GCSE Science:
Required practical activities

Introduction

Practical work is at the heart of science – that's why we have placed it at the heart of each of our GCSE science specifications. By carrying out carefully considered practical work, students will enhance their investigative thinking, improve their mastery of techniques and consolidate their understanding of key scientific concepts.

The assessment of practical skills is changing, so we are creating documents to help you and your students prepare for the changes including the *Required practical summary*. It provides further details on how the sample lessons in this document meet the specified practical skills, mathematical skills and Working scientifically skills.

This document contains the required practical activities for the separate sciences: Biology, Chemistry and Physics, as well as the combined sciences: Trilogy and Synergy. By undertaking the required practical activities, students will have the opportunity to experience all of the required apparatus and techniques needed for the qualifications. However, these activities are only suggestions and teachers are encouraged to develop activities, resources and contexts that provide the appropriate level of engagement and challenge for their own students.

These sample activities have been written by practising teachers and use apparatus and materials that are commonly found in most schools. The lessons are grouped according to the subjects biology, chemistry and physics. Where a required practical activity is listed that is applicable to separate science **only** and not for the combined sciences Synergy and Trilogy, it will be indicated.

Please note:

- there are 10 required practicals for biology, including the three additional practicals needed for the standalone GCSE Biology qualification – practicals 2, 8 and 10
- there are 8 required practicals for chemistry, including the two additional practicals needed for the standalone GCSE Chemistry qualification – practicals 2 and 7
- there are 10 required practicals for physics, including the two additional practicals needed for the standalone GCSE Physics qualification – practicals 2 and 10.

Getting started

Risk assessment

These required practical activities have been suggested by teachers who have successfully carried them out in the lab. However it is the responsibility of the centre to ensure that full risk assessments have been carried out in each case.

Trialling

The practical activities should be trialled before use with students to ensure that they match the resources available within the school or college.

GCSE science practical handbook

Further guidance on carrying out effective practical work will be made available in the new AQA *Science Practical Handbook* which will be published in the spring 2016. It will provide resources for teachers and students including:

1. cross-board apparatus and techniques and Ofqual regulations
2. practical skills assessment in question papers
3. sample practical lessons
4. guidelines for supporting students in practical work
5. improving the quality of practical work
    a. working scientifically
    b. collecting data
    c. graphing
    d. glossary of terms
6. practical progression ladders
7. student resources.

GCSE Biology required practical activity 1: Microscopy

Teachers' notes

Required practical activity	Apparatus and techniques
Use a light microscope to observe, draw and label a selection of plant and animal cells. A scale magnification must be included.	AT 1, AT 7

Using a light microscope to observe, draw and label cells in an onion skin

Materials

In addition to access to general laboratory equipment, each student needs:

- a small piece of onion
- a knife or scalpel
- a white tile
- forceps
- a microscope slide
- a coverslip
- a microscope
- iodine solution in a dropping bottle.

Technical information

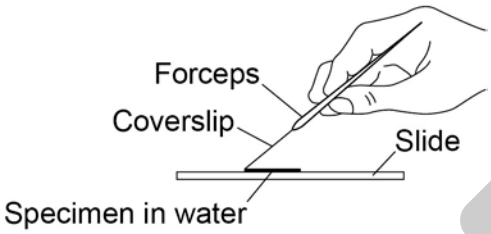
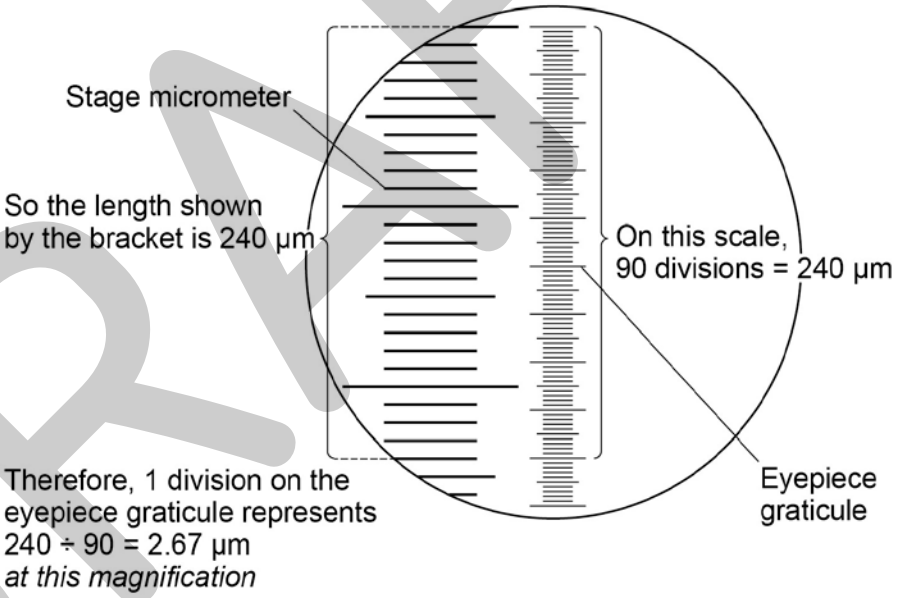
Iodine solution may be purchased ready-made or can be made up following the instructions on CLEAPSS recipe card number 50.

Additional information

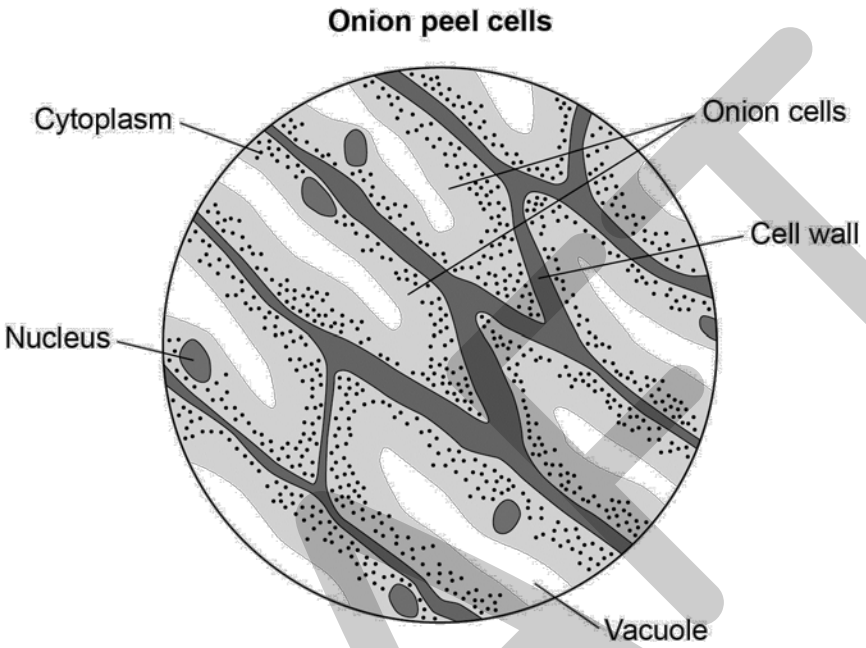
The techniques involved should be demonstrated to the students. The students should be allowed time to practice the technique of preparing a wet slide.

It is particularly important that they practise the technique of lowering the cover slip on to the slide so that no air bubbles are trapped.

Students should be familiar with the use of a microscope and how to use an eyepiece graticule.

Techniques requiring practice	Additional information
Lowering the coverslip on to the slide	
Using the microscope	Students should be given guidance in how to use an optical microscope, with particular reference to the coarse and fine focus controls.
Using an eyepiece graticule	Part of the stage micrometer viewed at x400 magnification  A simple eyepiece graticule, such as the one above, could be used. Students need to appreciate that with different objective lenses the distance between the lines on the graticule changes. Unless a stage micrometer is available, students will need to be told what each division on the graticule is worth for each different objective power.
Using a stage micrometer	If a stage micrometer is available students will need to be taught how to use it, using a diagram similar to the one above.

Students should be able to see the following using ×400 magnification.



Risk assessment

- Risk assessment and risk management are the responsibility of the school or college.
- Care should be taken when using iodine solution to avoid staining and ingestion.
- Safety goggles should be used when handling iodine solution.

Trialling

The practical should be trialled before use with students.

GCSE Biology required practical activity 1: Microscopy

Student sheet

Required practical activity	Apparatus and techniques
Use a light microscope to observe, draw and label a selection of plant and animal cells. A scale magnification must be included.	AT 1, AT 7

Using a light microscope to observe, draw and label cells in an onion skin

In this experiment you will prepare a microscope slide to show the cells and their contents in an onion leaf.

You will use an optical microscope to observe, draw and measure the cells in the onion skin. You will also need to identify structures within the cells.

Learning outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

Method

You are provided with the following:

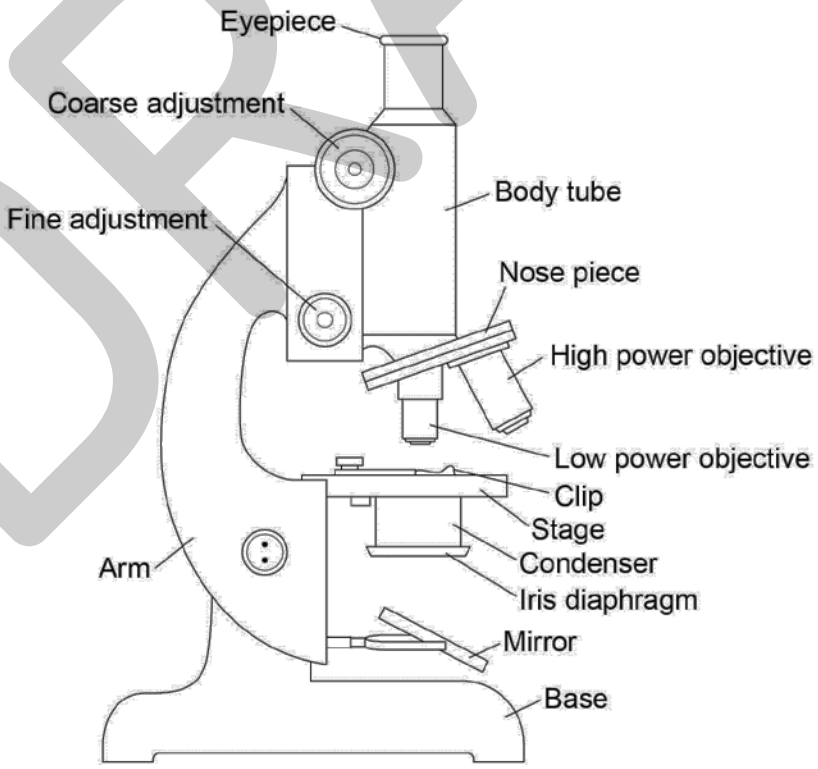
- a small piece of onion
- a knife or scalpel
- a white tile
- forceps
- a microscope slide
- a coverslip
- a microscope
- iodine solution in a dropping bottle.

You should read these instructions carefully before you start work.

1. Use a dropping pipette to put one drop of water onto a microscope slide.
2. Separate one of the thin layers of the onion.
3. Peel off a thin layer of epidermal tissue from the inner surface.
4. Use forceps to put this thin layer on to the drop of water that you have placed on the microscope slide.
5. Make sure that the layer of onion cells is flat on the slide.
6. Put two drops of iodine solution onto the onion tissue.
7. Carefully lower a coverslip onto the slide. Do this by placing one edge of the coverslip on the slide and then using a mounted needle to lower the other edge onto the slide.
8. Use a piece of filter paper to soak up any liquid from around the edge of the coverslip.
9. Put the slide on the microscope stage.

Using the microscope

The diagram shows a typical microscope.



This microscope has a mirror to reflect light up through the slide. Some microscopes have a built-in light instead of a mirror.

10. Turn the nosepiece to the lowest power objective lens.
11. Looking from the side (**not** through the eyepiece) turn the coarse adjustment knob so that the end of the objective lens is almost touching the slide.
12. Now looking through the eyepiece, turn the coarse adjustment knob in the direction to increase the distance between the objective lens and the slide. Do this until the cells come into focus.
13. Now rotate the nosepiece to use a higher power objective lens.
14. Slightly rotate the fine adjustment knob to bring the cells into a clear focus and use the low-power objective (×40 magnification) to look at the cells.
15. When you have found some cells, switch to a higher power (×100 or ×400 magnification).
16. In the space below make a clear, labelled drawing of some of these cells. Make sure that you draw and label any component parts of the cell.
17. Use an eyepiece graticule to measure the length of one of the epidermal cells that you have drawn. Remember to include the units.
18. Now measure the same cell in your drawing.
19. Calculate the magnification of your drawing, using the formula:

magnification = length of drawing of cell/actual length of cell

20. Write the magnification underneath your drawing.

GCSE Biology required practical activity 2: Osmosis

Teachers' notes

Required practical activity	Apparatus and techniques
Investigate the effect of a range of concentrations of salt or sugar solutions on the mass of plant tissue.	AT 1, AT 3, AT 5

Investigating osmosis in potato tissue

Materials

In addition to access to general laboratory equipment, each student needs:

- a potato
- a cork borer
- a ruler
- a 10 cm^3 measuring cylinder
- labels
- three boiling tubes
- a test tube rack
- paper towels
- a scalpel
- a white tile
- 1 M sugar solution
- 0.5 M sugar solution
- distilled water
- a top-pan balance.

Technical information

Make up a solution of 1 M sucrose solution by adding distilled water to 342.3 g of sugar (dissolve by heating) and making up to 1 litre in a volumetric flask. Measure out 500 ml of this 1 M solution and place in a separate flask. Make the original flask up to 1 litre again by adding more distilled water to make the 0.5 M solution. This will provide enough for a class as each student needs 10 cm^3 of each, in addition to 10 cm^3 of distilled water.

