynthesis (6.5)	✓	✓	✓	✓	✓				1a Recognise and use expressions in decimal form 1c Use ratios, fractions and percentages 2a Use an appropriate number of significant figures 2b Find arithmetic means

Biology Core Practical	Practical technique								Mathematical skills
	1	2	3	4	5	6	7	8	
									2d Understand the principles of sampling as applied to scientific data 2g Use a scatter diagram to identify a correlation between two variables 3a Understand and use the symbols: =, <, <<, >>, >, ∝, ~ 4a Translate information between graphical and numeric form 4c Plot two variables from experimental or other data 4d Determine the slope and intercept of a linear graph
7. Investigate the rate of respiration in living organisms (8.11)	✓		✓	✓	✓				1a Recognise and use expressions in decimal form 1c Use ratios, fractions and percentages 2a Use an appropriate number of significant figures 2b Find arithmetic means 2d Understand the principles of sampling as applied to scientific data 2g Use a scatter diagram to identify a correlation between two variables 3a Understand and use the symbols: =, <, <<, >>, >, ∝, ~ 4a Translate information between graphical and numeric form 4c Plot two variables from experimental or other data 4d Determine the slope and intercept of a linear graph
8. Investigate the relationship between organisms and their environment using field-work techniques including quadrats and belt transects (9.5)	✓			✓		✓	✓		1c Use ratios, fractions and percentages 2b Find arithmetic means 2c Construct and interpret frequency tables and diagrams, bar charts and histograms 2d Understand the principles of sampling as applied to scientific data 3a Understand and use the symbols: =, <, <<, >>, >, ∝, ~

Chemistry

Chemistry Core Practical	Practical technique								Mathematical skills
	1	2	3	4	5	6	7	8	
1. Investigate the composition of inks using simple distillation and paper chromatography (2.11)	✓	✓		✓		✓			1c Use ratios, fractions and percentages 2a Use an appropriate number of significant figures 3a Understand and use the symbols: =, <, <<, >>, >, ∝, ~ 3c Substitute numerical values into algebraic equations using appropriate units for physical quantities 4a Translate information between graphical and numeric form
2. Investigate the change in pH on adding powdered calcium hydroxide/calcium oxide to a fixed volume of dilute hydrochloric acid (3.6)	✓		✓		✓	✓			4c Plot two variables from experimental or other data
3. Investigate the preparation of pure, dry hydrated copper sulfate crystals starting from copper oxide including the use of a water bath (3.17)	✓	✓		✓		✓			None
4. Investigate the electrolysis of copper sulfate solution with inert electrodes and copper electrodes (3.31)	✓		✓			✓	✓		1a Recognise and use expressions in decimal form 1c Use ratios, fractions and percentages 2a Use an appropriate number of significant figures 2b Find arithmetic means 3a Understand and use the symbols: =, <, <<, >>, >, ∝, ~ 4a Translate information between graphical and numeric form 4b Understand that $y = mx + c$ represents a linear relationship 4c Plot two variables from experimental or other data

Chemistry Core Practical	Practical technique								Mathematical skills
	1	2	3	4	5	6	7	8	
5. Carry out an accurate acid-alkali titration, using burette, pipette and a suitable indicator (5.9C)	✓		✓		✓	✓		✓	1a Recognise and use expressions in decimal form 1c Use ratios, fractions and percentages 2a Use an appropriate number of significant figures 2b Find arithmetic means 3a Understand and use the symbols: =, <, <<, >>, >, ∝, ~ 3b Change the subject of an equation 3c Substitute numerical values into algebraic equations using appropriate units for physical quantities
6. Investigate the effects of changing the conditions of a reaction on the rates of chemical reactions by: a measuring the production of a gas (in the reaction between hydrochloric acid and marble chips) *b* observing a colour change (in the reaction between sodium thiosulfate and hydrochloric acid) (7.1)	✓	✓	✓		✓	✓			1a Recognise and use expressions in decimal form 1c Use ratios, fractions and percentages 2a Use an appropriate number of significant figures 2b Find arithmetic means 3a Understand and use the symbols: =, <, <<, >>, >, ∝, ~ 3b Change the subject of an equation 3c Substitute numerical values into algebraic equations using appropriate units for physical quantities 4a Translate information between graphical and numeric form 4c Plot two variables from experimental or other data 4d Determine the slope and intercept of a linear graph 4e Draw and use the slope of a tangent to a curve as a measure of rate of change 5c Calculate areas of triangles and rectangles, surface area and volumes of cubes
7. Identify the ions in unknown salts, using the tests for the specified			✓			✓		✓	None

Chemistry Core Practical	Practical technique								Mathematical skills
	1	2	3	4	5	6	7	8	
cations and anions in *9.2C, 9.3C, 9.4C, 9.5C* (9.6C)									
8. Investigate the temperature rise produced in a known mass of water by the combustion of the alcohols ethanol, propanol, butanol and pentanol (9.28C)	✓		✓		✓	✓			1a Recognise and use expressions in decimal form 1c Use ratios, fractions and percentages 2a Use an appropriate number of significant figures 2b Find arithmetic means 3a Understand and use the symbols: =, <, <<, >>, >, ∝, ~ 3b Change the subject of an equation 3c Substitute numerical values into algebraic equations using appropriate units for physical quantities 4a Translate information between graphical and numeric form

Physics

Physics Core Practical	Practical technique 1	2	3	4	5	6	7	8	Mathematical skills
1. Investigate the relationship between force, mass and acceleration by varying the masses added to trolleys (2.19)	✓	✓	✓						1a Recognise and use expressions in decimal form 2a Use an appropriate number of significant figures 2g Use a scatter diagram to identify a correlation between two variables 3a Understand and use the symbols: =, <, <<, >>, >, ∝, ~ 3b Change the subject of an equation 3c Substitute numerical values into algebraic equations using appropriate units for physical quantities 3d Solve simple algebraic equations 4b Understand that y = mx + c represents a linear relationship 4c Plot two variables from experimental or other data
2. Investigate the suitability of equipment to measure the speed, frequency and wavelength of a wave in a solid and a fluid (4.17)	✓			✓				✓	1a Recognise and use expressions in decimal form 1b Recognise and use expressions in standard form 2a Use an appropriate number of significant figures 3a Understand and use the symbols: =, <, <<, >>, >, ∝, ~ 3b Change the subject of an equation 3c Substitute numerical values into algebraic equations using appropriate units for physical quantities 3d Solve simple algebraic equations
3. Investigate refraction in rectangular glass blocks in terms of the interaction of electromagnetic waves with matter (5.9)				✓					4c Plot two variables from experimental or other data 5a Use angular measures in degrees

4. Investigate how the nature of a surface affects the amount of thermal energy radiated or absorbed (5.19P)				✓					4c Plot two variables from experimental or other data
5. Investigate the densities of solid and liquids (14.3)	✓								1a Recognise and use expressions in decimal form 2a Use an appropriate number of significant figures 3a Understand and use the symbols: =, <, <<, >>, >, ∝, ~ 3b Change the subject of an equation 3c Substitute numerical values into algebraic equations using appropriate units for physical quantities 3d Solve simple algebraic equations
6. Investigate the properties of water by determining the specific heat capacity of water and obtaining a temperature–time graph for melting ice (14.11)	✓				✓				1a Recognise and use expressions in decimal form 2a Use an appropriate number of significant figures 3a Understand and use the symbols: =, <, <<, >>, >, ∝, ~ 3b Change the subject of an equation 3c Substitute numerical values into algebraic equations using appropriate units for physical quantities 3d Solve simple algebraic equations 4c Plot two variables from experimental or other data
7. Construct electrical circuits to: a investigate the relationship between potential difference, current and resistance for a resistor and a filament lamp b test series and parallel circuits using resistors and filament lamps (10.17)						✓	✓		1a Recognise and use expressions in decimal form 2a Use an appropriate number of significant figures 3a Understand and use the symbols: =, <, <<, >>, >, ∝, ~ 3b Change the subject of an equation 3c Substitute numerical values into algebraic equations using appropriate units for physical quantities 3d Solve simple algebraic equations 4b Understand that y = mx + c represents a linear relationship 4c Plot two variables from experimental or other data

8. Investigate the extension and work done when applying forces to a spring (15.6)		✓			✓				1a Recognise and use expressions in decimal form 2a Use an appropriate number of significant figures 3a Understand and use the symbols: =, <, <<, >>, >, ∝, ~ 3b Change the subject of an equation 3c Substitute numerical values into algebraic equations using appropriate units for physical quantities 3d Solve simple algebraic equations 4b Understand that y = mx + c represents a linear relationship 4c Plot two variables from experimental or other data 4f Understand the physical significance of area between a curve and the x-axis and measure it by counting squares as appropriate

Appendix 3

GCSE Sciences: Equipment list

The list below is for all core practicals in GCSE Combined Science and Separate sciences. The separate science equipment is draft, and will be updated with a final version on the Edexcel website soon.

Biology

Spec statement	Equipment needed (per group)
1.6 Investigate biological specimens using microscopes, including magnification calculations and labelled scientific drawings from observations	Microscope and light source beaker of 1% Virkon stain (e.g. methylene blue, iodine solution) paper towels plant material (e.g. onion, rhubarb) pipette eye protection sterile (autoclaved) wooden spatula/tongue depressor gloves plain glass microscope slide coverslip toothpick/cocktail stick [Note: equipment listed at the top is for a group and that listed after the break is for an individual (making a slide)]
1.10 Investigate the effect of pH on enzyme activity	test tube soluble starch 1% amylase solution (or 0.5% pancreatin solution) water bath 5 cm^3 syringe or pipette, beaker eye protection 0.01 mol dm^{-3} iodine solution, well tray (spotting tile). hypochlorite (bleach) solution or 1% Virkon solution small beaker or other container for collecting saliva buffer solutions at set pH (using 0.2 mol dm^{-3} Na_2HPO_4 and 0.1 mol dm^{-3} citric acid or adding dilute hydrochloric acid and sodium hydrogen carbonate solution (prior to adding the amylase)
1.13B Investigate the use of chemical reagents to identify starch, reducing sugars, proteins and fats DRAFT	food samples: powdered potato, full and/or low fat powdered milk, whey (protein) powder, powdered egg white (use commercially available albumen), powdered glucose; water, measuring cylinder, spatula, powdered foods, paper towels, test tubes, racks and bungs, stirrer, iodine solution (1 g iodine in 100 cm3 0.5 mol dm3 potassium iodide solution) in dropper bottle, Benedict's solution (prepared according to CLEAPSS Recipe card 11 [qualitative] or 12 [for

Spec statement	Equipment needed (per group)
	quantitative measurements], Biuret solution (prepared according to CLEAPSS Recipe Sheet 15) in dropper bottle, Sudan III stain (dissolve 0.5 g dye in 70 cm3 ethanol [highly flammable] and 30 cm3 water, using a warm water bath and filter) in dropper bottle, water bath at 70 °C. (optional) icing sugar, hydrochloric acid, sodium hydroxide solution, water bath at 100 °C. Note: Sudan III test for lipids will now be optional. Emulsion test for lipids (using ethanol) is sufficient for core practical.
1.16 Investigate osmosis in potatoes	4 Potato strips four boiling tubes and rack (or beakers), waterproof pen, 550 g/dm^3 sucrose solution forceps agar cubes containing sodium hydroxide and universal indicator or phenolphthalein (one cube each of side lengths 2 cm, 1 cm and 0.5 cm or an agar block large enough for students to cut their own cubes), 20 cm^3 0.1 mol/dm^3 hydrochloric acid, 100 cm^3 beaker forceps white tile knife stopclock or watch eye protection
5.18B Investigate the effects of antiseptics, antibiotics or plant extracts on microbial cultures DRAFT	Petri dish with lid, of agar covered with a bacterial lawn (e.g. E.coli or Staphylococcus albus) prepared antibiotic discs in different concentrations sticky tape marker pen sterile forceps ethanol (IDA) incubator
6.5 Investigate the effect of light intensity on the rate of photosynthesis	pre-prepared algal (*Scenedesmus quadricauda*) balls (in a beaker of fresh distilled water) hydrogen carbonate indicator solution (cherry red colour (pH 8.4) and equilibrated with air) 5 - 8 small (bijou) bottles with caps (pre-washed in distilled water) metre rule lamp (with high light intensity, circa. 80 W incandescent or equivalent CFL/LED) spatula (clean and washed in distilled water) kitchen foil access to a display of bottles showing the colours of the hydrogen carbonate at different pH
8.11 Investigate respiration in living	small organisms (e.g. meal worms) 2 boiling tubes (containing 2 spatulas of soda lime held in place at the