To avoid students having to use sharp implements the potato cylinders can be prepared for them. They must be freshly prepared.

Ensure that potato cylinders do not have any skin on them as this affects the movement of water molecules.

Additional information

Other sugar concentrations could be used (eg 0.2 M, 0.4 M, 0.6 M, 0.8 M, 1.0 M and distilled water 0 M) and distributed across the class so that each student does three. The class data could then be collated before plotting the graph. Where the line of best fit crosses the x-axis is an approximation of the concentration inside the potato tissue.

The length of time that the potato cylinders are left in the sugar solutions can be adjusted to suit lesson timings. Better results are achieved if they are left for more than 30 minutes. They will start going mouldy if left for several days.

Risk assessment

- Risk assessment and risk management are the responsibility of the school or college.
- Care should be taken with the use of cork borers and scalpels when students are cutting their own potato cylinders. Small kitchen knives could be used if available.
- Care should be taken with the use of an electrical balance in the presence of water.

Trialling

The practical should be trialled before use with students.

Alternative practicals

Outline method	Suggested apparatus	Suggested reagents
Using salt solutions to investigate osmosis in potato tissue		
As above but with salt solution instead of sugar solution.	As above	Water, 1 M salt solution, 0.5 M salt solution
Investigating osmosis in onion cells		
Place slices of red onion into sugar solutions of different concentrations and leave overnight. Prepare a slide with a piece of onion tissue from each concentration. Observe the red onion cells under the microscope. Count 100 cells and record how many of these cells show signs of shrunken cell contents.	Red onion, white tile, scalpel, microscope, glass slide, cover slip, beakers	Water, 1 M sugar solution, 0.5 M sugar solution

GCSE Biology required practical activity 2: Osmosis

Student sheet

Required practical activity	Apparatus and techniques
Investigate the effect of a range of concentrations of salt or sugar solutions on the mass of plant tissue.	AT 1, AT 3, AT 5

Investigating osmosis in potato tissue

Osmosis is the movement of water through a selectively permeable membrane from an area of high concentration of water to an area of lower concentration of water.

Plant tissues, such as potato, can be used to investigate osmosis.

In this experiment potatoes are cut into equal sized cylinders. The changes in length and mass after leaving them overnight in sugar solution and distilled water can then be accurately compared.

Learning outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

Method

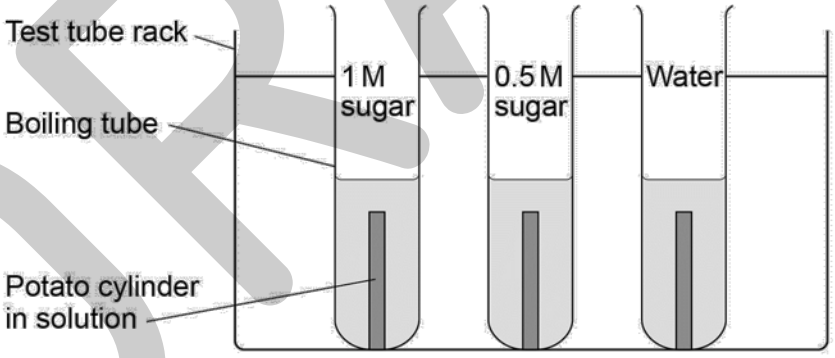
You are provided with the following:

- a potato
- a cork borer
- a ruler
- a 10 cm^3 measuring cylinder
- labels
- three boiling tubes
- a test tube rack
- paper towels
- a scalpel
- a white tile

- 1 M sugar solution
- 0.5 M sugar solution
- distilled water
- a top-pan balance.

You should read these instructions carefully before you start work.

1. Using a cork borer, cut three potato cylinders of the same diameter.
2. Trim the cylinders so that they are all the same length (about 3 cm).
3. Accurately measure and record the length and mass of each potato cylinder.
4. Measure out 10 cm^3 of the 1 M sugar solution and place into the first boiling tube (labelled 1 M sugar).
5. Measure out 10 cm^3 of 0.5 M sugar solution and place into the second boiling tube (labelled 0.5 M sugar).
6. Measure out 10 cm^3 of the distilled water into the third boiling tube (labelled water).
7. Add one potato cylinder to each tube (make sure you know which one is which in terms of the length and mass).



8. Record your lengths and masses in a table such as the one below.
9. Leave the potato cylinders in the boiling tubes overnight in the test tube rack.
10. Remove the cylinders from the boiling tubes and carefully blot them dry with the paper towels.
11. Re-measure the length and mass of each cylinder (make sure you know which is which).

	1 M sugar solution	0.5 M sugar solution	Distilled water
Initial length (mm)			
Final length (mm)			
Change in length (mm)			
Initial mass (g)			
Final mass in (g)			
Change in mass in (g)			

12. Draw a graph with ‘Change in mass in g’ on the y-axis against ‘Concentration of sugar solution’ on the x-axis.

GCSE Biology required practical activity 3: Enzymes

Teachers' notes

Required practical activity	Apparatus and techniques
Investigate the effect of pH on the rate of reaction of amylase enzyme. Students should use a continuous sampling technique to determine the time taken to completely digest a starch solution at a range of pH values. Iodine reagent is to be used to test for starch every 30 seconds. Temperature must be controlled by use of a water bath or electric heater.	AT 1, AT 2, AT 5, AT 8

Investigating the effect of temperature on the enzyme amylase

Materials

In addition to access to general laboratory equipment, each student needs:

- test tubes
- a test tube rack
- water baths (electrical or Bunsen burners and beakers)
- spotting tiles
- a 5 cm^3 measuring cylinder or syringe
- a glass rod
- a stop watch
- starch solution
- amylase solution
- iodine solution
- thermometers.

Technical information

A 1% solution of amylase and a 1% suspension of starch are appropriate for this experiment.

Amylase will slowly lose activity so it is best to make up a fresh batch, using the powdered enzyme, for each lesson. Otherwise any results collected on different days will not be comparable.

Starch suspension should also be made fresh. This can be done by making a cream of 5 g of soluble starch in cold water and pouring into 500 cm^3 of boiling water. Stir well and boil until you have a clear solution.

A 0.01 M solution of iodine is suitable for starch testing.

Additional information

It is best to check that the amylase breaks down the starch at an appropriate rate before students do this experiment. At around the optimum temperature, the end point should be reached within 1–2 minutes. Enzymes may degrade in storage. Testing beforehand will ensure that there is time to adjust concentrations or obtain fresh stocks if necessary.

It might be appropriate for each student to test only one or two temperatures, working in a pair or a group, so that results can be pooled. This would ensure that the tests were performed in the same lesson, and therefore are more comparable.

A wider range of temperatures could be investigated and class results could be collated. This would require more water baths, but students could make their own using beakers and Bunsen burners etc.

Risk assessment

- Risk assessment and risk management are the responsibility of the school or college.
- All solutions, once made up, are low hazard. Refer to Hazcard 33 for amylase.
- Iodine solution may irritate the eyes so safety goggles should be worn. Refer to Hazcards 54A and 54B.
- Safety goggles should be worn in the presence of hot water in water baths.
- Care should be taken with the use of naked flames in this experiment if students are using Bunsen burners to make water baths.
- Care should be taken with the presence of water and electrical equipment, if electrical water baths are being used.

Trialling

The practical should be trialled before use with students.

Alternative practicals

Outline method	Suggested apparatus	Suggested reagents
Investigating the effect of pH on the enzyme amylase		
As above but using different pH rather than temperatures.	Test tubes, test tube rack, spotting tiles, measuring cylinders or syringes, glass rods, stopwatch	As above plus buffer solutions of pH 4, 7 and 10
Investigating the effect of temperature on the enzyme pepsin		
Place egg albumen and pepsin solution into test tubes in water baths at different temperatures. Time how long it takes for the egg albumen to change from white to colourless.	Test tubes, test tube rack, water-baths, measuring cylinders or syringes, stopwatch	Egg albumen (boiled egg white), pepsin
Investigating the effect of pH on the enzyme pepsin		
As above but using different pH rather than temperatures.	Test tubes, test tube rack, measuring cylinders or syringes, stopwatch	Egg albumen (boiled egg white), pepsin, buffer solutions of pH 4, 7 and 10

GCSE Biology required practical activity 3: Enzymes

Student sheet

Required practical activity	Apparatus and techniques
Investigate the effect of pH on the rate of reaction of amylase enzyme. Students should use a continuous sampling technique to determine the time taken to completely digest a starch solution at a range of pH values. Iodine reagent is to be used to test for starch every 30 seconds. Temperature must be controlled by use of a water bath or electric heater.	AT 1, AT 2, AT 5, AT 8

Investigating the effect of temperature on the enzyme amylase

The enzyme amylase controls the breakdown of starch in our digestive system. We are able to simulate digestion, using solutions of starch and amylase in test tubes, and find the optimum conditions required.

The presence or absence of starch can be determined using iodine solution and, in this experiment, we can measure how long the amylase takes to break down the starch at different temperatures.

Learning outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

Method

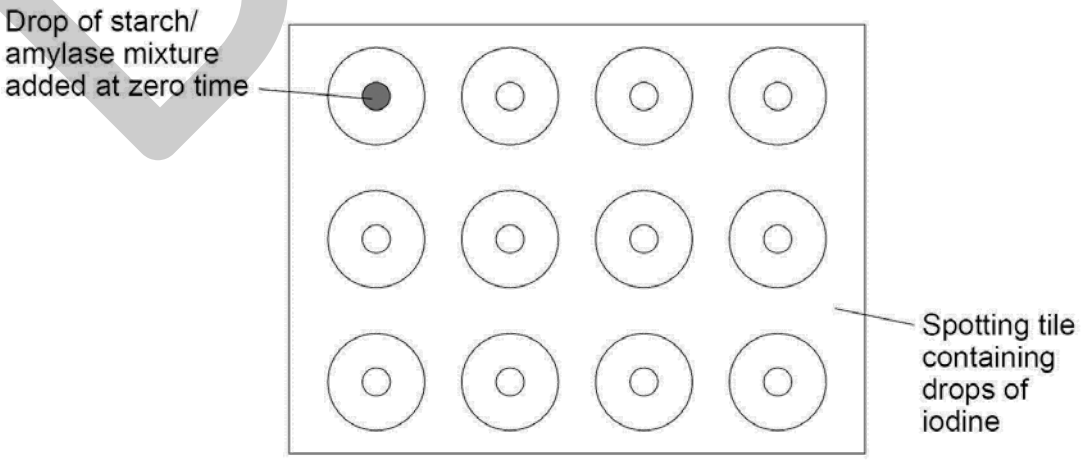
You are provided with the following:

- test tubes
- a test tube rack
- water baths (electrical or Bunsen burners and beakers)

- spotting tiles
- a 5 cm^3 measuring cylinder or syringe
- glass rods
- a stop watch
- starch solution
- amylase solution
- iodine solution
- thermometers.

You should read these instructions carefully before you start work.

1. Place one drop of iodine solution into each depression on the spotting tile.
2. Set up water baths for every temperature you want to test (suggest one cold with ice, one at room temperature, one around body temperature 35–40 °C and one above 50 °C).
3. Measure out 5 cm^3 of starch solution, using the measuring cylinder or syringe, into 4 test tubes.
4. Place one test tube of starch solution into each water bath.
5. Measure out 1 cm^3 of amylase solution, using a measuring cylinder or syringe, into 4 different test tubes.
6. Place one test tube of amylase solution into each water bath.
7. Leave the test tubes in the water baths until the contents of each test tube have reached the temperature of the water baths. Check this with a thermometer.
8. When the contents of the test tubes in one water bath have both reached the required temperature, make a note of this temperature. Then, carefully pour the amylase solution into the test tube with the starch solution and mix with the glass rod.
9. Remove one drop of the mixed solution on the end of the glass rod and place on the first depression of the spotting tile with the iodine solution. This is 'time zero'.



10. Immediately start the stop clock.
11. Using the glass rod, remove one drop every minute and place onto the iodine solution in the next depression on the spotting tile. Rinse the glass rod with water after each drop.
12. Continue until the iodine solution no longer turns black. This indicates that the starch has been broken down.
13. Record the temperature of the water bath and the time taken for the starch to be broken down in a table such as the one here.

Temperature of water bath in °C	**Time taken for amylase to completely break down the starch in minutes**

Repeat for the other temperatures.

GCSE Biology required practical activity 4: Food tests

Teachers' notes

Required practical activity	Apparatus and techniques
Use qualitative reagents to test for a range of carbohydrates, lipids and proteins. To include: Benedict's test for sugars; iodine test for starch; Biuret reagent for protein.	AT 2, AT 8

Using qualitative reagents to test for a range of carbohydrates, lipids and proteins

Materials

In addition to access to general laboratory equipment, each student needs:

- food to be tested
- a pestle and mortar
- a stirring rod
- a filter funnel and filter paper
- 5 × beaker, 250 ml
- a conical flask
- 4 × test tube
- Benedict's solution
- iodine solution
- Sudan III stain solution
- Biuret solution
- a Bunsen burner, tripod and gauze to heat water
- a heatproof mat
- a thermometer
- safety goggles.

Technical information

Benedict's qualitative reagent (CLEAPSS)

Benedict's solution or DNSA (see Recipe sheet 34) should be used in place of Fehling's solution to test for reducing sugars. This is because it is less hazardous.

Glucose, lactose and maltose are reducing sugars and give a positive test. Sucrose is a non-reducing sugar and does not give a positive result.

No hazard warning symbol is required on the bottle as the concentrations of each of the constituents are low.

Qualitative Biuret Reagent (CLEAPSS)

This does **not** keep so only prepare what is required.

General hazards:

- Sodium hydroxide (solid) and 2 M solution. See Hazcard 91.
- Copper sulphate, see Hazcard 27C.

Preparing 1 litre of Qualitative Biuret reagent:

- wear safety goggles
- weigh out 0.75 g of copper(II) sulfate(VI)-5 -water
- prepare 1 litre of 2 M potassium or sodium hydroxide solution
- dissolve the copper(II) sulfate(VI) in the alkali and label the solution CORROSIVE.

A purple or pink colouration indicates the presence of protein.

Iodine solution (CLEAPSS)

Iodine is only sparingly soluble in water (0.3 g/L). It is usual to dissolve it in aqueous potassium iodide solution (KI) or organic solvents such as ethanol. The procedure will take time even with stirring.

A 0.01 M solution is suitable as a test reagent for starch.

The concentration of solutions decreases with storage. Check that the solutions work before use in the laboratory.

The solution may be bought ready-made. Alternatively, use CLEAPSS Recipe card 50 to make up the solution.

Sudan III stain solution

Dissolve 0.5 g of dye in 70 ml of ethanol and 30 ml of water, using a warm water bath, and filter.

Ethanol is HIGHLY FLAMMABLE (see Hazcards 32 and 40). Label the solution HIGHLY FLAMMABLE.

Wear safety goggles.

Additional information

The techniques involved should be demonstrated to the students. Students should be allowed time to practice the techniques by testing pure substances first in order to see the expected colour change.

The following are suggested for this purpose:

- Biuret test – albumen solution
- Benedict's solution – glucose solution
- iodine solution – starch solution
- Sudan III – any suitable oil.

In particular students will need to practice the following:

Techniques requiring practice	Additional information
Use of a pestle and mortar	When crushing the food it may help to add a small amount of sharp sand
Filtration	Students may need to be taught how to fold the filter paper correctly
Use of water bath	Students may need to learn how to use a beaker of hot water as a water bath

Risk assessment

- Risk assessment and risk management are the responsibility of the school or college.
- Biuret solution contains copper sulfate, which is poisonous, and sodium hydroxide, which is caustic.

Suggested foods for testing

Proteins: milk, yogurt, cheese, meat, tofu, apple, potato, yeast, cooked beans, eggs.

Lipids: olive oil, sesame seed oil, grape seed oil, margarine, butter, lard, milks (full fat, semi-skimmed, skimmed), egg white solution, egg yolk solution.

Carbohydrates: potato, bread, cooked noodles, biscuits, sugar, apples, flour, corn starch.

Trialling

The practical should be trialled before use with students.

GCSE Biology required practical activity 4: Food tests

Student sheet

Required practical activity	Apparatus and techniques
Use qualitative reagents to test for a range of carbohydrates, lipids and proteins. To include: Benedict's test for sugars; iodine test for starch; Biuret reagent for protein.	AT 2, AT 8

1. Testing for sugars

In this experiment you will test one or more foodstuffs for the presence of carbohydrates.

Learning outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

Method

You are provided with the following:

- food to be tested
- a pestle and mortar
- a stirring rod
- filter funnel and filter paper
- 2 × beaker, 250 ml
- a conical flask
- 2 × test tube
- Benedict's solution
- iodine solution
- a Bunsen burner, tripod and gauze to heat water
- a heatproof mat
- a thermometer
- safety goggles.

2. Testing for lipids

In this experiment you will test one or more foodstuffs for the presence of lipids (fats).

Learning outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

Method

You are provided with the following:

- food to be tested
- a pestle and mortar
- a stirring rod
- a filter funnel and filter paper
- 2 × beaker, 250 ml
- a test tube
- Sudan III stain solution.

Risk assessment:

- Wear safety goggles.
- Sudan III contains ethanol, which is highly flammable. Keep the solution away from naked flames.

You should read these instructions carefully before you start work.

1. Use a pestle and mortar to grind up a small sample of food.
2. Transfer the ground up food into a small beaker and add distilled water.
3. Stir in order to allow some of the food content to dissolve in the water.
4. Use a filter funnel and filter paper to obtain as clear a solution as possible.
5. Half fill a test tube with some of this solution.
6. Add 3 drops of Sudan III stain to the solution in the test tube. Shake gently to mix.
7. A red-stained oil layer will separate out and float on the water surface if fat is present.

GCSE Biology required practical activity 5: Photosynthesis

Teachers' notes

Required practical activity	Apparatus and techniques
Investigate the effect of light intensity on the rate of photosynthesis using an aquatic organism such as pondweed.	AT 1, AT 3, AT 4, AT 5

Investigating the effect of light intensity on photosynthesis in pondweed

Materials

In addition to access to general laboratory equipment, each student needs:

- a boiling tube
- freshly cut 10 cm piece of pondweed (*Cabomba* or *Elodea*)
- a light source
- a ruler
- a test tube rack
- a stop watch
- 0.2% solution of sodium hydrogen carbonate solution
- a glass rod

Technical information

Cabomba or *Elodea* could be used as the pondweed in this investigation. Both can be bought from tropical fish shops and some large garden centres.

Cabomba is recommended as it is the most reliable as it produces the most bubbles. *Cabomba* should be kept in a well aerated tank prior to its use. If *Elodea* is used, it is suggested that the plant is placed in a beaker of water in front of a lamp for 2–3 hours before starting the investigation.

It is best to use an LED light source as they give off less heat. If these are not available, use a normal light bulb but place a beaker of water in between the boiling tube and the light source to reduce the chance of temperature affecting the results. Low energy light bulbs should not be used as the light intensity may be too low to promote measurable photosynthesis.

Additional information

Graphs can be drawn of number of bubbles per minute against distance from light source.

Light intensity is proportional to 1/distance^2. Higher attaining students may want to draw their graphs of number of bubbles against light intensity instead.

If no bubbles appear from the cut end of the pondweed when placed closest to the light source, cut a few millimetres off the end or, if necessary, use a new freshly-cut piece of pondweed.

Students could work within a group in order to investigate a wider range of distances and with increments of 5 cm instead of 10 cm. Group results could be collated.

Risk assessment

- Risk assessment and risk management are the responsibility of the school or college.
- 0.2% sodium hydrogen carbonate solution is low hazard. Refer to Hazcard 95C.
- Care should be taken when handling glassware.
- Care should be taken with the use of lamps that may get hot.
- Care should be taken with the presence of water and the electrical power supply for the lamp.

Trialling

The practical should be trialled before use with students.

Alternative practicals

Outline method	Suggested apparatus	Suggested reagents
Investigating the effect of light wavelength on photosynthesis in pondweed		
As above but keep the distance from the light the same and place different coloured filters between the test tube and the light.	As above plus coloured filters or coloured cellophane	As above
Investigating the effect of carbon dioxide concentration on photosynthesis in pondweed		
As above but keep distance from the light the same and place the pondweed in different concentrations of sodium hydrogen carbonate.	As above	Increments of 0.05g of sodium hydrogen carbonate powder added to distilled water will increase the available carbon dioxide

GCSE Biology required practical activity 5: Photosynthesis

Student sheet

Required practical activity	Apparatus and techniques
Investigate the effect of light intensity on the rate of photosynthesis using an aquatic organism such as pondweed.	AT 1, AT 3, AT 4, AT 5

Investigating the effect of light intensity on photosynthesis in pondweed

Plants use carbon dioxide and water to produce glucose and oxygen during the process of photosynthesis. Many factors, such as light intensity and light wavelength, affect the rate at which photosynthesis occurs.

Aquatic plants, such as pondweed, produce visible bubbles of oxygen gas into the surrounding water when they photosynthesise. These bubbles can be counted as a measure of the rate of photosynthesis.

The effect of light intensity can be investigated by varying the distance between pondweed and a light source. The closer the light source the greater the light intensity.

Learning outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

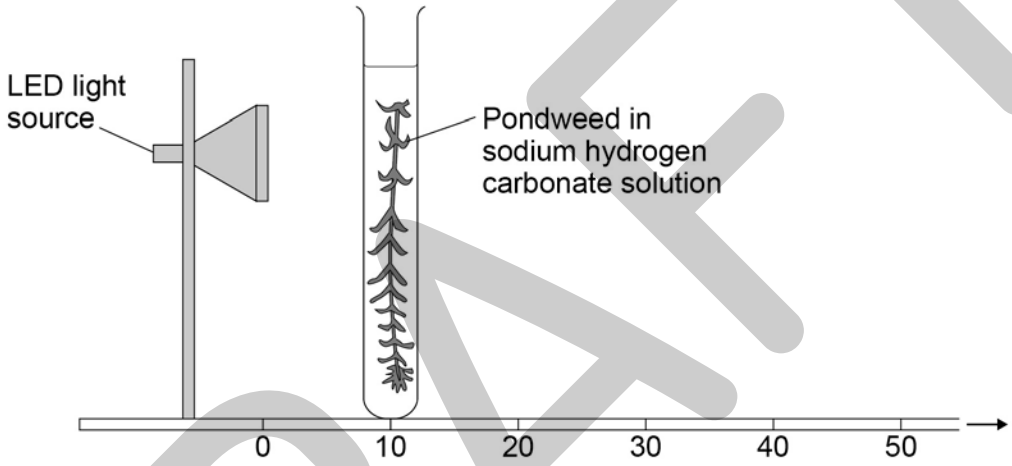
Method

You are provided with the following:

- a boiling tube
- freshly cut 10 cm piece of pondweed (*Cabomba* or *Elodea*)
- a light source
- a ruler
- a test tube rack
- a stop watch
- 0.2% solution of sodium hydrogen carbonate
- a glass rod.

You should read these instructions carefully before you start work:

1. Set up a test tube rack containing a boiling tube at a distance of 10 cm away from the light source
2. Fill the boiling tube with the sodium hydrogen carbonate solution.
3. Place the piece of pondweed into the boiling tube with the cut end uppermost. Gently push the pondweed down with the glass rod.
4. Leave the boiling tube for 5 minutes.
5. Start the stop watch and count the number of bubbles produced in one minute.



6. Record the results in a table such as the one here.

Distance between pondweed and light source in cm	Number of bubbles per minute			
	1	2	3	Mean
10				
20				
30				
40				

7. Repeat the count twice more so that the mean number of bubbles per minute can be calculated.
8. Move the test tube rack to a distance of 20 cm from the light source and repeat steps 4–6.
9. Repeat using distances of 30 cm and 40 cm between the test tube rack and the light source.

GCSE Biology required practical activity 6: Reaction Time

Teachers' notes

Required practical activity	Apparatus and techniques
Plan and carry out an investigation into the effect of a factor on human reaction time.	AT 1, AT 3, AT 4

Investigating whether practice reduces human reaction times

Materials

In addition to access to general laboratory equipment, each student needs a:

- metre ruler
- chair
- table
- partner.

Technical information

Students should use their weaker hand for the ruler drop test. They should ensure that they have not done any practicing before the start of the experiment but start taking measurements immediately so that the effects of any practicing can be seen.

Ruler measurements can be converted to reaction times using the conversion table below.

Additional information

The following conversion table can be given to students in order to determine reaction times.

Graphs of reaction time against attempt number can be drawn.

Reading from ruler (cm)	Reaction time (s)	Reading from ruler (cm)	Reaction time (s)	Reading from ruler (cm)	Reaction time (s)	Reading from ruler (cm)	Reaction time (s)	Reading from ruler (cm)	Reaction time (s)
1	0.05	21	0.21	41	0.29	61	0.35	81	0.41
2	0.06	22	0.22	42	0.29	62	0.36	82	0.41
3	0.08	23	0.22	43	0.30	63	0.36	83	0.41
4	0.09	24	0.22	44	0.30	64	0.36	84	0.41
5	0.10	25	0.23	45	0.30	65	0.36	85	0.42
6	0.11	26	0.23	46	0.31	66	0.37	86	0.42
7	0.12	27	0.23	47	0.31	67	0.37	87	0.42
8	0.13	28	0.24	48	0.31	68	0.37	88	0.42
9	0.14	29	0.24	49	0.32	69	0.38	89	0.43
10	0.14	30	0.25	50	0.32	70	0.38	90	0.43
11	0.15	31	0.25	51	0.32	71	0.38	91	0.43
12	0.16	32	0.26	52	0.33	72	0.38	92	0.43
13	0.16	33	0.26	53	0.33	73	0.39	93	0.44
14	0.17	34	0.26	54	0.33	74	0.39	94	0.44
15	0.18	35	0.27	55	0.34	75	0.39	95	0.44
16	0.18	36	0.27	56	0.34	76	0.39	96	0.44
17	0.19	37	0.28	57	0.34	77	0.40	97	0.45
18	0.19	38	0.28	58	0.34	78	0.40	98	0.45
19	0.20	39	0.28	59	0.35	79	0.40	99	0.45
20	0.21	40	0.29	60	0.35	80	0.40	100	0.45

Risk assessment

- Risk assessment and risk management are the responsibility of the school or college.
- It is advisable for the students who drop the ruler to wear goggles to avoid the possibility of the ruler hitting the floor and bouncing back up to hit the eyes.
- Care should be taken to ensure that students do not experience any discomfort when being used as the subjects of investigation.

Trialling

The practical should be trialled before use with students.

Alternative practicals

Outline method	Suggested apparatus	Suggested reagents
Investigating whether caffeine affects human reaction times		
As above but after the first test drink a cup of coffee (or caffeinated cola drink) before the second test. Drink a further cup of coffee before the third test.	As above plus coffee or cola	As above
Investigating whether aerobic exercise affects human reactions times		
As above but do the drop test before and after a period of exercise and then again after rest.	As above	As above

GCSE Biology required practical activity 6: Reaction Time

Student sheet

Required practical activity	Apparatus and techniques
Plan and carry out an investigation into the effect of a factor on human reaction time.	AT 1, AT 3, AT 4

Investigating whether practice reduces human reaction times

Messages travel very quickly around your body through the nervous system. This is so that you are able to respond to changes in the environment. The time it takes for you to respond to such a change is called your reaction time.