Spec statement	Equipment needed (per group)
organisms	bottom of the tube with a plug of cotton wool) (1 tube for test, 1 for control) cored bung(s) (to fit into boiling tube) L-shaped capillary tube(s) (to fit into cored bung) ruler eye protection plastic 'weighing boat' beaker of water containing strongly coloured (e.g. with food dye) solution access to water baths at different temperatures, with boiling tube racks
9.5 Investigate the relationship between organisms and their environment	quadrat (e.g. 1 metre square) long tape measure (at least 20 m) with securing pegs equipment for measuring appropriate physical factors (e.g. thermometer, light meter, data recorder with light, moisture or temperature sensors, soil pH meter) clipboards recording sheets

Chemistry

Spec statement	Equipment needed (per group)
2.11 Investigate the composition of inks using simple distillation and paper chromatography	250 cm^3 beaker chromatography paper a splint or pencil or glass rod/paper clips four different black felt pens or water-soluble marker pens labelled A–D selection of different coloured marker pens or felt-tip pens selection of pens with 'permanent' (non-water-soluble) inks solvent that will dissolve the permanent ink (for biro ink a mixture of butan-1-ol, ethanol, water (3:1:1 by volume) 880-ammonia ethanol, propanone or propan-2-ol eye protection a conical flask with side-arm, (an alternative is to use a two-hole bung with a thermometer and delivery tube) rubber bung with thermometer delivery tube test tube beaker (250 or 400 cm^3) crushed ice Bunsen burner tripod gauze heat-resistant mat ink antibumping granules
3.17 Investigate the preparation of copper sulfate crystals	eye protection 250 cm^3 conical flask 100 cm^3 beaker Bunsen burner gauze tripod stand heat mat Petri dish or watch glass 100 cm^3 measuring cylinder evaporating basin spatula stirring rod filter funnel filter paper tongs water bath 1 mol dm^{-3} sulfuric acid copper(II) oxide
3.6 Investigate the change in pH on adding powdered calcium hydroxide or calcium	eye protection 100 cm^3 beaker 50 cm^3 measuring cylinder ±0.1 g balance

Spec statement	Equipment needed (per group)
oxide to a fixed volume of dilute hydrochloric acid	spatula stirring rod white tile universal indicator paper pH colour chart dilute hydrochloric acid calcium hydroxide powder
3.31 Investigate the electrolysis of copper sulfate solution	emery paper low voltage supply (0-12 V) ammeter (0-1 A) variable resistor connecting leads crocodile clips 100 cm^3 beaker stop watch/clock 2 graphite rods 2 strips of copper foil about 2 cm wide and long enough to reach the bottom of the beaker copper sulfate solution (about 50 cm^3, 0.5 mol dm^{-3}) access to a beaker of propanone (about 50 cm^3) access to a balance (at least 2 d.p.)
5.9C Carry out an accurate acid-alkali titration, using burette, pipette and a suitable indicator DRAFT	Each group needs: burette burette stand or retort stand with burette clamp plastic funnel to fit in top of burette 25.0 cm3 pipette pipette filler conical flask white tile methyl orange or phenolphthalein indicator (few drops) hydrochloric acid (about 100 cm3, 0.1 mol dm-3) sodium hydroxide solution (about 100 cm3, 0.1 mol dm-3) access to distilled/de-ionised water
7.1 Investigate the effects of changing the conditions of a reaction on the rates of chemical reactions etc..	Eye protection, large sized marble chips, small sized marble chips, 0.5 mol dm^{-3} hydrochloric acid 250 cm^3 conical flask,100 cm^3 measuring cylinder or gas syringe, 0.1 mol dm^{-3} sodium thiosulfate, 1.0 mol dm^{-3}, 50 cm^3 measuring cylinder, stop clock or stopwatch, 10 cm^3 measuring cylinder thermometer water bath,
9.6C Identify the ions in unknown salts, using the tests for the specified cations and anions in 9.2C, 9.3C, 9.4C, 9.5C	Eye protection, Bunsen burner, heat-resistant mat, test tubes, test tube rack, test tube holder, flame test loops (or wooden splints soaked in water), spatula, dropping pipettes, 0.1 mol dm–3 barium chloride solution, 0.4 mol dm–3 hydrochloric acid, 2 mol dm–3 hydrochloric acid (if using flame test loops), 0.05 mol dm–3 silver

Spec statement	Equipment needed (per group)
DRAFT	nitrate solution, 0.4 mol dm–3 nitric acid, 0.4 mol dm–3 sodium hydroxide solution, red litmus paper, distilled water or deionised water. Solid substances for flame tests and carbonate test, e.g. lithium chloride, sodium chloride, potassium chloride, calcium chloride, copper(II) chloride, calcium carbonate. Approx. 0.2 mol dm–3 solutions for precipitate tests, e.g. sodium chloride, potassium bromide, potassium iodide, aluminium sulfate, calcium chloride, copper(II) sulfate, iron(II) sulfate, iron(III) sulfate, ammonium chloride.
9.28C Investigate the temperature rise produced in a known mass of water by the combustion of the alcohols ethanol, propanol, butanol and pentanol DRAFT	Eye protection, alcohol burners, 150 cm^3 conical flasks, thermometers (-10 to 110 °C, retort stands and clamps, electronic balance +/- 0.01 g, 100 cm^3 measuring cylinders, lighters or matches, methanol, ethanol, propan-1-ol, butan-1-ol, pentan-1-ol.

Physics

Spec statement	Equipment list
2.19 Investigate the relationship between force, mass and acceleration by varying the masses added to trolley	trolley, ramp, blocks, pulley, string, stacking masses, mass hanger, sticky tack, 2 light gates, 2 clamps and stands, access to balance, datalogger
4.17 Investigate the suitability of equipment to measure the speed, frequency and wavelength of a wave in a solid and a fluid	Speed of waves on water: ripple tank (ideally with beaches to prevent reflections), stopwatch, ruler, digital camera Speed of sound in solid: 2 clamps and stands; 2 rubber bands; long metal rod (up to a metre long); metre rule; hammer; smartphone with frequency app Speed of sound in air: 2 microphones, datalogger, connecting wires, two blocks of wood
5.9 Investigate refraction in rectangular	Ray box with single slit, power supply, rectangular

glass blocks in terms of the interaction of electromagnetic [PJ1] waves with matter.	glass block, protractor.
5.19P Investigate how the nature of a surface affects the amount of thermal energy radiated or absorbed DRAFT	4 beakers or test tubes; coloured paper or foil to cover at least 3 tubes, or 3 of the tubes painted different colours and card or foil to make lids; 4 thermometers; stopclock; hot water.
10.17 Construct electrical circuits to: a investigate the relationship between potential difference, current and resistance for a resistor and a filament lamp b test series and parallel circuits using resistors and filament lamps	Power supply, ammeters, voltmeters, resistors, filament lamps, connecting wires
14.3 Investigate the densities of solid and liquids	Samples of various materials (e.g. materials kit), displacement can, measuring cylinder, access to balance, beakers
14.11 Investigate the properties of water by determining the specific heat capacity of water and obtaining a temperature-time graph for melting ice	Ice, thermometer, beaker, tripod, gauze, Bunsen burner, kettle, polystyrene cup, balance, electric immersion heater, joulemeter (or ammeter and voltmeter), stopclock
15.6 Investigate the extension and work done when applying forces to a spring	Spring, stand with 2 clamps, ruler, stacking masses

Appendix 4

Student worksheets

Biology

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Chemistry

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Core practical 3: CC8c Preparing copper sulfate *(skeletal method)* 156
Core practical 4: CC10a Electrolysis of copper sulfate solution *(skeletal method)* 158
Core practical 6: CC14b: Investigating reaction rates *(skeletal method)* 159

Physics

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Core practical 6: CP12a Investigating densities *(skeletal method)* 166
Core practical 7: CP12c Investigating water *(skeletal method)* 167
Core practical 8: CP13b Investigating springs *(skeletal method)* 168

Notes:

- Some worksheets for core practicals are not yet final, and so have not been included in this guide.
- Once core practical worksheets are finalised, they will be added to this appendix, and the list above will be updated to reflect this. All core practical worksheets will be available as part of this guide.
- A skeletal method has been included for all core practicals listed above which do not yet have a full student worksheet.
- Separate science worksheets are not yet final, so there are no worksheets/methods. A draft equipment list has been included in Appendix 3 for these practicals.

Your teacher may watch to see if you can:

- handle microscopes and slides carefully and safely.

Aim

To use a microscope to observe cells and sub-cellular structures.

Method 1: Examining pre-prepared slides of cells

Apparatus

- light microscope
- lamp
- prepared slides
- transparent ruler

⚠ Handle slides with care.

A Set up your microscope on the lowest-magnification objective lens. Work out the total magnification and measure the diameter of the field of view (by using the microscope to observe a transparent ruler).

B Put the next most powerful objective lens in place. Work out the magnification and by how much it has increased from the magnification in step A (e.g. moving from a ×10 to a ×50 is an increase of 5 times). Now divide the diameter of the field of view from step A by the increase in magnification to give you the new diameter of the field of view (e.g. if the field of view in step A was 2 mm, then 2 ÷ 5 = 0.4 mm). Do this for each objective lens. Record the total magnification and field-of-view diameter for each objective lens.

C Now go back to the lowest magnification objective lens and observe a prepared slide.

D Use higher magnifications to observe the cells. Estimate the sizes using your field-of-view diameters.

E Identify the cell parts. Have a look for mitochondria (you may not find any as they are very difficult to see).

Method 2: Examining your cheek cells

Apparatus

- light microscope
- lamp
- microscope slide
- coverslip
- methylene blue stain
- pipette
- paper towel
- water
- gloves
- wooden toothpick/cocktail stick
- sterile wooden spatula/tongue depressor
- disinfectant

⚠ Handle slides with care. Anything that you have put into your mouth should be placed in disinfectant after use. Wear gloves if using stains. Wear eye protection.

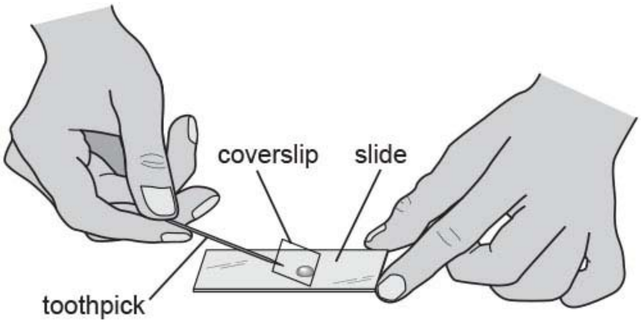
A Using the pipette, add a small drop of water to the slide.

B Stroke the inside of your cheek gently with the wooden spatula. You only want to collect loose cells, so do not scratch the inside of your mouth.

C Use the end of the spatula that has been in your mouth to stir the drop of water on the slide. Place the used spatula in disinfectant.

D Put on gloves and use a pipette to add a small drop of methylene blue stain. This makes cells easier to see.

E Place a coverslip onto the slide at a 45° angle on one edge of the drop. Then use a toothpick to gently lower the coverslip down onto the drop, as shown in the diagram on the right. Avoid trapping air bubbles, which appear as black-edged circles under a microscope.



F Touch a piece of paper towel to any liquid that spreads out from under the coverslip.

G Use the lowest magnification objective lens to observe the slide. The nuclei of the cheek cells will be dark blue.

H Use higher magnifications to observe the cells. Estimate the sizes using your field of view diameters.

I Identify the cell parts. Have a look for mitochondria (you may not find any as they are very difficult to see).

Method 3: Examining onion or rhubarb stem cells

Apparatus

- light microscope
- lamp
- microscope slide
- coverslip
- iodine stain
- pipette
- paper towel
- water
- forceps
- wooden toothpick
- piece of onion bulb or rhubarb stem
- gloves

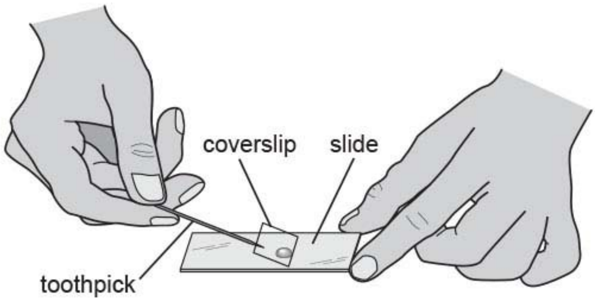
⚠ Handle slides and microscopes with care. Wear gloves if using stains. Wear eye protection.

A If you are going to look at onion cells, put on gloves and use a pipette to add a drop of iodine solution to a microscope slide. If you are going to look at rhubarb, add a drop of water to a microscope slide.

B Using forceps, remove a very small piece of the thin ‘skin’ on the inside of the fleshy part of the onion. It is very thin indeed and quite tricky to handle. Or remove a thin piece of red ‘skin’ from a rhubarb stem.

C Place the small piece of skin on the drop on the slide.

D Place a coverslip onto the slide at a 45° angle on one edge of the drop. Then use a toothpick to gently lower the coverslip down onto the drop, as shown in the diagram on the right. Avoid trapping air bubbles, which appear as black-edged circles under a microscope.



E Touch a piece of paper towel to any liquid that spreads out from under the coverslip.

F Use the lowest magnification objective lens to observe the slide. Then use higher magnifications to observe the cells in more detail. Estimate sizes as you observe.

G Identify the cell parts. Have a look for mitochondria (you may not find any as they are very difficult to see).

Method 4: Examining pondweed

Apparatus

- light microscope
- lamp
- microscope slide
- coverslip
- iodine stain
- pipette
- paper towel
- water
- forceps
- wooden toothpick
- piece of pondweed

⚠ Handle slides and microscopes with care. Wear eye protection.

A Tear off a very small piece of pondweed leaf; a square with sides of up to 2 mm.

B Place the leaf sample onto a microscope slide and add a drop of water.

C Place a coverslip onto the slide at a 45° angle on one edge of the drop. Then use a toothpick to gently lower the coverslip down onto the drop, as shown in the diagram above. Avoid trapping air bubbles, which appear as black-edged circles under a microscope.

D Touch a piece of paper towel to any liquid that spreads out from under the coverslip.

E Use the lowest magnification objective lens to observe the slide.

F Use higher magnifications to observe the cells in more detail. Estimate sizes as you observe.

G Identify the cell parts. If you watch very carefully when you have the cells under a high magnification, you may well see the chloroplasts moving as the cytoplasm moves inside the cells.

Recording your results

1 Make a drawing of each type of cell that you examine. Label the parts and record the magnification.

2 Label the cells and their parts with any sizes that you have estimated using the diameter of the field of view.

I can…

- identify the parts of plant and animal cells
- calculate total magnification using a formula
- make drawings of plant and animal cells using a light microscope and identify their parts.
- estimate sizes using microscope fields of view.

Amylase is an enzyme made in the salivary glands in your mouth and in the pancreas. It catalyses the breakdown of starch into smaller sugar molecules. The iodine test identifies the presence of starch, but does not react with sugar. You will use this test to show how effective amylase is in digesting starch at different pHs.

Your teacher may watch to see if you can:

- work safely
- collect accurate data.

Aim

To investigate the effect of pH on the rate of digestion of starch by amylase.

Prediction

1 Predict at which pH the amylase will digest starch fastest. Explain your prediction.

Method

Apparatus

⚠ Eye protection should be worn.

- iodine solution in dropping bottle
- dimple tile
- test tubes
- test-tube rack
- syringes
- pipette
- amylase solution
- starch solution
- solutions of specific pH
- stop clock

A Drop one drop of iodine solution into each depression of the dimple tile.

B Measure 2 cm^3 of amylase solution into a test tube using a syringe.

C Add 1 cm^3 of your pH solution to the test tube using a second syringe. Record the pH of the solution that you are using.

D Using a third syringe, add 2 cm^3 starch solution to the mixture and start the stop clock. Use the pipette to stir the mixture.

E After 20 seconds, take a small amount of the mixture in the pipette and place one drop of it on the first iodine drop on the tile. Return the rest of the solution in the pipette to the test tube.

F If the iodine solution turns black, then there is still starch in the mixture and you should repeat step E (after 10 seconds). If it remains yellow, then all the starch is digested and you should record the time taken for this to happen.

G If there is time, repeat the experiment using a solution with a different pH.

Recording your results

2 Collect data from all the groups in the class so that you have results for each of the different pHs. If you have more than one result for each pH, calculate a mean time for each one.

3 Draw a table to present these results clearly.

Considering your results

4 Plot a line graph to show the time taken for amylase to digest starch with the different pHs.

5 Use your graph to describe the effect of pH on the time taken for amylase to digest starch.

6 Suggest a reason for the shape of your graph.

Evaluation

7 Describe any problems you had with carrying out the experiment.

8 Suggest reasons for the problems and how the method could be changed to help reduce the problems.

9 Were any of the results surprising? If so, why?

10 Do you think you have enough results to support your conclusion? Explain your answer.

I can…

- describe the effect of pH on enzyme activity
- calculate the rate of enzyme activity from experimental data
- explain why pH affects enzyme activity.

Your teacher may watch to see if you can:

- measure accurately
- work carefully.

Osmosis is the overall movement of water molecules from a region where there are more of them in a particular volume to a region where there are fewer, through a semi-permeable membrane. The cells in a potato contain many substances dissolved in water. The cells are surrounded by cell membranes that are permeable to water. When a strip of potato is placed in a solution, the overall movement of water molecules between the potato cells and the solution will depend on which has the higher concentration of solutes. In this practical you will investigate osmosis in potato strips in terms of the percentage change in mass of potato in different solutions.

Aim

To investigate how solution concentration affects percentage change in mass of potato strips due to osmosis.

Prediction

1 For each of the solutions you will use, predict whether the potato strips will gain mass, lose mass or keep the same mass. Explain your predictions.

Method

Apparatus

- 4 potato strips
- accurate balance
- 4 boiling tubes and rack (or beakers)
- waterproof pen
- 4 sucrose solutions: 0%, 40%, 80%, 100%
- forceps
- paper towels

⚠ Do not drink any of the solutions or eat the potatoes.

A Using the waterproof pen, label each tube with the name of one of the solutions. Place the boiling tubes in the rack.

B Dry a potato strip carefully by blotting it with a paper towel. Measure its mass on the balance.

C Place the potato strip into one of the tubes. Record the label on the tube and the mass of the strip in your results table (see next page).

D Repeat steps B and C until all strips have been measured and placed in tubes.

E Carefully fill each tube with the appropriate solution, so that the potato is fully covered. Leave the tubes for at least 15 minutes.

F For each potato strip, use the forceps to remove it from its tube, blot dry on a paper towel and measure its mass again. Record all the masses in the results table.

Recording your results

2 Draw up a table with the following headings. Complete the first three columns with the solution descriptions and your measurements from the experiment.

Solution	A Mass of potato strip at start (g)	B Mass of potato strip at end (g)	C Change in mass (g) = B – A	% change in mass = $\frac{C}{A} \times 100\%$

3 Complete column **C** by calculating the change in mass for each potato strip using the formula shown.

4 Complete column 5 by calculating the percentage change in mass for each potato strip using the formula shown.

5 Compare the results for percentage change in mass from all groups in the class for each solution. Identify any results that seem very different from the others (outliers). Try to find a reason why they are so different.

6 Using all results except outliers, calculate a mean value for percentage change in mass for each solution.

7 Draw a suitable chart or graph to show the mean percentage change in the mass of each potato strip on the *y*-axis against the solution description on the *x*-axis.

Considering your results/conclusions

8 Describe the pattern shown in your chart or graph.

9 Explain the pattern shown in your chart or graph, using the word ‘osmosis’ in your answer.

10 Explain why you calculated percentage change in mass.

11 Explain why calculating a mean value from several repeats of the same experiment is more likely to give a value that can be reproduced by others.

Evaluation

12 Describe any problems that you had with the experiment. Suggest how these could be reduced or avoided to produce better results.

I can…

- calculate percentage gain and loss of mass in osmosis.

Aim

Investigate the effect of light intensity on the rate of photosynthesis

Your Task

You are going to use balls of jelly containing algal cells to investigate photosynthesis in different light intensities. You can vary the light intensity by altering the distance between a lamp and the algae. You are going to use hydrogen carbonate indicator to monitor the change in pH of the solution in which you placed the balls.

Method

⚠ Wear eye protection.

A Decide on the different distances between the algae and the lamp you are going to use. □

B For each distance you will need one clear glass bottle. You will also need one extra bottle. □

C Add 20 of the algae balls to each bottle. □

D Add the same amount of indicator solution to each bottle, and put on □the bottle caps. □

E Your teacher will have a range of bottles showing the colours of the indicator at different pHs. Compare colour in your tubes with this pH range to work out the pH at the start. □

F Set up a tank of water between the lamp and the area where you will place your tubes. Take extreme care not to spill water near electrical apparatus (such as a lamp). □

G Cover one bottle in kitchen foil, so that it is in the dark. □

H Measure the different distances from the lamp. Place your bottles at those distances. Put the bottle covered in kitchen foil next to the bottle that is closest to the lamp. □

I Turn on the lamp and wait until you can see obvious changes in the colours in your bottles. The longer you can wait, the more obvious your results are likely to be. □

J Compare the colours of all your bottles with the pH range bottles. Write down the pHs of the solutions in your bottles. □

K For each bottle, calculate the ‘change in pH/hour’.

L Plot a suitable graph or chart of your results.

Aim

Investigate the rate of respiration in living organisms.

Your task

You are going to use a simple respirometer to measure the oxygen consumption of some small organisms (e.g. meal worms) and to find out how the rate of respiration depends on temperature.

Method

⚠ Wear eye protection.

A Collect a tube with some soda lime, held in place with cotton wool. The soda lime absorbs carbon dioxide. Soda lime is corrosive, so do not handle it. The cotton wool is there to protect you and the organisms.

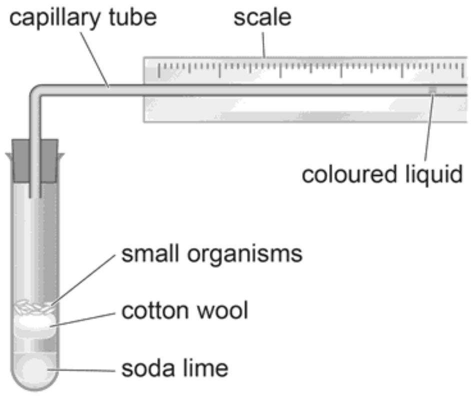
B Carefully collect some of the small organisms in a weighing boat.