Athletes spend hours practicing to try to reduce their reaction time in order to improve performance in their particular sport. Responding quicker to the starter's pistol in a race can gain you the advantage over other runners.

In this investigation you will conduct a simple, measurable experiment called the ruler drop test to determine whether your reaction time can be reduced with practice.

Learning outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

Method

You are provided with the following:

- a metre ruler
- a chair
- a table
- a partner

You should read these instructions carefully before you start work:

1. You should use your weaker hand for this experiment. If you are right handed then your left hand is your weaker hand.
2. Sit down on the chair with good upright posture and eyes looking across the room.
3. Place the forearm of your weaker arm across the table with your hand overhanging the edge of the table.
4. Your partner will hold a ruler vertically with the bottom end (the end with the 0 cm) in between your thumb and first finger. Practice holding the ruler with those two fingers.
5. Your partner will take hold of the ruler and ask you to remove your fingers.
6. Your partner will hold the ruler so the zero mark is level with the top of your thumb and tell you to prepare to catch the ruler.
7. Your partner will then drop the ruler without telling you.
8. You must catch the ruler as quickly as you can when you sense that the ruler is dropping.
9. After catching it, look at the number level with the top of your thumb on the ruler. Record this as a measure of how fast you caught it in a table such as the one here.

Drop test attempts	Ruler measurements in cm		Reaction times in seconds	
	Person 1	Person 2	Person 1	Person 2
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

10. Have a short rest and then repeat the drop test. Record the number on the ruler as attempt 2.
11. Continue to repeat several times.
12. Swap places with your partner and repeat the experiment to get their results.
13. Use a conversion table to convert your ruler measurements into reaction times.

GCSE Biology required practical activity 7: Field investigations

Teachers' notes

Required practical activity	Apparatus and techniques
Measure the population size of a common species in a habitat. Use sampling techniques to investigate the effect of a factor on the distribution of this species.	AT 1, AT 3, AT 4, AT 6, AT 8

Investigating the population size of daisies in trampled and un-trampled parts of a school field

Materials

In addition to access to general laboratory equipment, each student needs:

- a 1 m^2 quadrat
- a 30 m tape measure
- a clipboard
- a pen
- paper.

Technical information

A good trampled area of the field might be a football pitch, and the un-trampled area could just be along the very edge of the field where the grass has not been cut or not cut as often.

A shorter transect line could be used if space is limited and quadrats could be placed closer together. A 0.5 m^2 quadrat could be used instead if more appropriate or if a 1 m^2 quadrat is not available.

Several students can work independently along one transect line if the number of tape measures is limited. Alternatively string or rope can be used as the transect line by marking 5 m intervals along it with a marker pen.

Additional information

Exactly what counts as a daisy plant should be demonstrated to students to ensure they are counting whole plants (rosettes) and not just counting flowers. Students will need to kneel or

crouch down and may need to use their hands to determine how many plants are within the quadrat (especially in the longer grass of the un-trampled area).

Risk assessment

- Risk assessment and risk management are the responsibility of the school or college.
- It is advisable not to undertake this experiment if the conditions are very wet as students may slip on wet grass.
- The areas to be used should be checked beforehand to ensure that no hazardous materials, such as broken glass, are present. This is especially necessary where items could be hidden in the longer grass.
- Care should be taken when using tape measures that may recoil back if not carefully locked in place.
- Care should be taken to ensure that students place the quadrats carefully along the transect line and do not throw them around, as this could cause injury to other students.
- If during the course of this experiment students get soil on their hands, they should wash hands thoroughly afterwards.

Trialling

The practical should be trialled before use with students.

Alternative practical

Outline method	Suggested apparatus	Suggested reagents
Using the capture-mark-recapture technique to estimate population size Place about five large handfuls of dried beans into a container to represent the animals. Capture ten of the 'animals' and mark them with a marker pen. Place them back into the container and stir them around. Recapture a handful of beans without looking. Perform the recapture ten times, each time recording how many you have captured and how many are marked. Use the total number recaptured and the total number that were marked to estimate the population size. Count the beans in the bag and compare estimate with the actual number. Perform a further ten recaptures and add the totals to the first set to see whether a larger sample size increases accuracy of estimate.	Container such as bag or box, dried beans, marker pen	n/a

GCSE Biology required practical activity 7: Field investigations

Student sheet

Required practical activity	Apparatus and techniques
Measure the population size of a common species in a habitat. Use sampling techniques to investigate the effect of a factor on the distribution of this species.	AT 1, AT 3, AT 4, AT 6, AT 8

Investigating the population size of daisies in trampled and un-trampled parts of a school field

The size of a population of animals or plants in a habitat can be estimated by taking samples of the organisms from the habitat. The larger the sample, the more accurate your estimate of the population size is likely to be.

Plants can be sampled more easily than animals because they are unable to move around within the habitat. By sampling, population sizes can be compared between different areas.

In this experiment, you will compare the population sizes of daisies in trampled and un-trampled parts of your school field using a transect line and a quadrat.

Learning outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

Method

You are provided with the following:

- a 1 m^2 quadrat
- a 30 m tape measure
- a clipboard
- a pen
- paper.

You should read these instructions carefully before you start work:

1. Place the 30 m tape measure across a well-trampled part of the school field to form a transect line.
2. Place the 1 m^2 quadrat against the transect line so that one corner of it touches the 0 m mark on the tape measure.
3. Count the number of daisy plants within the quadrat.
4. Record the number of daisies counted within the quadrat in a table such as the one here.

Distance along the transect line in m	Number of daisy plants per 1 m^2 quadrat	
	Trampled	Un-trampled
0		
5		
10		
15		
20		
25		
30		
Mean number of daisy plants per m^2		

5. Move the quadrat 5 m up the transect line and count the number of daisy plants again. Record in the table.
6. Continue to place the quadrat at 5 m intervals and count the number of daisy plants in each quadrat.
7. Calculate the mean number of daisy plants per m^2 for the trampled area.
8. Move the 30 m tape measure to an un-trampled part of the school field to form the new transect line.
9. Place the quadrat at 5 m intervals as before and count the number of daisy plants in each quadrat. Record in the table.
10. Calculate the mean number of daisy plants per m^2 for the un-trampled area.
11. Compare the population size of daisies in the well-trampled and un-trampled parts of the field.

GCSE Biology required practical activity 8: Microbiology (biology only)

Teachers' notes

Required practical activity	Apparatus and techniques
Investigate the effect of antiseptics or antibiotics on bacterial growth using agar plates and measuring zones of inhibition.	AT 1, AT 3, AT 4, AT 8

Investigating the effect of antiseptics on the growth of bacteria

Materials

In addition to access to general laboratory equipment, each student needs:

- a nutrient agar plate
- a Bunsen burner
- a heatproof mat
- a disposable plastic pipette
- a culture of bacteria (*E. coli*)
- a glass spreader
- filter paper discs
- three antiseptics (such as mouthwash, TCP, and antiseptic cream)
- disinfectant bench spray
- a 'discard beaker' of disinfectant
- a small beaker of ethanol
- forceps
- clear tape
- hand wash
- a wax pencil
- access to an incubator.

Technical information

Cultures of *E. coli* bacteria, nutrient agar, and suitable disinfectants for the bench spray and the 'discard beaker' can be bought from educational suppliers. The instructions, and any risk assessment information, which accompany them should be followed carefully.

Plastic petri dishes should be used as these can be destroyed by melting in an autoclave or large pressure cooker, in a specialist autoclave bag (or roasting bag), immediately after obtaining the

results. Discs can be cut from filter paper using a hole-punch. Glass spreaders are made by bending a 3–4 mm diameter glass rod into an L-shape.

Additional information

The techniques involved should be demonstrated to the students and they should be allowed time to practice the techniques. Students can use water in place of the bacterial culture, before performing this experiment.
It is important that students can work carefully but quickly to minimise contamination. The lids on the agar plates should be lifted for as short a time as possible at each step of the experiment. The lid should be replaced on the culture bottle immediately once the sample of bacteria has been removed with the pipette. At no point should any lids be placed down on the bench (it is less easy to forget the lid is off if you have it in your hands and no microorganisms are transferred to the bench).

In particular students will need to practice the following:

Techniques requiring practice	Additional information
Flaming the neck of the culture bottle	This must be done whilst still holding the pipette and the lid of the culture bottle in your other hand (neither should be placed down on the bench at any point). The bottle must not be held still in the flame as the glass will crack – it should be rotated as it is very briefly passed through the flame.
Lifting the lid of the agar plate at an angle	The lid should only be opened at the side facing the Bunsen burner to avoid contamination
Spreading the bacteria thoroughly around the agar plate right to the edges	This is best done by holding the glass spreader still up to the edge of the plate and rotating the plate. The lid of the plate must be held over it at the same time to avoid contamination.
Placing the filter paper discs onto the agar plate in the right positions	Students should hold the first disc with the forceps. They should lift the lid of the agar plate at an angle (as before) and place the disc flat onto the central dot in the first third of the plate. The lid of the agar plate should be replaced whilst the next disc is collected. This is repeated so that all three discs are in position.

Clear zones are not always perfectly circular so students should measure the diameter twice (at 90° to each other) and calculate a mean diameter for each clear zone.

Risk assessment

- Risk assessment and risk management are the responsibility of the school or college.
- Care should be taken to ensure that appropriate aseptic techniques are used when handling microorganisms.
- Care should be taken to ensure that appropriate aseptic techniques are used when handling microorganisms.
- Food for human consumption should not be kept in a refrigerator that is used to store microorganisms.
- Care should be taken with the use of ethanol and naked flames in this experiment. Refer to Hazcard 40A.
- Students should ensure that their work spaces and hands are thoroughly cleaned before and after the experiment.
- Care must be taken to ensure that the lids on the agar plates are secured in place (but not completely sealed). Students must not remove the lids when making their clear zone measurements.
- All equipment that has come into contact with the microorganisms should be suitably destroyed or sterilised immediately after the experiment.

Trialling

The practical should be trialled before use with students.

Alternative practical

Outline method	Suggested apparatus	Suggested reagents
Investigating the effect of antibiotics on the growth of bacteria As above but use three antibiotic discs instead of the filter paper disc. These are commercially prepared – either with different antibiotics or different concentrations of the same antibiotic. Care should be taken to ensure that these discs are only handled using forceps as allergic reactions to antibiotics, such as penicillin, can occur.	As above but with antibiotic discs	As above

GCSE Biology required practical activity 8: Microbiology (biology only)

Student sheet

Required practical activity	Apparatus and techniques
Investigate the effect of antiseptics or antibiotics on bacterial growth using agar plates and measuring zones of inhibition.	AT 1, AT 3, AT 4, AT 8

Investigating the effect of antiseptics on the growth of bacteria

In this experiment you will prepare a lawn plate of bacteria before testing the effectiveness of three different antiseptics.

Care must be taken when handling microorganisms such as bacteria.

You will use techniques called aseptic techniques during this experiment to avoid contamination.

Contamination can be where microorganisms from:

- the surroundings get into your experiment and spoil your results
- your experiment get into the surroundings and cause a potential health hazard.

You will measure the diameter of the 'clear zone' around the disc where there is no bacteria growing. The larger the clear zone, the more effective the antiseptic.

Learning outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

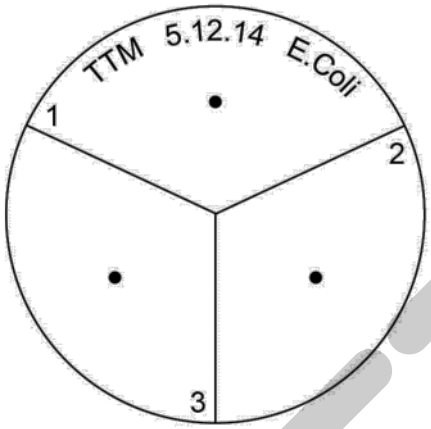
Method

You are provided with the following:

- a nutrient agar plate
- a Bunsen burner
- a heatproof mat
- a disposable plastic pipette
- a culture of bacteria (*E. coli*)
- a glass spreader
- filter paper discs
- three antiseptics (such as mouthwash, TCP, and antiseptic cream)
- disinfectant bench spray
- a 'discard beaker' of disinfectant
- a small beaker of ethanol
- forceps
- clear tape
- hand wash
- a wax pencil
- access to an incubator.

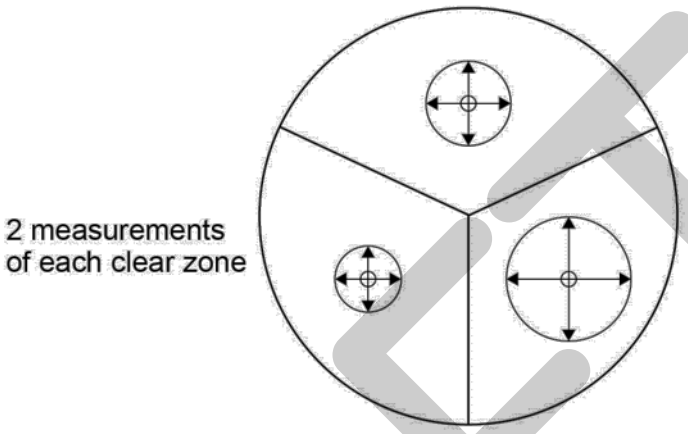
You should read these instructions carefully before you start work.

1. Set up your working area by first spraying the bench with the disinfectant spray and wiping with paper towels.
2. Place the Bunsen burner on the heatproof mat in the middle of your working area and light the Bunsen on a yellow flame.
3. Wash your hands with the antibacterial hand wash.
4. Mark the underneath of a nutrient agar plate (not the lid) with the wax pencil as follows (making sure that the lid stays in place to avoid contamination):
    - divide the plate into three equal sections as if you were cutting a pie into three and number them 1, 2 and 3 around the edge
    - place a dot into the middle of each section
    - around the edge write your initials, the date and the name of the bacteria (*E. coli*).