C Gently shake the organisms out of the container and into the tube.

D Insert the bung and capillary tube, as shown in diagram B.

E Set up a control tube.

F Place both tubes into a rack in a water bath at a set temperature. It is best to tilt the rack slightly so that the capillary tubes hang over the side of the water bath at an angle.



B a simple respirometer

G Wait for five minutes to let the organisms adjust to the temperature of the water bath.

H Hold a beaker of coloured liquid to the ends of the capillary tubes, so that liquid enters.

I Mark the position of the coloured liquid in the tube and time for five minutes.

J Mark the position of the coloured liquid again, and measure the distance it has travelled.

K Repeat the experiment at different temperatures.

Aim

Investigate the relationship between organisms and their environment using field-work techniques, including quadrats and belt transects.

Your task

You will use a belt transect to study the effect of abiotic factors on the abundance of low-growing plants. The transect will stretch between open ground and heavy shade under a large tree. Several abiotic factors will vary along the transect. Before you start, you will need to decide which abiotic factors to measure and how to measure them. You will also need to decide which plants to record and how you will record their abundance within a quadrat.

Method

A Peg out a long tape measure (at least 20 m) on the ground, starting where there is no shade and ending in heavy shade. This is the transect line.

B You will need to make measurements at regular intervals along the transect line. Decide on your measurement intervals, which may depend on how long the line is and how much time you have to record information.

C Place the top left-hand corner of the quadrat at a measurement point on the transect line.

D Measure the abiotic factors at that point and record them.

E Record the abundance of your selected plants in the quadrat.

F Repeat steps C to E at each measurement point along the transect.

Your teacher may watch to see if you can:

- follow instructions carefully
- draw conclusions from your results.

Introduction

Many inks contain a mixture of dyes. This method can be used to identify inks – for example inks from crime scenes or from documents that may have been forged.

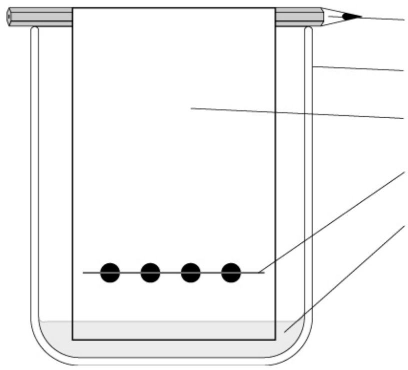
Aim

You are going to test some inks to see how many dyes they contain. You will then plan your own investigation.

Method

Apparatus

- beaker
- chromatography paper attached to rod
- 4 black marker pens or felt-tip pens



A Check that your chromatography paper hangs close to the bottom of the empty beaker without touching it (as shown in the diagram).

B Take the paper out of the beaker and draw a pencil line on the paper, about 2 cm from the bottom.

C Put a small spot of ink from each pen on your pencil line.

D Label underneath each spot with a pencil.

E Pour some water into the beaker to a depth of about 1 cm.

F Lower the chromatography paper into the beaker so that the bottom of the paper is in the water, but the water level is below the spots.

G Leave the paper in the beaker until the water reaches near the top of the paper.

H Take the paper out and immediately use a pencil to mark the location of the solvent front (the level the water has reached) before it evaporates. Leave it to dry.

Recording your results

1 Describe the coloured dyes that mixed to produce the black ink in each pen.

2 Measure the distance the solvent has risen from the pencil line.

3 Measure the distance that each dye spot has risen from the pencil line. Write your results in a table.

Considering your results

4 Calculate the R_f value for each separate colour in the four inks.

5 Were any of the black inks a pure colour? Explain your conclusion.

6 Did the same coloured dyes appear in more than one ink? If so, do you think they were the same chemical compound? Explain your answer.

Evaluation

7 Why was the starting line drawn in pencil?

8 Why did you have to label the spots?

9 Why is the chromatography paper hung with the bottom just in the water?

10 Why must the water level in the beaker be below the spots?

11 How easy was it to identify the level to which each coloured dye had travelled? How would this affect the accuracy of the R_f values you calculated?

I can…

- separate the dyes in ink using chromatography
- identify pure substances and mixtures on chromatograms
- calculate R_f values and use them to identify substances.

Name ______________________ Class __________ Date ____________

Your teacher may watch to see if you can:

- carry out experiments safely, reducing the risks from hazards.

Aim

To use distillation to produce pure water from ink.

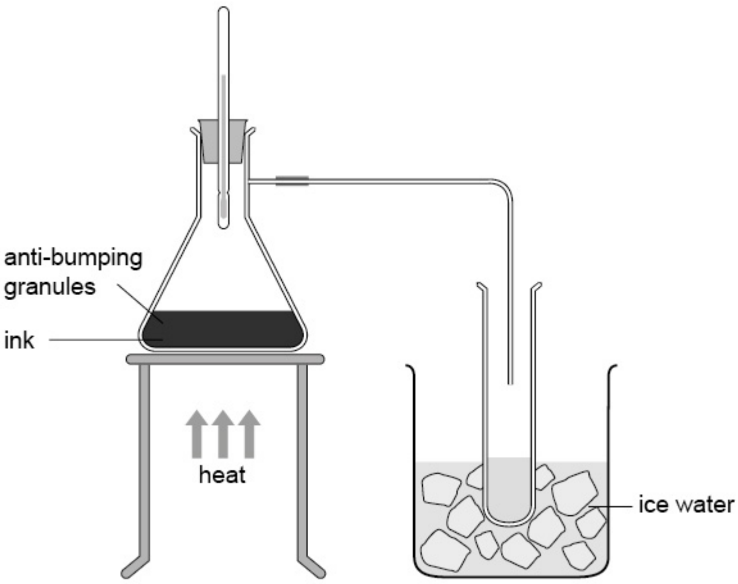
Method

Apparatus

- eye protection
- conical flask with side arm
- delivery tube
- test tube
- ink
- Bunsen burner
- gauze
- rubber bung with thermometer
- 250 cm^3 beaker
- ice
- tripod
- heat-resistant mat

⚠ Eye protection should be worn at all times.

⚠ Anti-bumping granules should be used to reduce the risk of the liquid boiling over.



A Set up your apparatus as shown in the diagram.

B Adjust the Bunsen burner so that you have a gentle blue flame.
The air hole should be about half open and the gas tap should be about half on.

C Heat the ink until it boils.

D Collect the distillate in the test tube and note the temperature of the vapour.

Planning and predicting

1 When you distil the ink, how will you know if you have successfully purified the water?

2 Predict the temperature reading on the thermometer when the ink is boiling. Explain your answer.

3 What is the purpose of the ice water shown in the diagram?

4 The conical flask might be knocked off the tripod.

a Why is the conical flask a hazard?

b How can the risk of harm from this hazard be reduced?

5 Suggest one other hazard and a way of reducing the risk from this hazard.

6 What air hole and gas settings should you have for the Bunsen burner:

a when you are not using it

b when you are using it to heat the ink?

Considering your results

7 Did you purify the water successfully? Explain your answer.

8 Explain what happened when the ink was distilled. In your explanation, use the following words: boil, condenser, evaporate, liquid, steam, temperature, vapour.

I can…

- describe how to carry out and what happens in simple distillation
- explain what happens when distillation takes place
- explain what precautions are needed to reduce risk in a distillation experiment.

Aim

Investigate the preparation of pure, dry, hydrated copper sulfate crystals starting from copper oxide including the use of a water bath.

Your task

Copper oxide reacts with warm sulfuric acid to produce a blue solution of the salt copper(II) sulfate. You are going to use these reactants to prepare pure, dry hydrated copper sulfate crystals.

Method

⚠ Wear eye protection.

A Measure 20 cm^3 of dilute sulfuric acid using a measuring cylinder and pour it into a small conical flask.

B Warm the acid in a water bath set at 50 °C. Use a thermometer to measure the temperature.

C Add a little copper oxide powder to the acid and stir.

D If all the copper oxide reacts, and disappears, add a little more. Stop when the copper oxide is in excess and no longer reacts.

E Filter the mixture and transfer the filtrate to an evaporating basin.

F Heat the evaporating basin by placing it over a beaker of water heated with a Bunsen burner using a Bunsen burner until about half of the water has evaporated and then stop heating.

G Pour the solution into a watch glass and leave for a few days to allow all the water to evaporate.

Your teacher may watch to see if you can…

- carry out an experiment appropriately
- use apparatus accurately and safely.

Aim

Powdered calcium hydroxide reacts with hydrochloric acid. Calcium chloride solution and water are produced:

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

You will investigate what happens to the pH of a fixed volume of dilute hydrochloric acid when you add calcium hydroxide to it.

Apparatus

- eye protection
- 100 cm^3 beaker
- 50 cm^3 measuring cylinder
- ±0.1 g balance
- spatula
- stirring rod
- white tile
- universal indicator paper
- pH colour chart
- dilute hydrochloric acid
- calcium hydroxide powder
- graph paper

⚠ Safety

Wear eye protection.
Calcium hydroxide is an irritant with a risk of serious damage to eyes.
Dilute hydrochloric acid is an irritant.

Method

A Use the measuring cylinder to add 50 cm^3 of dilute hydrochloric acid to the beaker.

B Estimate and record the pH of the contents of the beaker:

- Put a piece of universal indicator paper onto the white tile.
- Dip the end of the glass rod into the liquid, then tap it onto the universal indicator paper.
- Wait 30 seconds, then match the colour to the appropriate pH on the pH colour chart.
- Rinse the glass rod with water.

C Measure out 0.3 g of calcium hydroxide powder onto a piece of paper or a 'weighing boat'.

D Add the calcium hydroxide powder to the beaker, stir, then estimate and record the pH of the mixture.

E Repeat step **D** seven times so that you add a total of 2.4 g of calcium hydroxide powder to the acid.

Recording your results

1 Make a table with columns for the mass of calcium hydroxide powder added, and the pH of the mixture. Remember to leave a row for the first pH measurement (before you have added any calcium hydroxide).

Considering your results

2 Plot a line graph to show pH on the vertical axis and mass of calcium hydroxide added on the horizontal axis. Draw a curve of best fit.

3 Describe what happens to the pH of the reaction mixture as calcium hydroxide continues to be added.

4 Use your graph to determine the mass of calcium hydroxide that must be added to reach pH 7.

Evaluation

5 Explain one way to improve the accuracy of the experiment.

CC10a Electrolysis of copper sulfate solution

Aim

Investigate the electrolysis of copper sulfate solution with inert electrodes and copper electrodes.

Your task

You will set up an electrolysis cell to investigate the effect of changing the current on the mass of the copper electrodes used in the electrolysis of copper sulfate solution. You will also investigate the products formed during the electrolysis of copper sulfate solution using inert (graphite) electrodes.

Method

Using copper electrodes

⚠ Wear eye protection.

A Select two clean pieces of copper foil. Label one 'anode' and the other 'cathode'. Measure and record the masses of the two electrodes. □

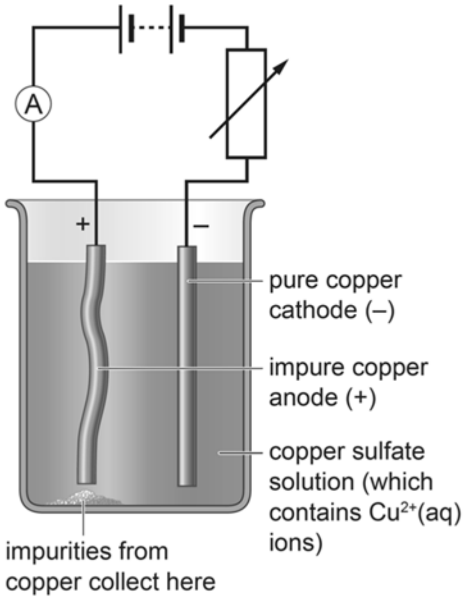
B Set up an electrolysis circuit as shown in diagram B. □

C Turn on the power and adjust the variable resistor to give a current of about 0.2 A. Record the current and adjust the variable resistor to keep it constant. Leave the power on for 20 minutes. □

D Turn on the power and remove the electrodes from the beaker. Gently wash the electrodes with distilled water then dip them into propanone. Li the electrodes out and gently shake o the propanone. Allow the remainder of the propanone to evaporate. □

E Measure and record the masses of the dry electrodes. □

F Repeat the experiment using currents of 0.3 A, 0.4 A and 0.5 A.

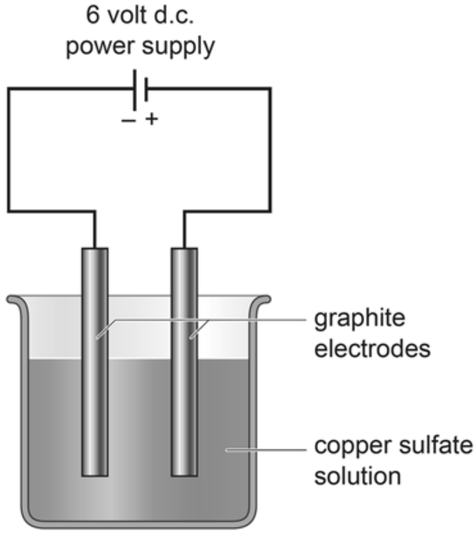


B Purifying copper by electrolysis. The copper to be purified is used as the anode and some very pure copper is used as the cathode.

Using graphite electrodes

G Set up the circuit as shown in diagram C.

H Turn on the power and observe what happens at each electrode.



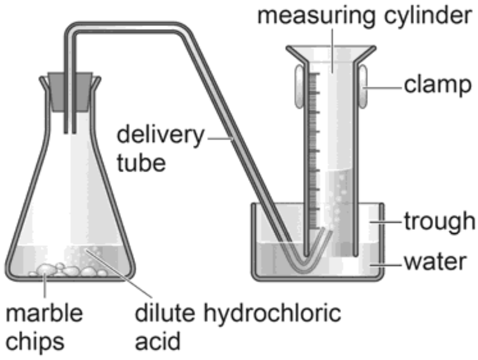
C electrolysis circuit for using graphite electrodes

Aim

Investigate the effects of changing the conditions of a reaction on the rates of chemical reactions.

Your task 1 – measuring volumes of gases

You are going to investigate the reaction between hydrochloric acid and marble chips (calcium carbonate) and how the surface area of the marble chips affects the rate. You will monitor the progress of the reaction by measuring the volume of carbon dioxide produced.



A investigating volumes of gas produced

Method 1

⚠ Wear eye protection.

A Set up the apparatus as shown in diagram A.

B Measure 40 cm^3 of dilute hydrochloric acid into a conical flask.

C Add 5 g of small marble chips to the flask.

D Immediately stopper the flask and start the stop clock.

E Note the total volume of gas produced after every 30 seconds until the reaction has finished.

F Repeat the experiment using 5 g of larger marble chips.

Your task 2 – observing a colour change

You are going to investigate the effect of temperature on the rate of reaction between sodium thiosulfate and hydrochloric acid. You will monitor the progress of the reaction by observing a colour change (as shown in photo B).

B We can follow the rate of the reaction between sodium thiosulfate and hydrochloric acid by measuring the time taken for a 'cross' drawn beneath the reaction beaker to disappear.

Method 2

⚠ Wear eye protection.

G Place 50 cm^3 of sodium thiosulfate solution into a 300 cm^3 conical flask.

H Measure out 5 cm^3 of dilute hydrochloric acid in a test tube.

I Clamp the conical flask in place in a water bath at a certain temperature. Place the test tube in a rack in the same water bath. Record this temperature.

J After 5 minutes, remove the flask and place it on a piece of white paper marked with a cross.

K Add the acid to the thiosulfate and start the stop clock.

L Looking down from above, stop the clock when the cross disappears.

M Note this time and take the final temperature of the mixture.

N Repeat at three or four other temperatures, between 20 and 50 °C.

CP2d.1 Investigating force, mass and acceleration

Your teacher may watch to see if you can…

- follow instructions carefully
- take careful measurements.

Aim

To investigate the effect of mass on the acceleration of a trolley.

Prediction

1 You will accelerate a trolley using a constant force. What effect do you think the mass of the trolley will have on the acceleration? Explain your prediction if you can.

Method

Apparatus

- trolley
- ramp
- blocks to prop up the end of the ramp
- string
- pulley
- masses
- sticky tape
- card
- sticky putty
- balance
- 2 light gates
- datalogger
- 2 clamps and stands
- box of crumpled newspaper

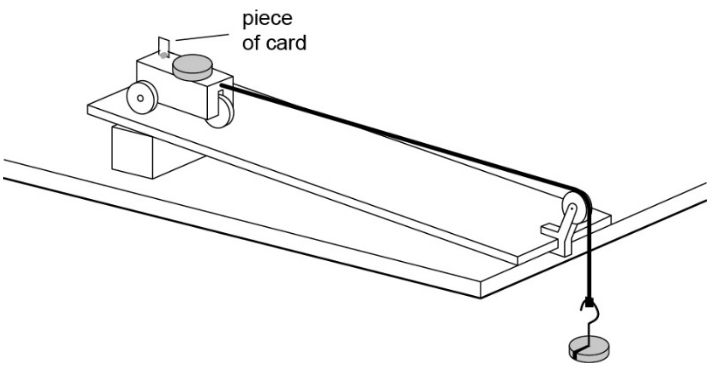
⚠ Make sure masses cannot fall on your feet by placing a box of crumpled newspaper on the floor beneath them.

A Prop up one end of the ramp and place a trolley on it. Adjust the slope of the ramp until the trolley just starts to move on its own. Gravity pulling the trolley down the slope is now slightly greater than the friction in the trolley's wheels.

B Stick a piece of card to the top of the trolley using sticky putty. Leave enough space to stack some masses on top of the trolley. Measure the length of the card and write it down.

C Find the mass of the trolley and write it down.

D Fasten the pulley at the bottom end of the ramp, and arrange the string and masses as shown below.



E Set up two light gates, one near the top of the ramp and one near the bottom. Adjust their positions so that the card on the top of the trolley passes through each gate as it runs down the ramp.

F Put a mass on the end of the string. You will keep this mass the same for all your tests. You will have to decide what mass to use.

G Release the trolley from the top of the ramp and write down the speed of the trolley (from the datalogger) as it passes through *each* light gate. Also write down the time it takes for the trolley to go from one light gate to the other.

H Repeat step **G** for other masses on the trolley. You will have to decide what masses to use, how many different masses you are going to test, and whether you need to repeat any of your tests.

Recording your results

2 Draw a table like this for recording your results.

Mass added to trolley (kg)	Total mass of trolley and masses (kg)	Run number	*u* – 1st velocity reading (m/s)	*v* – 2nd velocity reading (m/s)	Time between velocity measurements (s)	Acceleration (m/s^2)
		1				
		2				
		3				
		Mean				

3 Calculate the acceleration for each run using the formula in the box.

4 Find the mean acceleration for each trolley mass. Considering your results/conclusions

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time}}$$

$$a = \frac{(v - u)}{t}$$

Considering your results

5 Plot a scatter graph to show your results. Put the total mass of the trolley on the horizontal axis and the acceleration on the vertical axis. Draw a line or curve of best fit through your points.

6

a What relationship between acceleration and mass does your graph show?

b Is this what you predicted?

Evaluation

7

a How close are the points on your graph to the line of best fit?

b What does this tell you about the quality of the data you have gathered?

8 How do your results compare to the results obtained by other groups?

9 How certain are you that your conclusion is correct? Explain your answer.

I can…

- describe what an acceleration is
- investigate the factors that affect the acceleration of an object.

Your teacher may watch to see if you can…

- follow instructions carefully
- make accurate measurements.

Introduction

The speed, frequency and wavelength of waves can be measured in different ways. The most suitable equipment for carrying out these measurements depends on the type of wave and on its speed.

Aim

To measure waves in different ways and evaluate the suitability of the equipment.

Part 1. Speed of waves on water

Apparatus

- ripple tank
- stopwatch
- ruler
- digital camera

⚠ Safety

Mop up any spilled water straight away

Method

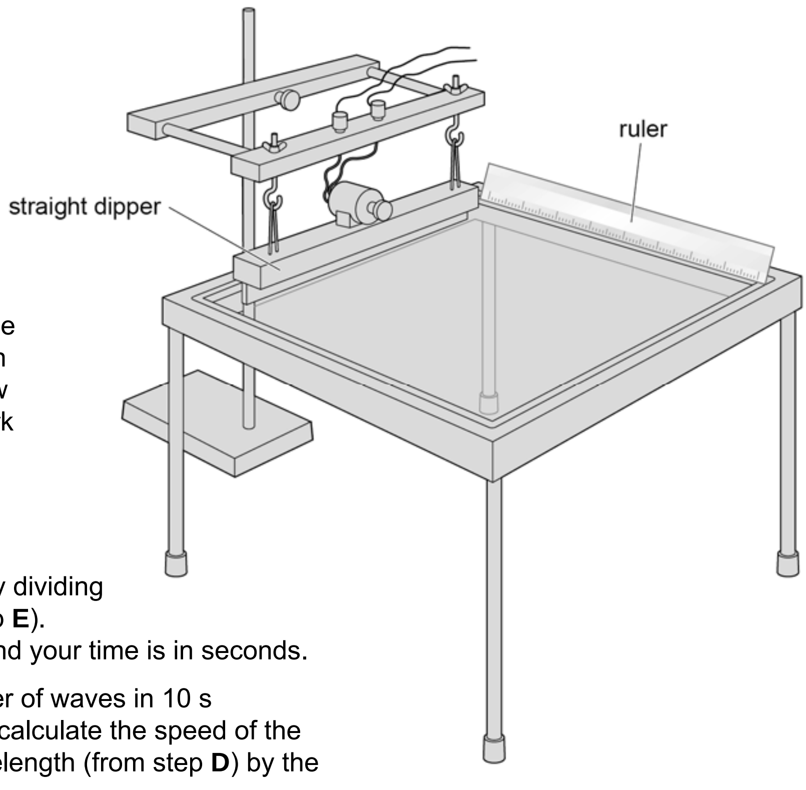
A Set up a ripple tank with a straight dipper near one of the short sides of the tank. Fasten a ruler to one of the long sides so you can see the markings above the water level.

B Vary the current to the motor until you get waves with a wavelength about half as long as the ripple tank (so you can always see two waves).

C Count how many waves are formed in 10 s and write it down.

D Look at the waves against the ruler. Use the markings on the ruler to estimate the wavelength of the waves. If you have one, use a camera to take a photo of the waves with a ruler held just above them.

E Mark two points on the edge of the ripple tank and measure the distance between them. Use the stopwatch to find out how long it takes a wave to go from one mark to the other.



Recording your results

1 Calculate the speed of a single wave by dividing the distance by the time (both from step **E**). Make sure your distance is in metres and your time is in seconds.

2 Find the frequency by taking the number of waves in 10 s (from step **C**) and dividing by 10. Then calculate the speed of the series of waves by multiplying the wavelength (from step **D**) by the frequency you have just worked out.