5. Turn the Bunsen flame to blue.
6. Remove the lid of the bottle containing the culture of bacteria (keep the lid in your hand) and flame the neck of the bottle through the Bunsen flame, quickly twisting the bottle from side to side. Using the disposable pipette, collect approximately 1 ml of the bacterial culture.
7. Quickly flame the neck of the bottle again and replace the lid.
8. Lift the lid of the agar plate at an angle so that it is only fully open on the Bunsen burner side.
9. Pipette the bacteria onto the agar plate and replace the lid.
10. Place the pipette into the 'discard beaker' and turn the Bunsen burner flame back to yellow.
11. Dip the glass spreader into the ethanol. Remove the glass spreader and tap off the excess ethanol, then pass the glass spreader through the flame (holding the glass spreader horizontally to ensure nothing drips down onto your hand).
12. Allow the flame on the glass spreader to go out and allow the spreader to cool for a count of 20.
13. Lift the lid of the agar plate, again at an angle so only the side next to the Bunsen burner is fully open, and spread the bacteria around the plate using the glass spreader.
14. Lower the lid of the agar plate and place the glass spreader into the discard beaker.
15. Place different antiseptics onto the three filter paper discs by either soaking them in the liquid or spreading the cream or paste onto them.
16. Lift the lid of the agar plate as before and, using the forceps, carefully place each disc onto one of the dots drawn on with the wax pencil.
17. Make a note of which antiseptic is in each of the three numbered sections of the plate.
18. Secure the lid of the agar plate in place using two small pieces of clear tape (do not seal the lid all the way around as this creates anaerobic conditions, which will prevent the *E. coli* bacteria from growing and can encourage some other very nasty bacteria to grow).
19. Incubate the plate at 25 °C for 48 hours.

20. Measure the diameter of the clear zone around each disc by placing the ruler across the centre of the disc. Measure again at 90° to the first measurement so that the mean diameter can be calculated.



21. Record your results in a table such as the one here.

Type of antiseptic	Diameter of clear zone in mm		
	1	2	Mean
Mouthwash (1)			
TCP (2)			
Antiseptic cream (3)			

GCSE Biology required practical activity 9: Germination (biology only)

Teachers' notes

Required practical activity	Apparatus and techniques
Investigate the effect of light or gravity on the growth of germinating seeds. Record results as both length measurements and as careful, labelled biological drawings to show the effects.	AT 1, AT 3, AT 4, AT 7

Investigating the effect of light intensity on the growth of mustard seedlings

Materials

In addition to access to general laboratory equipment, each student needs:

- white mustard seeds
- petri-dishes
- cotton wool
- a ruler
- water
- access to a light windowsill and a dark cupboard.

Technical information

Cotton wool should be damp but not in excess water. The amount of cotton wool and water needed should be determined before students do the experiment.

Seeds will require a day or so to germinate (depending on how warm it is). Alternative seeds, such as cress or *Brassica rapa*, could be used instead of white mustard seeds. However, white mustard seeds are bigger and easier to handle so these are recommended.

Partial light can be achieved by alternating a day on the windowsill with a day in the dark cupboard.

Additional information

To measure the height of the seedlings students should rest the ruler on the cotton wool and then gently hold the seedling to its full height against the ruler. Care should be taken to ensure the seedlings are not damaged during measuring.

Risk assessment

- Risk assessment and risk management are the responsibility of the school or college.
- The equipment and techniques used in this experiment are not hazardous.

Trialling

The practical should be trialled before use with students.

Alternative practical

Outline method	Suggested apparatus	Suggested reagents
Investigate the effect of light wavelength on the growth of mustard seedlings As above but place the petri-dishes in boxes with a window cut out and coloured filters or coloured cellophane covering the window.	As above plus coloured filters or coloured cellophane	As above

GCSE Biology required practical activity 9: Germination (biology only)

Student sheet

Required practical activity	Apparatus and techniques
Investigate the effect of light or gravity on the growth of germinating seeds. Record results as both length measurements and as careful, labelled biological drawings to show the effects.	AT 1, AT 3, AT 4, AT 7

Investigating the effect of light intensity on the growth of mustard seedlings

Germination is the start of growth in a seed. Water, oxygen and warmth are required for the seed to germinate. Once germinated, the shoots will only continue to grow if placed into the correct conditions.

Mustard seeds germinate easily and quickly when placed on damp cotton wool. The effect of light on the growth of the newly germinated shoots can be determined by measuring their height with a ruler.

Learning outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

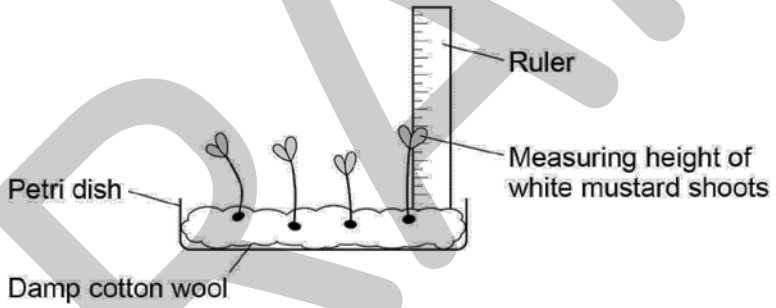
Method

You are provided with the following:

- white mustard seeds
- petri-dishes
- cotton wool
- a ruler
- water
- access to a light windowsill and a dark cupboard.

You should read these instructions carefully before you start work:

1. Set up three petri dishes with cotton wool soaked in equal amounts of water.
2. Place ten mustard seeds in each petri dish.
3. Place the petri dishes in a warm place where they will not be disturbed or moved.
4. Allow the mustard seeds to germinate, adding more water if the cotton wool gets dry (equal amounts to each dish).
5. Once the mustard seeds have germinated, make sure that the number of seedlings in each dish is the same. Remove excess seedlings from any dish that has too many. For example, one dish has eight seedlings which is the fewest compared to the other petri dishes. Therefore remove seedlings from the other dishes so that each dish has eight.
6. Move the petri dishes into position. One should be placed on a windowsill in full sunlight. One should be placed in a dark cupboard. The third should be placed in partial light.
7. Every day, for at least a week, measure the height of each seedling and record in a table such as the one here. You will need one table for full sunlight, one for partial light and one for darkness.



Day	Height of seedling in full sunlight in mm								
	1	2	3	4	5	6	7	8	Mean
1									
2									
3									
4									
5									
6									
7									

8. Calculate the mean height of the seedlings each day.
9. Compare the mean heights in full sunlight, partial light and darkness by drawing a graph of 'mean height' against 'time' for each.

GCSE Biology required practical activity 10: Decay (biology only)

Teachers' notes

Required practical activity	Apparatus and techniques
Investigate the effect of temperature on the rate of decay of fresh milk by measuring pH change.	AT 1, AT 3, AT 4, AT 5

Investigating the effect of temperature on the rate of decay of fresh milk by measuring pH change

Materials

In addition to access to general laboratory equipment, each student needs:

- a small beaker containing milk (full fat or semi-skimmed, but not UHT)
- a small beaker containing sodium carbonate solution (0.05 mol dm^{-3})
- a small beaker containing 5% lipase solution
- 250 cm^3 beakers, to be used as water baths
- test tubes
- a test tube rack
- a marker pen
- 10 cm^3 plastic syringes
- a stirring thermometer
- stop clock / stopwatch
- phenolphthalein in a dropper bottle
- an electric kettle, for heating water
- ice, for investigating temperatures below room temperature.

Technical information

Sodium carbonate solution, 0.05 M. Make with 5.2 g of anhydrous solid or 14.2 g of washing soda per litre of water. See CLEAPSS Hazcard; it is an IRRITANT at concentrations over 1.8 M.

Phenolphthalein solution contains methanol which is highly flammable and should be kept away from naked flames.

Lipase solution is should be freshly made, but it can be kept for a few days in a refrigerator.

Additional information

If electric water baths are available this would be preferable to using hot water in beakers.

Ideally, at least five different temperatures should be investigated, ranging around 60 °C.

If timer is short, class results may be pooled rather than individual students carrying out a number of different temperatures and repeats.

Risk assessment

- Risk assessment and risk management are the responsibility of the school or college.
- Phenolphthalein is described as low hazard on CLEAPSS Hazcard 32. Refer to Recipe card 33 (acid-base indicators).
- Sodium carbonate solution, 0.05 M. Make with 5.2 g of anhydrous solid, or 14.2 g of washing soda per litre of water. See CLEAPSS Hazcard; it is an IRRITANT at concentrations over 1.8 M.
- Ethanol (IDA) in the phenolphthalein indicator is described as HIGHLY FLAMMABLE on the CLEAPSS Hazcard (flash point 13 °C) and HARMFUL (because of presence of methanol).

Trialling

The practical should be trialled before use with students.

Alternative practical

Outline method	Suggested apparatus	Suggested reagents
Investigating the effect of temperature on the rate of decay of fresh milk by measuring pH change		
As above but using a pH probe connected to a data logger instead of phenolphthalein.	As above but using a pH probe connected to a data logger instead of phenolphthalein	As above but without phenolphthalein

GCSE Biology required practical activity 10: Decay (biology only)

Student sheet

Required practical activity	Apparatus and techniques
Investigate the effect of temperature on the rate of decay of fresh milk by measuring pH change.	AT 1, AT 3, AT 4, AT 5

Investigating the effect of temperature on the rate of decay of fresh milk by measuring pH change

In this experiment you will use an alkaline solution of milk. When lipase is added the fat in the milk is broken down into fatty acids. This makes the pH of the solution lower.

Phenolphthalein is an indicator that is pink in alkaline solutions of about pH 10. When the pH drops below pH 8.3 phenolphthalein becomes colourless.

Learning Outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

Method

You are provided with the following:

- a small beaker containing milk
- a small beaker containing sodium carbonate solution
- a small beaker containing lipase solution
- 250 cm^3 beakers, to be used as water baths
- test tubes
- a test tube rack
- a marker pen
- 10 cm^3 plastic syringes
- a stirring thermometer
- a stop clock / stopwatch

- phenolphthalein in a dropper bottle
- an electric kettle, for heating water
- ice, for investigating temperatures below room temperature.

You should read these instructions carefully before you start work.

1. Set up a water bath by half filling one of the 250 cm^3 beakers with hot water from the kettle.
2. Label two test tubes: one 'lipase' and the other 'milk'.
3. In the first test tube put 5 cm^3 of lipase solution.
4. In the other test tube put five drops of phenolphthalein solution.
5. Use a calibrated dropping pipette to add 5 cm^3 of milk to the tube containing the phenolphthalein.
6. Use another pipette to add 7 cm^3 of sodium carbonate solution to this test tube. The solution should be pink.
7. Put a thermometer into this test tube.
8. Put both test tubes into the water bath and wait until the contents reach the same temperature as the water bath.
9. Use another dropping pipette to transfer 1 cm^3 of lipase into the tube containing the milk and phenolphthalein. Immediately start timing.
10. Stir the contents of the test tube until the solution loses its pink colour.
11. Record the time taken for the pink colour to disappear.
12. Repeat the above steps for different temperatures of water bath. You can obtain temperatures below room temperature by using ice in the beaker instead of hot water.
13. Record your results in a table such as the one here and plot a graph of your results.

Temperature of milk in °C	**Time taken for pink colour to disappear in seconds**			
	Trial 1	**Trial 2**	**Trial 3**	**Mean**

GCSE Chemistry required practical activity 1: Making salts

Teachers' notes

Required practical activity	Apparatus and techniques
Preparation of a pure, dry sample of a soluble salt from an insoluble oxide or carbonate, using a Bunsen burner to heat dilute acid and a water bath or electric heater to evaporate the solution.	AT 2, AT 3, AT 4, AT 6

Preparation of pure dry copper sulfate crystals

Materials

In addition to access to general laboratory equipment, each candidate needs:

- $40cm^3$ 1.0M dilute sulfuric acid
- copper(II) oxide powder

Technical information

If crystallising dishes are not available, petri dishes (without lids) make good substitutes. If small conical flasks are not available, a second small beaker is an acceptable replacement.

To prepare 1.0M dilute sulfuric acid, consult CLEAPSS Recipe Book 98 and Guide L195.

$40cm^3$ of dilute acid will react with approximately 3.2g copper (II) oxide powder, but more than this will be used due to the excess added.

Additional information

Students should be warned not to boil the acid. If students add copper (II) oxide to hot acid in large portions, the resulting frothing may go over the top of the beaker. Students should be reminded of the importance of good filtering technique (e.g. correct paper folding, liquid level not above top edge of filter paper.) Students will also need to be reminded not to allow the water bath to boil dry.

The procedure may require two 60 minute lessons to complete. If so, it is suggested that the filtrate is retained at the end of the first lesson for evaporation during the second.

Students must not be allowed to take their crystals home. The waste crystals can be recycled to make up new copper (II) sulfate stock solutions.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- Safety goggles should be worn throughout.
- 1.0M dilute sulfuric acid (IRRITANT) is covered by Hazcard 98A
- copper(II) oxide (HARMFUL) is covered by Hazcard 26
- copper(II) sulfate (HARMFUL) is covered by Hazcard 27C

Trialling

The practical should be trialled before use with students.

Alternative practical

Outline method	Suggested apparatus	Suggested reagents
Add zinc carbonate to cold dilute sulfuric acid in small amounts with stirring until in excess. Filter and evaporate filtrate to concentrate. Leave to crystallise.	Beaker, conical flask, filter funnel & paper, glass rod, spatula, Bunsen burner, tripod, gauze, clamp stand, heatproof mat, evaporating basin, crystallising dish.	Dilute sulfuric acid, zinc carbonate.