Considering your results/conclusions

3 Compare your results from questions 1 and 2 with results obtained by other groups.

Evaluation

4 How easy was it to measure the frequency in step **C**? Why did you count the number of waves in 10 s?

5 How easy was it to measure the wavelength in step **D**? Why did you use a digital camera to help you?

6 How easy was it to time a single wave in step **E**? Is there any way you could improve this measurement?

Part 2. Measuring waves in a solid

Method

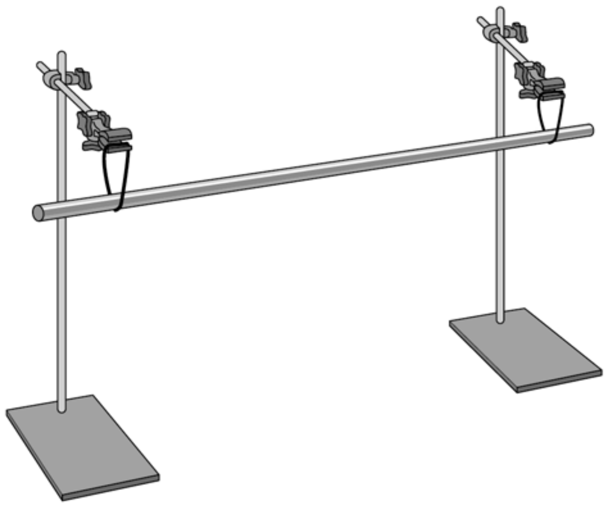
F Suspend a metal rod horizontally using clamp stands and rubber bands, as shown in the diagram below.

G Hit one end of the rod with a hammer. Hold a smartphone with a frequency app near the rod and note down the peak frequency.

H Measure the length of the rod and write it down. The wavelength will be twice the length of the rod.

Apparatus

- metre rule
- hammer
- 2 clamps and stands
- long metal rod
- rubber bands
- smartphone with frequency app



Recording your results

7 Use the frequency (from step **G**) and the wavelength (from step **H**) to calculate the speed of sound in the metal rod.

Considering your results/conclusions

8 What is the speed of sound in the material you tested?

Evaluation

9 Explain which of your measurements is the more accurate: the wavelength or the frequency.

10 Draw up a table to summarise the equipment you used for the measurements in both parts of this investigation, and how suitable the equipment was. You can use headings like this:

What was measured?	Which material was this measured for?	How was it measured?	Why was this method chosen?

11 You can measure walking speed using a tape measure and a stopwatch. Explain why these instruments are not suitable for measuring the speed of sound in a solid.

Aim

Investigate refraction in rectangular glass blocks in terms of the interaction of electromagnetic waves with matter.

Your task

Your task is to investigate how the direction of a ray of light changes as it enters and leaves a rectangular glass block.

Method

A Place a piece of plain paper on the desk. Set up the power supply, ray box and single slit so that you can shine a single ray of light across the paper on your desk. Take care, as ray boxes can become very hot.

B Place a rectangular glass block on the paper. Draw around the block.

C Shine a ray of light into your block. Use small crosses to mark where the rays of light go.

D Take the block off the paper. Use a ruler to join the crosses to show the path of the light, and extend the lines so they meet the outline of the block. Join the points where the light entered and left the block to show where it travelled inside the block.

E Measure the angles of incidence and refraction where the light entered the block, and measure the angles where it left the block.

F Repeat steps C to E with the ray entering the block at different angles.

G Move the ray box so that the light ray reaches the interface at right angles. Note what happens to the light as it enters and leaves the block.

Aim

Construct electrical circuits to:

a investigate the relationship between potential difference, current and resistance for a resistor and a filament lamp

b test series and parallel circuits using resistors and filament lamps.

Your task

You will construct a circuit to investigate the link between potential difference, current and resistance for a resistor and a filament lamp.

You will then find out what happens to the current through filament lamps when they are used in series and parallel circuits.

Method

Investigating resistance

A Set up circuit C. Use a power pack that can provide different potential differences. Ask your teacher to check your circuit before you switch it on.

B Set the power pack to its lowest voltage (potential difference) and switch on. Write down the readings on the ammeter and voltmeter and then switch the power pack off.

C Repeat step B for 5 different voltage settings, up to a maximum of 6 V.

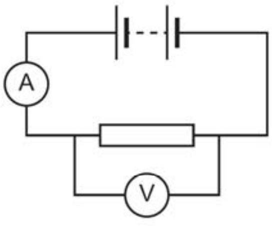
D Replace the resistor in the circuit with a filament lamp, and repeat steps B and C.

Filament lamps in series and parallel circuits

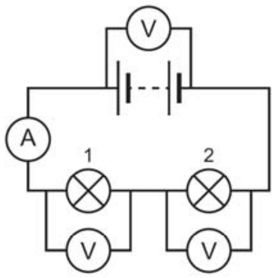
E Set up circuit D. Ask your teacher to check your circuit before you switch it on.

F Set the power pack to its lowest voltage. Write down the readings on the ammeter and the voltmeters. Repeat with the power pack set to provide different voltages, up to a maximum of 6 V.

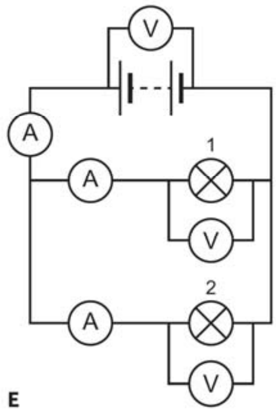
G Now set up circuit E and ask your teacher to check it. Repeat step F for several different voltage settings.



C



D



E

Aim

Investigate the densities of solids and liquids.

Your task

You are going to measure the densities of some different solids and liquids.

Method

Solids

A Find the mass of the solid and write it down. To find the volume of an irregular shape:

B Stand a displacement can on the bench with its spout over a bowl. Fill it with water until the water just starts to come out of the spout.

C Hold a measuring cylinder under the spout and carefully drop your object into the can. If your object floats, carefully push it down until all of it is under the water. Your finger should not be in the water.

D Stand the measuring cylinder on the bench and read the volume of water you have collected. This is the same as the volume of your object. Write it down.

E

Liquids

F Put an empty beaker on a balance, and set the balance to zero.

G Use a measuring cylinder to measure 50 cm^3 of a liquid and then pour it into the beaker. Write down the reading on the balance. This is the mass of 50 cm^3 of the liquid.

Aim

Investigate the properties of water by determining the specific heat capacity of water and obtaining a temperature–time graph for melting ice.

Your task

You will find out what happens to the temperature of ice as it melts, and how much energy is needed to increase the temperature of a certain mass of water by 1 °C.

Method

Melting ice

⚠ Wear eye protection.

A Put a boiling tube full of crushed ice into a beaker. Put a thermometer in the ice and note the temperature.

B Put the beaker onto a tripod and gauze. Pour hot water from a kettle into the beaker, and keep it warm using a Bunsen burner.

C Measure the temperature of the ice every minute and record your results in a table. Stop taking readings 3 minutes after all the ice has melted.

D Note the times at which the ice starts to melt and when it appears to be completely molten.

Specific heat capacity

E Put a polystyrene cup onto a battery powered balance and zero the balance. Then fill the cup almost to the top with water and write down the mass of the water.

F Put a thermometer in the water and support it. Put a 12 V electric immersion heater into the water, making sure the heating element is completely below the water level. Connect the immersion heater to a joulemeter.

G Record the temperature of the water, and then switch the immersion heater on. Stir the water in the cup gently using the thermometer.

H After five minutes record the temperature of the water again and also write down the reading on the joulemeter.

Aim

Investigate the extension and work done when applying forces to a spring.

Your task

Investigate the force needed to stretch springs and calculate how much work is done when a spring is stretched.

The work done to stretch a spring is calculated using the following equation:

$$\underset{(J)}{\text{energy transferred in stretching}} = \frac{1}{2} \times \underset{(N/m)}{\text{spring constant}} \times \underset{(m)^2}{(\text{extension})^2}$$

Method

⚠ Wear eye protection while you carry out this investigation.

A Set up the apparatus as shown in photo B. The zero on the ruler should be level with the bottom of the unstretched spring.

B Measure the length of the spring with no weights hanging on it and write it down.

C Hang a 1 newton weight on the spring. Record the new length of the spring.

D Repeat step C until you have found the length of the spring with 10 different masses.

E Repeat steps A to D for a different spring.

F Use your results to calculate the spring constant for each spring.

Appendix 5

Teacher worksheets

Biology

Core practical 1: CB1b Plant and animal cells 170
Core practical 2: CB1g Enzyme activity 172
Core practical 4: CB1h Transporting substances 174

Chemistry

Core practical 1: CC2c and d Paper chromatography and distillation 176
Core practical 2: CC8d Alkalis and balancing equations 179

Physics

Core practical 1: CP2d Newton's Second Law 180
Core practical 2: CP4b: Wave velocities 182

Notes:

- Some core practicals are not yet final, and so the teacher and technician sheets are not yet included in this guide.
- Once core practical support sheets are finalised, they will be added to this appendix, and the list above will be updated to reflect this.
- A rough method has been included for all core practicals which do not yet have a full worksheet. These can be found in appendix 4.

Separate science worksheets are not yet final, so there are no worksheets/methods. A draft equipment list has been included in Appendix 3 for all practicals.

Objectives

B1.4 Demonstrate an understanding of size and scale, including the use of estimations and when they should be used.

B1.6 *Investigate biological specimens using microscopes, including magnification calculations and labelled scientific drawings from observations.*

Maths requirements

1d Make estimates of the results of simple calculations, without using a calculator.

2h Make order of magnitude calculations.

Learning outcomes

S5 **CB1.1** Identify the parts of plant and animal cells.

S5 **CB1.1** Recall the parts of plant and animal cells.

S5 **CB1.1, CB1.6** Make drawings of plant and animal cells using a light microscope and identify their parts.

S6 **CB1.5** Estimate sizes using microscope fields of view.

S6 **CB1.5** Estimate sizes using scale bars.

Exploring

Examining plant and animal cells – core practical

Students use Worksheet CB1b.1 (which is the core practical) to look at simple animal and/or plant cells and identify their component parts. The first page of the worksheet looks at animal cells; students can use pre-prepared cells (Method 1) or prepare slides of their own cheek cells (Method 2). The second page of the worksheet gives various options for examining plant cells (Methods 3 and 4). The worksheet suggests a range of cell types that can be used. There is no requirement to cover all the cell types given on the worksheet, but students must prepare their own slides, use a microscope, calculate magnifications and make drawings of their observations.

It is recommend that all students do steps A and B of Method 1 to begin with, whatever cells they are then going on to observe. This will allow students to refresh their memories on microscope use, particularly those who have missed the work in the previous topic, and Skills Sheet UE 3 can be used to support this. These two steps at the start of Method 1 will also give students the opportunity to perform magnification calculations and measure the different fields of view that they will later use to observe cells. Skills Sheet UE 4 can be used to provide help with fields of view. When students are making their own slides, it is worth demonstrating what they need to do beforehand. Skills Sheet UE 2 can be used to support this.

Students should make drawings of their observations and add appropriate labels.

For demonstration, it is worth showing some pre-prepared cells in which mitochondria show up. These can be bought commercially or you can make your own using methylene blue − basic fuchsin stain, although the staining procedure (freely available on the Internet) is quite involved.

Support: Have an appropriate micrograph of human cheek cells/onion cells/rhubarb cells/*Elodea* cells on the board to help students identify the cells under the microscope and label them appropriately. You may need to give them the magnification. Help students with field of view measurements by giving them the sizes of the fields of view with the different objective lenses (or omit field of view work with very weak students). The diameters of the fields of view between different objective lenses are proportional, and so if you know the field of view with the low power objective you can work out the fields of view with the more powerful objective lenses. For example, if the total magnification using the lowest power objective is ×20 and using the next most powerful objective gives a total of x100, the conversion factor between them is 100/20 = 5. That is to say, the diameter of this field of view is 5 times smaller than the diameter of the lowest power objective field of view.

Stretch: Encourage students to complete as many of the different cell types as possible, and to add scale bars to their drawings.

⚠ Wear eye protection. Do not allow students to angle microscope mirrors towards the Sun, as this can seriously damage eyesight. Students should not eat the onion or rhubarb. Students should take care not to cut themselves when using glass slides. The use of one arm of a pair of forceps or a cocktail stick is preferred for lowering coverslips, rather than the use of mounted needles. Students should wear gloves if working with stains. Anything that has been in the mouths of students needs to be placed in disinfectant after use.

Expected results

Students should identify, draw and label cells and their parts. It is likely that they will not be able to see mitochondria, even on the highest magnification, although they may see small granules within the cytoplasm that may be a range of things depending on the cell type.

Course resources

AAP: Worksheet CB1b.1, Optional: Skills Sheets UE 2, UE 3, UE 4

Equipment

microscope, sterile (autoclaved) wooden spatulas/tongue depressors, access to beaker of 1% Virkon in which to dispose of used spatulas/tongue depressors, selection of pre-prepared slides of plant and animal cells (e.g. cheek cells, epithelial cells, palisade cells), plant material (e.g. onion, rhubarb and/or Elodea − decide before the practical whether to provide one tissue types for all students or to provide a range so that some or all students have the opportunity to observe different types of plant cells), stain (e.g. methylene blue, iodine solution), paper towel, gloves, plain glass microscope slide, coverslip, pipette, water

Objectives

B1.9 Explain the effects of temperature, substrate concentration and pH on enzyme activity.

B1.11 Demonstrate an understanding of rate calculations for enzyme activity.

B1.10 *Investigate the factors that affect enzyme activity.*

Maths requirements

1a Recognise and use expressions in decimal form.

1c Use ratios, fractions and percentages.

2b Find arithmetical means.

2c Construct and interpret frequency tables and diagrams, bar charts and histograms.

4a Translate information between graphical and numerical form.

4e Draw and use the slope of a tangent to a curve as a measure of rate of change.

Learning outcomes

S8 CB1.9 Describe the effect of pH on enzyme activity.

S8 CB1.9 Explain what is meant by the optimum pH/temperature of an enzyme.

S9 CB1.11 Calculate the rate of enzyme activity from experimental data.

S9 CB1.9 Explain why temperature, substrate concentration and pH affect enzyme activity.

Exploring

Enzyme activity (pH and/or substrate concentration)

Full instructions for an investigation into the effect of pH on enzyme activity are given on Worksheet CB1g.1, which is the core practical for this topic. It uses the same reaction (amylase and starch) as for Exploring 1 in *CB1f Enzyme action*. This investigation could be adapted to look at the effect of substrate concentration at a set temperature and pH (e.g. using 2%, 1.6%, 1.2%, 0.8% and 0.4% starch solutions).

For investigations into the effect of pH using starch/amylase, the buffer solutions of different pH can be made as follows:

pH	**3**	**4**	**5**	**6**	**7**	**8**
Volume of 0.2 mol dm^{-3} Na_2HPO_4	20.55	38.55	51.50	63.15	82.35	97.25
Volume of 0.1 mol dm^{-3} citric acid	79.45	61.45	48.50	36.85	17.65	2.75

Alternatively, addition of dilute hydrochloric acid and sodium hydrogen carbonate solution (prior to adding the amylase) and testing with pH paper/ meter will give a reasonable range of pHs to test. Human amylase works best at a pH of about 7.

Before the lesson, check the speed of the reaction using 2 cm^{-3} of starch with 2 cm^{-3} of amylase and 1 cm^3 of buffer at pH 6. It should take about 60 seconds. If the reaction is too fast either reduce the enzyme volume or increase the starch volume. If the reaction is too slow increase the enzyme volume or concentration or reduce the starch volume or concentration.

This practical can be followed using datalogging equipment and a colorimeter or light sensor, though this is not always successful. It is advisable to try this out yourself first.

⚠ Students should wear eye protection while working with iodine solution, and should avoid splashing the solution. Treat splashes on skin or clothing with 0.1 mol dm^{-3} sodium thiosulfate solution until the brown stain is removed, then wash with water. Students should take care when working with water above 50 °C. If using saliva, students should only work with their own saliva. Contaminated apparatus should be rinsed after the activity and placed in bleach or disinfectant solution for about 30 minutes before washing normally.

Support: Restrict the pHs tested by the students to 4, 6 and 8. This should simplify interpretation and produce a peak at pH 6.

Stretch: Ask students to identify the limitations of the method they have used (in particular the limits created by the number of different pHs to be investigated), and consider how best to overcome these given the restrictions of time and equipment available.

Expected results

The optimum pH for human salivary amylase is pH 7. Other amylases may vary from this value, but there should be one pH that clearly allows greater enzyme activity than the others.

Course resources

AAP: Worksheet CB1g.1

Equipment

In amylase/starch investigation in the effect of pH, for each pH tested: test tube containing 5 cm^3 freshly made 1% starch suspension (mix 5 g soluble starch with a little cold water, pour into 500 cm^3 of boiling water and stir well, then boil until you have a clear solution), test tube containing 1 cm^3 1% amylase solution (or 0.5% pancreatin solution) or saliva collected by student (see instructions in CB1e Exploring 1), water bath at optimum temperature for the enzyme (e.g. 37 °C), buffer solution at a set pH (see table above), 5 cm^3 syringe or pipette, beaker of water for washing pipette, eye protection, 0.01 mol dm^{-3} iodine solution, well tray (spotting tile).

Optional: if using saliva – hypochlorite (bleach) solution or 1% Virkon solution for disinfection of equipment and benches, small beaker or other container for collecting saliva

Objectives

- **B1.15** Explain how substances are transported by diffusion, osmosis and active transport.
- **B1.16** *Investigate osmosis in potatoes.*
- **B1.17** Calculate percentage gain and loss of mass in osmosis.

Maths requirements

- **1c** Use percentages.
- **2b** Find arithmetic means.
- **4a** Translate information between graphical and numeric forms.

Learning outcomes

- **S7** **CB1.15** State that substances are transported by diffusion, osmosis and active transport.
- **S6** **CB1.15** Explain how substances are transported by diffusion.
- **S9** **CB1.15** Explain how substances are transported by osmosis.
- **S8** **CB1.16** Investigate osmosis in potatoes.
- **S9** **CB1.17** Calculate percentage gain and loss of mass in osmosis.

Exploring

Diffusion and osmosis

Worksheet CB1h.1 provides support for the core practical on osmosis in potato slices (specification statement B1.16). This practical includes calculations that some students may have problems with. In the osmosis practical, results from different groups are collated and compared to check for outliers, then mean values calculated for each solution. It may help to prepare a class spreadsheet for displaying all the results for discussion. The identification of outliers may provide useful information for the evaluation of the investigation. If students need further practice in calculating means, this can be added to the diffusion practical by comparing groups' results in a similar way.

Osmosis: The osmosis practical measures the percentage change in mass of strips of potato placed in different concentrations of solution. Using a coloured sugar syrup, such as blackcurrant squash (not sugar-free), makes it easier for students to see that the solutions are of different concentrations. However, a concentrated sucrose solution with added food colouring, which is then used to produce different dilutions, is also suitable.

Note that some students may be confused by the idea that a more concentrated solution contains proportionately fewer water molecules than a weaker or more dilute solution. So it may be worth checking understanding of this when students are carrying out this practical. If needed, talk in terms of a higher concentration of solute containing fewer water molecules.

The following table starts with a sucrose or blackcurrant squash concentration of about 550 g/dm^3 of sucrose.

Concentration of initial solution (%)	Volume of blackcurrant squash needed to make 30 cm^3 of solution	Volume of water needed to make 30 cm^3 of solution	Final volume of solution made (cm^3)
0 (pure water)	0	30	30
40	12	18	30
80	24	6	30
100	30	0	30

Cut the potato strips as near to lesson time as possible using a cork borer or potato chipper to get identical diameters/widths. Then cut them all to the same length. Make sure this length will fit inside a boiling tube if that is what students will be using. Wrap the strips in a damp cloth or plastic film until the lesson. This means that the strips placed in pure water should gain mass during the experiment, as the cells will not be fully turgid at the start.

Support: Students may need help in drawing up their table and completing the calculations. They may also need help working out how to record negative numbers on their chart.

Stretch**:** Ask students how they could adapt this practical to find the concentration inside potato cells.

⚠ Students should be warned not to taste or drink any of the solutions, or taste the potato.

Expected results

Students should find that the potato strip in pure water gains mass, while the rest lose mass in relation to how much water was in the solution (i.e. the potato in the solution with least water (100% solution) loses most mass).

Course resources

AAP: Worksheets CB1h.1

Equipment (per group)

Osmosis: four potato strips of identical size, accurate balance, four boiling tubes and rack (or beakers), waterproof pen, four labelled solutions containing different concentrations of initial (approx. 550 g/dm^3) sucrose solution (0%, 40%, 80%, 100%), forceps, paper towels

Objectives

C3.3	Explain the experimental techniques for separation of mixtures by: (e) paper chromatography.
C3.4	Describe an appropriate experimental technique to separate a mixture, knowing the properties of the components of the mixture.
C3.5	Describe paper chromatography as the separation of mixtures of soluble substances by running a solvent (mobile phase) through the mixture on the paper (the paper contains the stationary phase), which causes the substances to move at different rates over the paper.
C3.6	Interpret a paper chromatogram: (c) to distinguish between pure and impure substances (d) to identify substances by comparison with known substances (e) to identify substances by calculation and use of R_f values.
C3.7	*Investigate the composition of inks using simple distillation and paper chromatography*.

Maths requirements

1c	Use ratios, fractions and percentages.
3a	Understand and use the symbols: =, <, <<, >>, >, ∝ and ~.
3c	Substitute numerical values into algebraic equations using appropriate units for physical quantities.
4a	Translate information between graphical and numeric form.

Learning outcomes

S5	CC3.3	Describe how some mixtures can be separated by chromatography.
S5	CC3.6a	Identify pure substances and mixtures on chromatograms.
S5	CC3.6b	Identify substances that are identical on chromatograms.
S6	CC3.5	Draw and interpret diagrams showing how chromatography is done.
S6	CC3.5	Explain how substances can be separated by chromatography.
S6	CC3.6c	Calculate R_f values and use them to identify substances.

Exploring

Chromatography of ink

This practical forms part of the core practical requirement of the specification. Worksheet CC2c.1 provides instructions to help students to compare the mixtures of dyes in the inks used in black marker pens or felt-tip pens. Have a selection of pens available, labelled with letters for ease of identification. These should be tested before the lesson to ensure that they do contain different mixtures of dyes. One set of pens will be sufficient for the whole class. Alternatively bottles of black inks from different manufacturers could be used instead of pens.

This is a relatively simple procedure, similar to chromatography investigations that students will have done during KS3 work. The second side of the worksheet contains two separate sheets that can be used to help students plan a further investigation. The first suggests investigating the mixtures of dyes in inks other than black, or looking at mixtures in 'permanent' inks. Students will need to use solvents other than water for this.

The second sheet uses a crime scenario, asking students to test different pens to see if one of them could have been used to write a 'poison pen' letter. Have a selection of pens available, and also a pre-prepared chromatogram made from one of them, with the final solvent level marked to allow students to make R_f calculations from it. This is the chromatogram supposedly made using ink extracted from the letter. Also have available a short paragraph of text describing how the chromatogram was made. You could follow this up by discussing whether or not identifying the type of pen used for writing the letter actually proves that the suspect from whose home the pen was taken was the writer (no – because many other people own a similar pen; or the pen could have been left in their home by someone else).