GCSE Chemistry required practical activity 1: Making salts

Student sheet

Required practical activity	Apparatus and techniques
Preparation of a pure, dry sample of a soluble salt from an insoluble oxide or carbonate, using a Bunsen burner to heat dilute acid and a water bath or electric heater to evaporate the solution.	AT 2, AT 3, AT 4, AT 6

Preparation of pure dry copper sulfate crystals

In this investigation you will use the reaction between an acid and an insoluble base to prepare an aqueous solution of a salt. After filtering to remove excess unreacted base, you will evaporate the filtrate to leave a concentrated solution of the salt, which will crystallise as it cools and evaporates further. These crystals, when dry, will be of high purity.

Learning outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

Method

You are provided with the following:

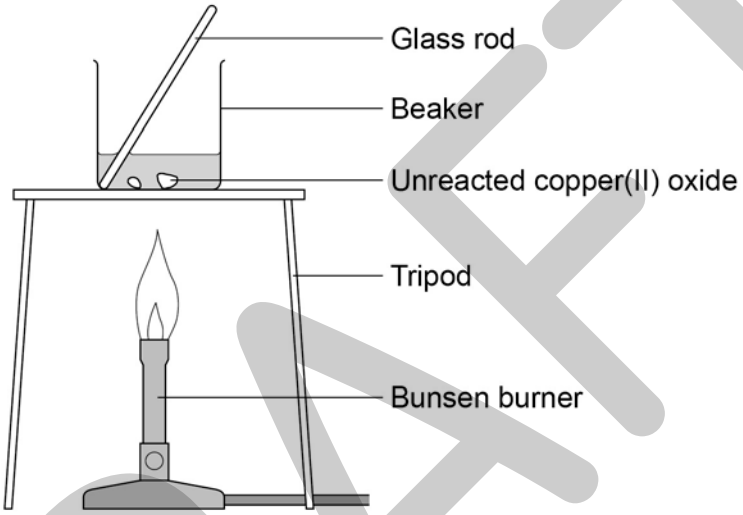
- $40cm^3$ 1.0M dilute sulfuric acid
- Copper (II) oxide powder
- Spatula, glass rod
- $100cm^3$ beaker, Bunsen burner, tripod, gauze, heatproof mat.
- Filter funnel and paper, clamp stand, conical flask.
- $250cm^3$ beaker, evaporating basin, crystallising dish.

Risk Assessment

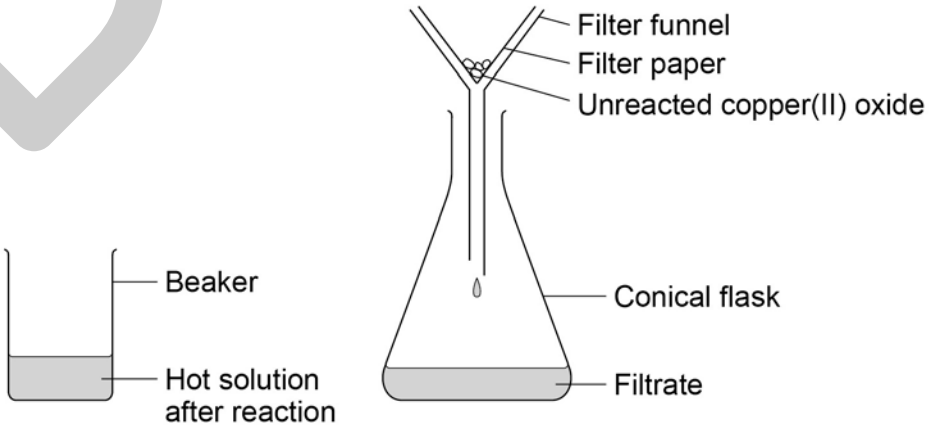
Safety goggles must be worn throughout

You should read these instructions carefully before you start work.

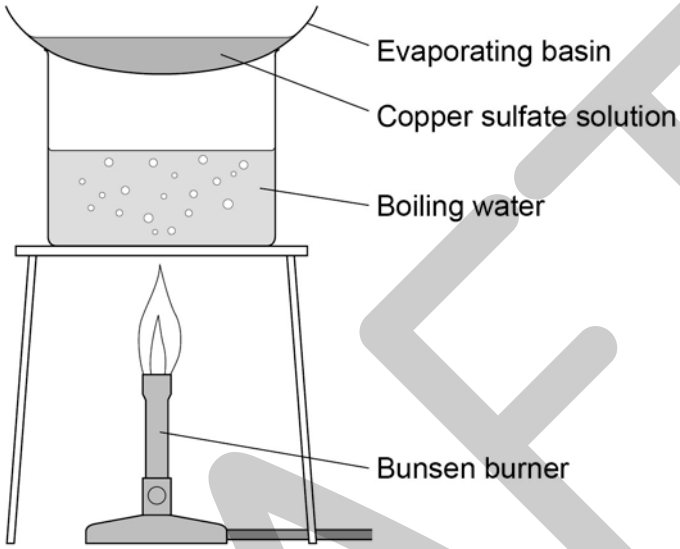
1. Measure 40cm^3 sulfuric acid into the beaker. The volume does not need to be very accurate, so you can use the graduations on the beaker.
2. Set up the tripod, gauze and heatproof mat. Heat the acid **gently** using the Bunsen burner until it is almost boiling. Turn off the burner.



3. Using the spatula, add **small** amounts of copper (II) oxide powder at a time, stirring with the glass rod. Continue to do this if, after stirring, the black powder disappears and the solution is clear blue.
4. Stop adding it when some black powder remains after stirring.
5. Set up the filter funnel and paper over the conical flask, using the clamp stand to hold the funnel. Filter the contents of the beaker from step 3.



6. When filtration is complete, pour the contents of the conical flask into the evaporating basin. Evaporate this gently using a water bath on the tripod and gauze (see diagram) until around half of the solution remains. You will have to estimate this volume.



7. Transfer the remaining solution to the crystallising dish. Leave this in a cool place for at least 24 hours.
8. Remove the crystals from the concentrated solution with a spatula and **gently** pat them dry between two pieces of filter paper. These are pure dry crystals of copper (II) sulfate.

GCSE Chemistry required practical activity 2: Electrolysis

Teachers' notes

Required practical activity	Apparatus and techniques
Investigate what happens when aqueous solutions are electrolysed using inert electrodes. This should be an investigation involving developing a hypothesis	AT 3, AT 7, AT 8 (Chemistry only)

Investigating the elements formed at each electrode when different salt solutions are electrolysed.

Materials

In addition to access to general laboratory equipment, each student needs:

- 0.5M copper(II) chloride solution
- 0.5M copper(II) sulfate solution
- 0.5M sodium chloride solution
- 0.5M sodium sulfate solution
- Petri dish lid with bored holes
- Two carbon rod electrodes with support bungs
- Two crocodile / 4mm plug leads
- Low voltage power supply
- Blue litmus paper
- Tweezers

Technical information

To prepare 0.5M copper (II) chloride solution and 0.5M copper (II) sulfate solution, consult CLEAPSS Recipe Book 31 and Guide L195.

To prepare 0.5M sodium chloride solution, consult CLEAPSS Recipe Book 82 and Guide L195.

Preparation of sodium sulfate solution is not covered by the Recipe Book.

Small petri dish lids fit 100cm^3 beakers well and can be drilled out at 180^o spacing to take the two electrodes. If the carbon rods are then fitted with holed bungs that are positioned to rest on the lid above the holes, the rods will be stabilised well and the risk of short circuits will be much reduced. Proprietary electrolysis cells are available, and can be substituted if available.

Additional information

Chlorine is produced during the first two electrolyses. Students should be warned not to inhale it, and the laboratory should be well ventilated. Limiting the p.d. to 4v and the electrolysis times to 5 minutes will minimize the risk of chlorine exposure.

Much longer times will be needed to collect enough oxygen and hydrogen for testing. If a Hofmann voltameter is available, it could be set up with sodium sulfate (or sulfuric acid) at the beginning of the lesson. This will usually produce enough oxygen and hydrogen for testing by the end of the lesson.

Much frustration can be avoided if the crocodile leads are tested for electrical continuity before this activity.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- Safety goggles must be worn throughout.
- 0.5M copper (II) chloride solution is covered by Hazcard 27A
- 0.5M copper (II) sulfate solution is covered by Hazcard 27C
- 0.5M sodium chloride solution is covered by Hazcard 47B
- 0.5M sodium sulfate solution is covered by Hazcard 98B
- Chlorine is covered by Hazcard 22A

Trialling

The practical should be trialled before use with students.

Alternative practicals

Outline method	Suggested apparatus	Suggested reagents
Place solution of NaBr in beaker. Electrolyse using dc power supply and carbon rods. Identify products at electrodes. Repeat for some of: NaI, $AgNO_3$, H_2SO_4, HCl	Small beaker, lid, carbon rods, crocodile / 4mm plug leads, dc power supply.	Dilute solutions of sodium bromide, sodium iodide, silver nitrate, sulfuric acid, hydrochloric acid.

GCSE Chemistry required practical activity 2: Electrolysis

Student sheet

Required practical activity	Apparatus and techniques
Investigate what happens when aqueous solutions are electrolysed using inert electrodes. This should be an investigation involving developing a hypothesis	AT 3, AT 7 AT 8 (Chemistry only)

Investigating the elements formed at each electrode when different salt solutions are electrolysed.

In this investigation you will use a low voltage power supply and carbon rod electrodes to pass a current through four different salt solutions. You will identify the element formed at the positive and negative electrode in each case.

Learning outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

Method

You are provided with the following:

- Copper(II) chloride solution
- Copper(II) sulfate solution
- Sodium chloride solution
- Sodium sulfate solution
- 100cm^3 beaker with petri dish lid
- Two carbon rod electrodes
- Two crocodile / 4mm plug leads
- Low voltage power supply
- Blue litmus paper
- Tweezers

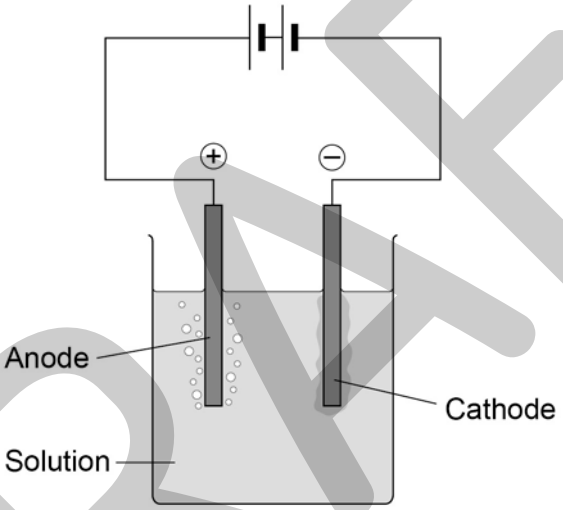
Risk assessment

Safety goggles must be worn throughout.

You should read these instructions carefully before you start work.

1. Pour copper (II) chloride solution into the beaker to about 50cm^3.
2. Add the lid and insert carbon rods through the holes. **The rods must not touch each other.**

   Attach crocodile leads to the rods. Connect the rods to the **dc (red and black)** terminals of a low voltage power supply.



3. Select 4v on the power supply and switch on.
4. Look at both electrodes. Is there bubbling at neither, one or both electrodes?
5. Using tweezers hold a piece of blue litmus paper in the solution next to the positive electrode (the one connected to the red terminal). You will need to lift the lid temporarily to do this. Write your observations in the first blank row of the table below. What is this element?
6. After no more than five minutes, switch off and examine the negative electrode (the one connected to the black terminal). Is there evidence of a metal coating on it? What could it be? Record your results in the table.
7. Clean out the equipment carefully and repeat the investigation with solutions of copper (II) sulfate, sodium chloride and sodium sulfate.

Additional information:

If a gas is produced at the positive electrode which does **not** bleach blue litmus paper, it is oxygen. The amounts produced are usually too small to identify by testing.

If a gas is produced at the negative electrode, it is hydrogen. The amounts produced are usually too small to identify by testing.

solution	Positive electrode (anode)		Negative electrode (cathode)	
	Observations	Element formed	Observations	Element formed
copper (II) chloride				
copper (II) sulfate				
sodium chloride				
sodium sulfate				

GCSE Chemistry required practical activity 3: Temperature changes

Teachers' notes

Required practical activity	Apparatus and techniques
Investigate the variables that affect temperature changes in reacting solutions such as, acid plus metals, acid plus carbonates, neutralisations, displacement of metals.	AT 1, AT 3, AT 5, AT 6

Investigation of the temperature changes which take place when an acid is neutralised by an alkali.

Materials

In addition to access to general laboratory equipment, each student needs:

- 2M dilute hydrochloric acid
- 2M sodium hydroxide solution
- Expanded polystyrene cups and lids with thermometer holes
- 0-110^{o}C thermometers

Technical information

To prepare 2M dilute hydrochloric acid, consult CLEAPSS Recipe Book 43 and Guide L195.

To prepare 2M sodium hydroxide solution, consult CLEAPSS Recipe Book 85 and Guide L195.

30cm thermometers are preferable to 15cm as they are easier to read over the small temperature increases expected and additionally the bulk of the thermometer scale will be above the hole in the lid.

Lids for polystyrene cups can be purchased and perforated; otherwise wooden lids can easily be constructed.

Additional information

Students may need to be reminded to keep thermometer bulbs fully immersed whilst making measurements.

Additional guidance may need to be provided to students regarding the drawing of the two lines of best fit so that they intersect.

The solutions used are quite concentrated in order to produce reasonable temperature changes. 2M sodium hydroxide is particularly hazardous to the eyes. The risk assessment should take account of the ability and behaviour of the group and concentrations lowered if necessary. For example, 10cm^3 portions of 1M sodium hydroxide could be substituted.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- Safety goggles must be worn throughout.
- 2M dilute hydrochloric acid (IRRITANT) is covered by Hazcard 47A
- 1M sodium hydroxide solution (CORROSIVE) is covered by Hazcard 91

Trialling

The practical should be trialled before use with students.