⚠ The solvent suggested for biro ink is flammable and harmful – ensure there are no naked flames in the lab.

Support: The further investigation looking at the range of dyes in different coloured pens is the most suitable for students working at this level. Help them to write a simple plan for their investigation, and check that their apparatus is set up correctly to obtain suitable chromatograms.

Stretch: If doing the 'Poison Pen' activity, some of the pens provided could contain water-soluble inks and some could contain permanent inks – this will allow rapid elimination of some of them. In addition, students could be provided with several types of chromatography paper, so they will need to find out the type of paper used in the pre-prepared chromatogram and use that type so that they can compare R_f values.

Expected results

Black inks usually include black dyes and blue dyes, and sometimes other colours as well. The results of the other investigations will depend on the pens available.

Course resources

AAP: Worksheet CC2c.1

Equipment

250 cm^3 beaker, chromatography paper cut to fit the beaker used and stapled to a splint or attached to a pencil or glass rod using paper clips, four different black felt pens or water-soluble marker pens labelled A–D

For the chromatography investigations: selection of different coloured marker pens or felt-tip pens, selection of pens with 'permanent' (non-water-soluble) inks, solvent that will dissolve the permanent ink (for biro ink a mixture of butan-1-ol, ethanol, water (3:1:1 by volume) is suitable; and the addition of a few drops of 880-ammonia may produce a better chromatogram). For other permanent inks try ethanol, propanone or propan-2-ol, but test them before the lesson to see if they work with the pens to be used.

For the 'Poison Pen' investigation: selection of four or more pens of one colour (blue or black) with different combinations of dyes, labelled Suspect 1, Suspect 2 etc., pre-prepared chromatogram made using one of the pens using the same paper that students will use, suitable solvent (see above) if the pens to be tested have permanent inks.

Objectives

C3.3 Explain the experimental techniques for separation of mixtures by:

(a) simple distillation

C3.4 Describe an appropriate experimental technique to separate a mixture, knowing the properties of the components of the mixture.

C3.7 *Investigate the composition of inks using simple distillation*.

C0.6 Evaluate the risks in a practical procedure and suggest suitable precautions for a range of practicals including those mentioned in the specification.

Maths requirements

1c Use ratios, fractions and percentages.

4c Plot two variables from experimental or other data.

Learning outcomes

S5 **CC3.3** Describe how to carry out, and explain what happens in, simple distillation.

S6 **CC3.3** Explain what precautions are needed to reduce risk in a distillation experiment.

Exploring

Distillation

This practical forms part of the core practical requirement of the specification. It is supported by the information in the Student Book *CC2d Distillation*. Students follow the instructions on Worksheet CC2d.1 using simple distillation apparatus to purify ink. The first page has the experimental instructions. Ink will show an obvious visual indication that the water has been purified. Depending on the precise dimensions of the delivery tube, the beaker of ice water may need to be supported above bench height.

Support: Demonstrate the procedure first, showing how to clamp the flask and how to heat it gently.

Stretch: Give students a list of available apparatus and ask them to design their own set-up to successfully purify the water, instead of giving them the first page of the worksheet with instructions to follow.

⚠ Wear eye protection.

⚠ Warn students of the risk of scalding from hot steam. Explain the use of anti-bumping granules to help the liquid boil more smoothly and reduce the risk of boiling over.

Expected results

Students will produce a clear liquid (pure water) as the distillate. The steam should have a temperature of 100 °C.

Course resources

AAP: Worksheet CC2d.1

Equipment

For each group: eye protection, a conical flask with side-arm, rubber bung with thermometer, delivery tube, test tube, beaker (250 or 400 cm^3), crushed ice, Bunsen burner, tripod, gauze, heat-resistant mat, ink, anti-bumping granules

If side-arm flasks are not available, an alternative is to use a two-hole bung with a thermometer and delivery tube.

Objectives

C0.1 Recall the formulae of elements, simple compounds and ions.

C3.6 *Investigate the change in pH on adding powdered calcium hydroxide or calcium oxide to a fixed volume of dilute hydrochloric acid.*

Maths requirements

1c Use ratios, fractions and percentages.

4a Translate information between graphical and numeric form.

4c Plot two variables from experimental or other data.

Learning outcomes

CC0.1 Recall the chemical formulae of some common compounds.

6 **CC0.3** Recall and use state symbols.

Exploring

Neutralising an acid – Core practical

This is a Core practical in which students add successive weighed portions of calcium hydroxide powder to a fixed amount of dilute hydrochloric acid, and estimate the pH of the reaction mixture using universal indicator paper. They then plot a graph of pH against mass of calcium hydroxide added.

The practical activity on Worksheet CC8d.1 is written for the use of universal indicator paper to estimate pH, but you may prefer to use pH meters to measure the pH instead.

Support: Provide eight 0.3 g pre-weighed portions of calcium hydroxide powder to each group that needs it. Provide graph paper with suitable axes already drawn on it (pH 0–14 on vertical axis; mass of calcium hydroxide 0–2.4 g on horizontal axis). Additionally, or alternatively, Skills Sheets PD5 and PD6 may be useful in helping students to draw their graphs.

Stretch: Give students narrow range indicator paper to increase the precision of their pH estimates.

Expected results

The pH will increase as more calcium hydroxide is added, with the end-point at approximately 1.85 g of calcium oxide. Calcium hydroxide is sparingly soluble (about 0.17 g/100 cm^3 H_2O) so beyond this excess calcium hydroxide will be seen.

Course resources

AAP: Worksheet CC8d.1. Optional: Skills Sheets PD5, PD6

Equipment

eye protection, 100 cm^3 beaker, 50 cm^3 measuring cylinder, ±0.1 g balance, spatula, stirring rod, white tile, universal indicator paper, pH colour chart, dilute hydrochloric acid, calcium hydroxide powder, graph paper

Safety

Eye protection should be worn. Students should wash their hands afterwards. Calcium hydroxide is an irritant, with a risk of serious damage to eyes. Dilute hydrochloric acid is an irritant.

Objectives

P1.13 Recall and use Newton's Second Law as force (newton, N) = mass (kilogram, kg) × acceleration (metre per second squared, m/s^2), $F = m \times a$.

P1.15 *Investigate the relationship between force, mass and acceleration (such as an investigation that uses stacked trolleys.*

Maths requirements

3a Understand and use the symbols: =, <, <<, >>, >, ∝, ~.

3b Change the subject of an equation.

3c Substitute numerical values into algebraic equations using appropriate units for physical quantities.

3d Solve simple algebraic equations.

Learning outcomes

S6 **CP1.13** Describe what an acceleration is.

S6 **CP1.13** List the factors that affect the acceleration of an object.

Exploring

Investigating force, mass and acceleration

This practical forms part of the core practical requirement of the specification. See Worksheet CP2d.1 for a full method for this practical. The method on the worksheet assumes that students are investigating the effects of mass on acceleration with a constant force.

If sufficient light gates are not available, students should mark a measured length on the ramp and use a stop clock to time how long the trolley takes to travel this distance. The acceleration can then be calculated using $a = (v - u) / t$ (students will have met this if they have studied Unit CP1).

Support: The practical could be simplified for students working at lower levels by asking them to time how long it takes the trolley from release to the end of the ramp. The time can be used as a measure of the acceleration. It will also be helpful to suggest the masses to be used and the number of repeats needed in their investigation. Ensure that students know how to draw a curve of best fit. Skills sheet PD6 *Scatter graphs* may be useful.

Stretch: Show students the apparatus and discuss the idea of a friction-compensated ramp. Show them how to set up light gates, and then ask them to plan their own method to investigate the effects of force and mass on acceleration. If time permits, students could investigate both variables or groups could be given just one of them to investigate. For students investigating the effects of force, note that the falling masses are also being accelerated and so form part of the overall system mass. The total mass of the system must therefore be kept the same. This is best done by using the same total number of masses for each run and transferring them from the trolley to the hanging stack to increase the force.

⚠ Ensure masses cannot fall on feet by placing a box full of crumpled newspaper beneath the weights.

⚠ Take care when moving ramps as these can be heavy. If the large 2 m ramps are being used, set these out before the lesson.

Expected results

If investigating the effect of mass, they should find that the acceleration is inversely proportional to mass (encourage students to plot acceleration against 1/mass to check for inverse proportionality). Students investigating the effects of force should find that acceleration is proportional to force if a fixed total mass is used.

Course resources

AAP: Skills sheet PD 6, Worksheet CP2d.1

Equipment

trolley, ramp, blocks, pulley, string, stacking masses, mass hanger, sticky tape, card, sticky tack, 2 light gates, 2 clamps and stands, access to balance, datalogger (set up to measure velocities from the light gate readings and the time between the two readings – students will need to enter the length of the card mounted on their trolley), box of crumpled newspaper

Objectives

P4.6	Recall and use both the equations below for all waves: wave speed (metre/second, m/s) = frequency (hertz, Hz) × wavelength (metre, m) $v = f \times \lambda$ wave speed (metre/second, m/s) = distance (metre, m) ÷ time (second, s) $v = x/t$
P4.7	Describe how to measure the velocity of sound in air and ripples on water surfaces.
P4.17	*Investigate the suitability of equipment to measure the speed/frequency/wavelength of a wave in a solid and a fluid.*

Maths requirements

1a	Recognise and use expressions in decimal form.
1b	Recognise and use expressions in standard form.
2a	Use an appropriate number of significant figures.
2b	Find arithmetic means.
3a	Understand and use the symbols: =, <, <<, >>, >, ∝, ~.
3b	Change the subject of an equation.
3c	Substitute numerical values into algebraic equations using appropriate units for physical quantities.
3d	Solve simple algebraic equations.

Learning outcomes

6	CP4.6	Recall the equation relating wave speed, frequency and wavelength
8	CP4.6	Use the equation relating wave speed, frequency and wavelength.
6	CP4.6	Recall the equation relating wave speed, distance and time.
8	CP4.6	Use the equation relating wave speed, distance and time.
7	CP4.7	Describe how to measure the velocity of sound in air.
7	CP4.7	Describe how to measure the velocity of waves on the surface of water.

Exploring

1. Measuring waves in liquids and solids – Core practical

This practical forms part of the Core Practical requirement of the specification. It is supported by the information on *CP4b Investigating waves* in the Student Book. This practical is described in two parts on Worksheet CP4b.1.

Speed of waves on water: Each group needs a ripple tank. Students are asked to estimate the speed of a wave by measuring how far it travels in a certain time, and also to calculate it from measurements of frequency and wavelength. Note that the speed of a wave in water depends on the wavelength and the depth, so the results students obtain will depend on both the depth of water in their tank and the frequency they set. They should use digital cameras, if available, to help them with the measurements.

Measuring waves in a solid: The method uses the fact that a standing wave in a cylindrical object has a wavelength twice the length of the object, but students are not expected to recall this fact. The rod is suspended using rubber bands and hit on one end with a hammer. Use a smartphone frequency app to detect the highest frequency.

Support: Students may need help setting up the ripple tank.

Stretch: If different lengths of rod are available, students could repeat the measurements in a solid and compare their results for various lengths (there should be no difference), and/or look up the speed of sound in the materials used and compare their results with published data.

Expected results

To compare the appropriateness of the apparatus used for measuring waves in different materials.

Course resources

AAP: Worksheet CP4b.1

Equipment

Speed of waves on water: ripple tank (ideally with beaches to prevent reflections), stopwatch, ruler, digital camera

Speed of sound in solid: 2 clamps and stands, 2 rubber bands, long metal rod (up to 1 m long), metre rule, hammer, smartphone with frequency app