Alternative practicals

Outline method	Suggested apparatus	Suggested reagents
Add a fixed mass of finely divided magnesium, zinc, iron and copper to dilute hydrochloric acid in an expanded polystyrene cup. Stir. Measure maximum temperature change for each metal.	Expanded polystyrene cup and lid, thermometer, stirring rod, spatula, measuring cylinder, balance.	Zinc powder, magnesium powder, iron filings, copper turnings, dilute hydrochloric acid.

GCSE Chemistry required practical activity 3: Temperature changes

Student sheet

Required practical activity	Apparatus and techniques
Investigate the variables that affect temperature changes in reacting solutions such as, acid plus metals, acid plus carbonates, neutralisations, displacement of metals.	AT 1, AT 3, AT 5, AT 6

Investigation of the temperature changes which take place when an acid is neutralised by an alkali.

In this investigation you will monitor the temperature rise as small volumes of sodium hydroxide solution are added to dilute hydrochloric acid in an insulated cup. You will then plot a graph of your results and work out how much sodium hydroxide was needed to fully react with the acid.

Learning outcomes
1
2
Teachers to add these with particular reference to working scientifically

Method

You are provided with the following:

- 2M dilute hydrochloric acid
- 2M sodium hydroxide solution
- Expanded polystyrene cup and lid
- 250cm^3 beaker
- 10cm^3 and 50cm^3 measuring cylinders.
- thermometer

Risk Assessment

Safety goggles must be worn throughout.

You should read these instructions carefully before you start work.

1. Use the large measuring cylinder to put 30cm^3 dilute hydrochloric acid into the polystyrene cup.
2. Stand the cup inside the beaker. This will make it more stable.
3. Use the thermometer to measure the temperature of the acid. Record it in the first blank column of the table on the back of this sheet.
4. Put 5cm^3 sodium hydroxide solution into the small measuring cylinder.
5. Pour the sodium hydroxide into the cup, quickly fit the lid and gently stir the solution with the thermometer through the hole. When the reading on the thermometer **stops changing,** write the temperature in the next space in the table.
6. Repeat steps 4 and 5 to add further 5cm^3 portions of sodium hydroxide to the cup until a total of 40cm^3 has been added. The last few additions should produce a temperature fall rather than a rise.
7. Repeat the **whole investigation** (steps 1 – 6) and record the results in the second blank column of the table.
8. Calculate the **mean** maximum temperature reached for each of the sodium hydroxide volumes and record it in the third blank column.
9. Plot a line graph of total volume of sodium hydroxide added in cm^3 (x axis) against mean maximum temperature in ^{o}C (y axis). Draw two straight lines of best fit - one through the points which are increasing, and another through those which are decreasing. Ensure the two lines are extended so they cross each other.
10. Use the graph to estimate how much sodium hydroxide solution was needed to neutralise 25cm^3 dilute hydrochloric acid.

Total volume of sodium hydroxide added (cm^3)	**Maximum temperature (^{o}C)**		
	First trial	**Second trial**	**Mean**
0			
5			
10			
15			
20			
25			
30			
35			
40			

GCSE Chemistry required practical activity 4: Rates of reaction

Teachers' notes

Required practical activity	Apparatus and techniques
Investigate how changes in concentration affect the rates of reactions by a method involving measuring the volume of a gas produced and a method involving a change in colour or turbidity. This should be an investigation involving developing a hypothesis.	AT 1, AT 3, AT 5, AT 6

Investigation into how the concentration of a solution affects the rate of a chemical reaction.

Materials

In addition to access to general laboratory equipment, each candidate needs:

- 40g/dm^3 sodium thiosulfate solution.
- 2.0M dilute hydrochloric acid
- printed black paper cross
- stopclock

Technical information

To prepare 40g/dm^3 sodium thiosulfate solution, consult CLEAPSS Recipe Book 87 and Guide L195. The concentration is specified in g/dm^3 rather than mole/dm^3 to simplify graph plotting for students. However, if it is desired that a Higher Tier group work in mole/dm^3 then the base thiosulfate solution should be 0.2M. The diluted solutions prepared by students will then be 0.16, 0.12, 0.08 and 0.04mole/dm^3

To prepare 2.0M dilute hydrochloric acid, consult CLEAPSS Recipe Book 43 and Guide L195.

Printed crosses may give a greater likelihood of students obtaining reproducible results between groups.

Additional information

This required practical should form the basis of a complete investigation and will probably require two 60 minute laboratory lessons to complete.
Sulfur dioxide is released during the reaction which can exacerbate breathing difficulties in people with pre-existing conditions such as asthma. The laboratory should be well ventilated. Consult CLEAPPS Guide L195 for additional safety information.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- Safety goggles should be worn throughout.
- 40g/dm3 sodium thiosulfate (LOW RISK) is covered by Hazcard 95C
- 2.0M dilute hydrochloric acid (IRRITANT) is covered by Hazcard 47A
- Sulfur dioxide (TOXIC) is covered by Hazcard 97

Trialling

The practical should be trialled before use with students.

Alternative practicals

Outline method	Suggested apparatus	Suggested reagents
Add different concentrations of dilute hydrochloric acid to a fixed mass of marble chips. Either measure the volume of CO_2 produced every 30 seconds using a gas syringe or inverted measuring cylinder, or perform on a tared balance and measure the loss in mass every 30 seconds.	Conical flask, delivery tube with bung, trough, measuring cylinder, gas syringe, stopclock, balance.	Marble chips, dilute hydrochloric acid.

GCSE Chemistry required practical activity 4: Rates of reaction

Student sheet

Required practical activity	Apparatus and techniques
Investigate how changes in concentration affect the rates of reactions by a method involving measuring the volume of a gas produced and a method involving a change in colour or turbidity. This should be an investigation involving developing a hypothesis.	AT 1, AT 3, AT 5, AT 6

Investigation into how the concentration of a solution affects the rate of a chemical reaction.

In this investigation you will use the reaction between sodium thiosulfate and hydrochloric acid to find out how the rate of reaction changes as the thiosulfate solution becomes more dilute.

Learning outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

Method

You are provided with the following:

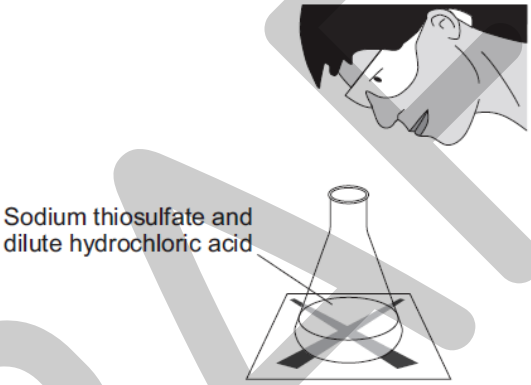
- 40g/dm^3 sodium thiosulfate solution.
- 2.0M dilute hydrochloric acid
- 10cm^3 and 100cm^3 measuring cylinders
- 100cm^3 conical flask
- printed black paper cross
- stopclock

Risk assessment

Safety goggles must be worn throughout.

You should read these instructions carefully before you start work.

1. Use a measuring cylinder to place 10cm^3 sodium thiosulfate solution into the conical flask. Again using a measuring cylinder, dilute this by adding 40cm^3 water. This will make a solution of thiosulfate with a concentration of 8g/dm^3. Put the conical flask on the black cross.
2. Put 10cm^3 of dilute hydrochloric acid into the small measuring cylinder.
3. As you tip this acid into the flask, swirl it gently and at the same time start the stopclock.
4. Looking down through the top of the flask, stop the clock when you can no longer see the cross.



5. Write the time taken **in seconds** in the first blank column of the table on the back of this sheet. You will need to multiply any minutes by 60 and then add the extra seconds.
6. Repeat **steps 1 - 4** four times, but **in step 1** use:

   - 20cm^3 sodium thiosulfate + 30cm^3 water (concentration 16g/dm^3)
   - 30cm^3 sodium thiosulfate + 20cm^3 water (concentration 24g/dm^3)
   - 40cm^3 sodium thiosulfate + 10cm^3 water (concentration 32g/dm^3)
   - 50cm^3 sodium thiosulfate + no water (concentration 40g/dm^3)

7. Repeat the **whole investigation** (steps 1 – 5) twice more and record the results in the second and third blank columns of the table.
8. Calculate the **mean** time for each of the thiosulfate concentrations and record it in the fourth blank column, leaving out of your calculations any anomalous values.
9. Plot a line graph of thiosulfate concentration in g/dm^3 (x axis) against mean time taken to obscure the cross in seconds (y axis). Draw a smooth curved line of best fit. What can you say about the effect of the independent variable (concentration) on the dependent variable (time taken for the cross to disappear)? What were your control variables?

10. Compare your results with those of others in the class. Is there evidence that this investigation is reproducible?

Concentration of sodium thiosulfate (g/dm^3)	Time taken for cross to disappear (seconds)			
	First trial	Second trial	Third trial	Mean
8				
16				
24				
32				
40				

GCSE Chemistry required practical activity 5: Chromatography

Teachers' notes

Required practical activity	Apparatus and techniques
Investigate how paper chromatography can be used to separate and tell the difference between coloured substances. Students should calculate Rf values.	AT 1, AT 4

Investigation in to the use of paper chromatography to separate and identify a mixture of food colourings.

Materials

In addition to access to general laboratory equipment, each candidate needs:

- Four known food colourings labelled A – D
- Unknown food colouring labelled U
- Rectangle of chromatography paper
- Capillary melting point tubes

Technical information

There are several brands of food colouring available. It will be necessary to experiment to obtain a type which gives good results. The unknown mixture should contain two of the known food colouring and a third colour **not** from A – D. Best results will be obtained if A – D are single dyes and not mixtures themselves.

Additional information

It is suggested that chromatography paper is pre-cut for student use so that it will not touch the beaker walls (if it does, capillary rise at the edges will distort the solvent front).

Melting point tubes take up food dye by capillary attraction and are a convenient way of making small reproducible spots.

Wet chromatography paper is difficult to take measurements from. Because of the drying time involved it may be necessary to make measurements and do calculations during the following lesson.

Students should be told to resist the temptation to move or touch the beaker once the experiment is under way.

A lid is sometimes suggested for good results, especially when the solvent is volatile, but is not essential with water. However, to illustrate good practice, if desired, a petri dish or lid makes a suitable lid. Cut-outs in the wall can be made at 180^{o} to each other to clear the ends of the glass rod.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- Safety goggles must be worn throughout.
- There are no significant safety issues.
- Care should be taken with sharp broken melting point tubes.

Trialling

The practical should be trialled before use with students.

Alternative practicals

Outline method	Suggested apparatus	Suggested reagents
Use rectangular chromatography paper suspended in a large beaker to separate mixed dyes alongside the pure components of the mixtures, using water, ethanol and/or water-ethanol mixtures as solvent. Dry, take measurements and compare the effect of different solvents on R_f values.	Large beaker, glass rod, chromatography paper, melting point tubes for spotting,	Ethanol, inks, food colourings.

GCSE Chemistry required practical activity 5: Chromatography

Student sheet

Required practical activity	Apparatus and techniques
Investigate how paper chromatography can be used to separate and tell the difference between coloured substances. Students should calculate Rf values.	AT 1, AT 4

Investigation into the use of paper chromatography to separate and identify a mixture of food colourings.

In this investigation you will use paper chromatography to separate the different colours present in an unknown mixture of food colourings. You will then measure the distance travelled by each colour and the solvents to calculate R_f values.

Learning outcomes
1
2
Teachers to add these with particular reference to working scientifically

Method

You are provided with the following:

- $250cm^3$ beaker
- Glass rod
- A rectangle of chromatography paper
- Four known food colourings labelled A to D
- An unknown mixture of food colourings labelled U
- Glass capillary tubes

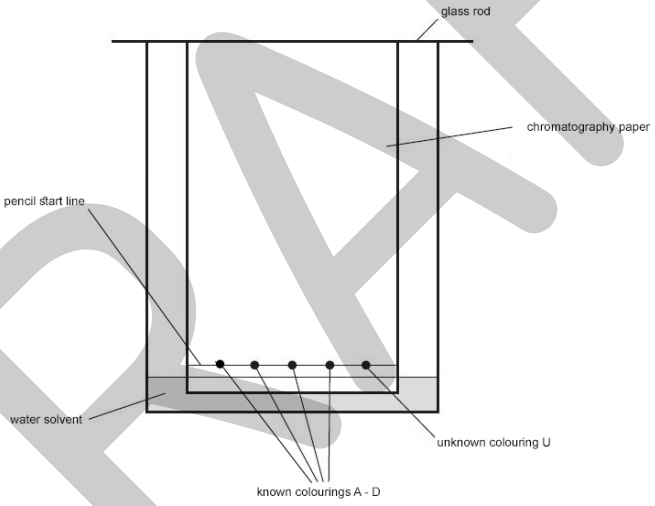
Risk assessment

Safety goggles must be worn throughout.

You should read these instructions carefully before you start work.

1. Using a ruler, draw a horizontal pencil line 2cm from a short edge of the chromatography paper. Mark five pencil spots at equal intervals across the line, keeping at least 1cm away from each end.
2. Use a glass capillary tube to put a small spot of each known colouring and the unknown one on the five pencil spots. Try to make sure each spot is no more than 5mm in diameter. Label each spot **in pencil.**
3. Pour water into the beaker to a depth of **no more than 1cm.**
4. Attach the edge of the paper furthest from the spots to the glass rod so that when the rod is rested on the top edge of the beaker, the bottom edge of the paper dips into the water.

   Ensure that the pencil line is above the water surface, and that the sides of the paper do not touch the beaker wall.



5. Without disturbing the beaker, wait for the water solvent to travel at least three quarters of the way up the paper. Carefully remove it and draw another pencil line on the dry part of the paper as close to the wet edge as possible.
6. Hang the paper up to dry thoroughly.
7. Measure the distance in mm between the two pencil lines. This is the distance travelled by the water solvent. Write the same distance in the table below for each colouring.
8. For each of the four known colours, measure the distance in mm from the bottom line to the centre of each spot. Write each measurement in the table.
9. Use the equation:

$$R_f = \frac{\text{distance } \textit{moved by substance}}{\textit{distance moved by solvent}}$$

   to calculate the R_f value for each of the known colours. Write them in the table.

10. Match the spots in the unknown sample U with those from A – D using the colour and distance travelled to help you. Which of colourings A – D are in mixture U? Are there any other colourings in U which do **not** match A – D?

Food colouring	Distance travelled (mm)		Rf value
	Solvent	Spot	
A			
B			
C			
D			

11. Match the spots in the unknown sample U with those from A – D using the colour and distance travelled to help you. Which of colourings A – D are in mixture U? Are there any other colourings in U which do **not** match A – D?

GCSE Chemistry Required practical activity 6: Water purification

Teachers' notes

Required practical activity	Apparatus and techniques
Analysis and purification of water samples from different sources, including pH, dissolved solids and distillation.	AT 2, AT 3, AT 4

Distillation of salt water to produce potable water

Materials

In addition to access to general laboratory equipment, each candidate needs:

- 50cm^3 salt water (concentration unimportant but should give good positive test results for sodium and chloride ions)
- nichrome wire mounted in handle
- 0.4M dilute nitric acid
- 0.05M silver nitrate solution
- A few ice cubes

Technical information

Nichrome wires can be mounted in lengths of glass capillary tube to form a handle. Two right-angled delivery tubes can be linked with rubber tubing to create the double right-angle required. The tubes should be pre-inserted into suitable rubber bungs.

Although only a small quantity of water needs to be distilled, enough needs to be present in the flask to avoid it boiling dry and cracking.

To prepare 0.4M dilute nitric acid, consult CLEAPSS Recipe Book 61 and Guide L195.

To prepare 0.05M silver nitrate solution, consult CLEAPSS Recipe Book 77 and Guide L195.

Additional information

Students will need to be cautioned to remove the heat source if it seems likely the salt water will boil over through the delivery tube. They should also be told to keep the delivery tube at least 2cm from the bottom of the collecting test tube; otherwise the distillate level may rise above it, creating the possibility of suck-back when heating is discontinued.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- Safety goggles should be worn throughout.
- 0.4M dilute nitric acid (IRRITANT) is covered by Hazcard 67
- 0.05M silver nitrate (LOW RISK at this concentration) is covered by Hazcard 87

Trialling

The practical should be trialled before use with students.

Supplementary demonstration

Outline method	Suggested apparatus	Suggested reagents
Distillation of solutions to obtain water using Liebig condenser. Place solution in clamped side arm distillation flask over tripod, gauze and Bunsen burner or electric heating mantle. Fit thermometer and Liebig condenser and distil into conical flask.	Tripod, gauze, clamp stand, heatproof mat, Bunsen burner OR electric heating mantle, side arm distillation flask, thermometer in bung, Liebig condenser, conical flask.	Salt water, copper sulfate solution, diluted ink, diluted food colouring.

GCSE Chemistry Required practical activity 6: Water purification

Student sheet

Required practical activity	Apparatus and techniques
Analysis and purification of water samples from different sources, including pH, dissolved solids and distillation.	AT 2, AT 3, AT 4

Distillation of salt water to produce potable water

In this investigation you will test salt water for the presence of sodium and chloride ions. After distillation, you will test the water again to check that these ions have been removed, making the water fit to drink.

Learning outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

Method

You are provided with the following:

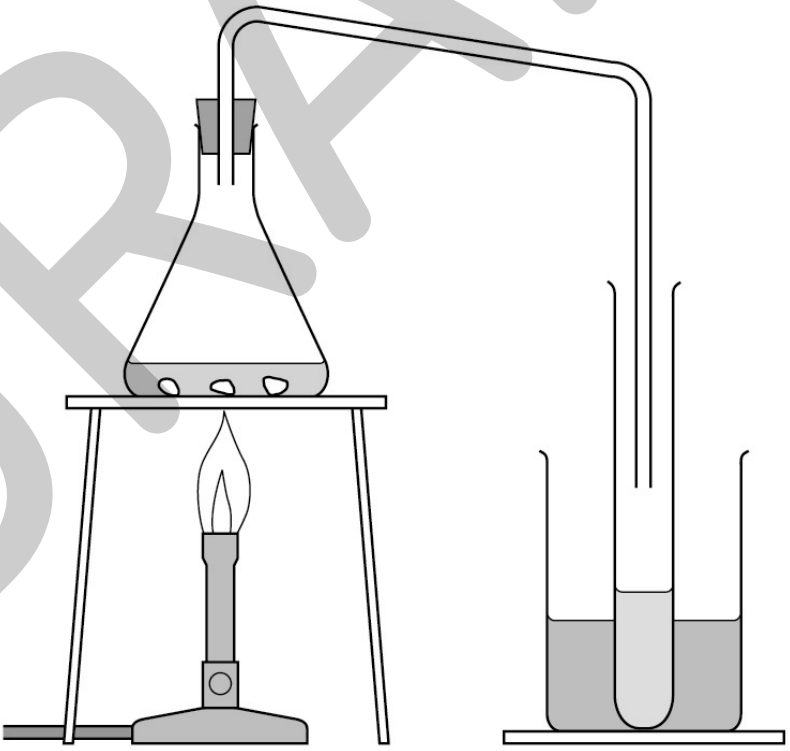
- 50cm^3 salt water.
- Bunsen burner, tripod, gauze, heatproof mat.
- 250cm^3 beaker, clamp stand, 250cm^3 conical flask, delivery tube with bung, test tube, ice.
- An additional test tube, test tube rack, nichrome wire, dilute nitric acid, silver nitrate solution.

Risk assessment

Safety goggles must be worn throughout.

You should read these instructions carefully before you start work.

1. Pour around 1cm depth of the salt water into the test tube in the rack. Dip the nichrome wire into this solution, and then hold the tip of the wire in a blue Bunsen burner flame. Record your observation in the table on the back of this sheet.
2. Now add a few drops of dilute nitric acid to this solution, followed by 1cm depth of silver nitrate solution. Again, record your observations in the table.
3. Place the remaining salt water in the conical flask and set up the apparatus for distillation as shown in the diagram. Make sure the conical flask is held on the tripod and gauze using the clamp stand. Place a mixture of ice and water in the beaker surrounding the test tube.
4. Heat the water with the Bunsen burner until it starts to boil. Then reduce the heat so that the water boils gently. Distilled water will collect in the cooled test tube. Collect about 1cm depth of water in this way, then stop heating.
5. Repeat the tests in steps 1 and 2 again using the distilled water, making sure that the nichrome wire and test tube have been cleaned. Again, record your results in the table.



	Flame test	Nitric acid and silver nitrate
Salt water		
Distilled water		

A yellow flame test confirms the presence of sodium ions. A white precipitate with nitric acid and sliver nitrate solution confirms the presence of chloride ions.

GCSE Chemistry Required practical activity 7: Neutralisation (chemistry only)

Teachers' notes

Required practical activity	Apparatus and techniques
Determination of the reacting volumes of solutions of a strong acid and a strong alkali by titration. **Higher Tier only** Determination of the concentration of one of the solutions in mol/dm3 and g/dm3 from the reacting volumes and the known concentration of the other solution.	AT 1, AT 8

Investigation to find the volume of dilute sulfuric acid needed to neutralise a known volume of sodium hydroxide solution. (FT)

Investigation to find the concentration of a dilute sulfuric acid solution, using a sodium hydroxide solution of known concentration. (HT)

Materials

In addition to access to general laboratory equipment, each student needs:

- $25cm^3$ volumetric pipette
- Pipette filler
- $50cm^3$ burette
- White tile
- 0.1M sodium hydroxide solution (concentration shown on label for HT)
- 0.08M sulfuric acid (concentration NOT shown on label for HT)
- Methyl orange indicator

Technical information

To prepare 0.08M dilute sulfuric acid, consult CLEAPSS Recipe Book 98 and Guide L195.

To prepare 0.1M sodium hydroxide solution, consult CLEAPSS Recipe Book 85 and Guide L195.

To prepare methyl orange indicator, consult CLEAPSS Recipe Book 46.

$25cm^3$ 0.1M NaOH is neutralised by $15.6cm^3$ 0.08M H_2SO_4. Therefore it should be possible to complete all three titrations using one fill of a standard $50cm^3$ burette. However, the student sheet assumes for simplicity that the burette is refilled each time to $0cm^3$. Some teachers may wish to use burette reading subtractions with able groups. In this case the table will need to be expanded to hold start and finish volumes as well as volume of acid required.

Similarly, some traditional procedures, such as rinsing glassware, eye level meniscus reading, preliminary (rough) titrations and pipette draining (rather than blowing) have been omitted from the student sheet. Teachers may want to mention these to able groups.

It will be necessary to demonstrate the use of the particular type of pipette filler available in the centre.

Phenolphthalein indicator can be substituted if methyl orange is used. The colour change on the sheet will need to be altered to pink to colourless.

Additional information

If volumetric pipettes and fillers are not available, 50 cm^3 measuring cylinders could be substituted, although accuracy will be reduced. Clean heatproof mats could be used instead of white tiles. It is very difficult to manage without burettes, however.

Sodium hydroxide solution is particularly hazardous to the eyes.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- Safety goggles must be worn throughout.
- 0.08M dilute sulfuric acid is covered by Hazcard 98A
- 0.1M sodium hydroxide solution (IRRITANT) is covered by Hazcard 91
- Acid-base indicators (TOXIC) are covered by Hazcard 32

Trialling

The practical should be trialled before use with students.

Alternative practicals

The experiment can also be done with hydrochloric acid and an alternative indicator. Furthermore, the alkali could be the reagent of unknown concentration instead of the acid.

Outline method	Suggested apparatus	Suggested reagents
Place NaOH (aq) of known (HT: unknown) concentration in conical flask using graduated pipette and filler. Titrate with dilute HCl of known concentration from burette. Repeat and calculate mean titre and (HT only) concentration of alkali.	Graduated pipette, pipette filler, conical flask, white tile, burette, clamp stand, small funnel.	Dilute sodium hydroxide solution, dilute hydrochloric acid, phenolphthalein.

GCSE Chemistry required practical activity 7: Neutralisation (chemistry only)

Student sheet – Foundation Tier

Required practical activity	Apparatus and techniques
Determination of the reacting volumes of solutions of a strong acid and a strong alkali by titration.	AT 1, AT 8

Investigation to find the volume of dilute sulfuric acid needed to neutralise a known volume of sodium hydroxide solution.

In this investigation you will use the colour change in an acid-base indicator to find the volume of dilute sulfuric acid needed to exactly neutralise 25cm^3 of sodium hydroxide solution.

Learning outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

Method

You are provided with the following:

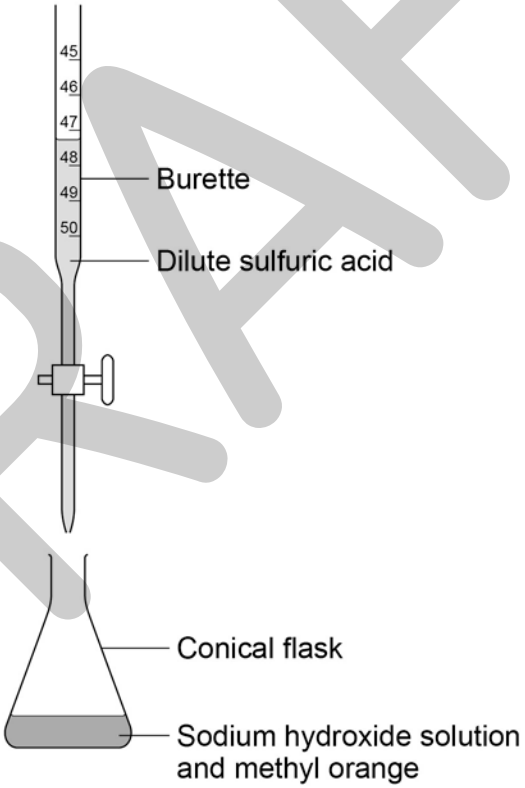
- 25cm^3 volumetric pipette and pipette filler
- Burette, small funnel and clamp stand
- 250cm^3 conical flask
- White tile
- Dilute sulfuric acid
- Sodium hydroxide solution
- Methyl orange indicator

Risk assessment

Safety goggles must be worn throughout

You should read these instructions carefully before you start work.

1. Use the pipette and pipette filler to put exactly 25cm^3 sodium hydroxide solution into the conical flask. Your teacher will show you how to do this. Stand the flask on a white tile.
2. Clamp the burette vertically in the clamp stand about halfway up its length, so that there is just enough room underneath for the conical flask and tile.
3. Making sure the burette tap is closed; use the small funnel to carefully fill the burette with dilute sulfuric acid to the 0cm^3 line. You should do this at a low level so that you are not pouring acid from above head height – for example, with the clamp stand temporarily on a lab stool or the floor.
4. Put 5 – 10 drops of methyl orange indicator into the conical flask, swirl to mix and place under the burette with the tile.



5. Carefully open the tap so that sulfuric acid flows into the flask at a dropwise rate. Whilst adding acid, constantly swirl the flask and look for a colour change from yellow to red in the indicator.
6. When there are signs that the colour change is close to being permanent, use the tap to slow the drops down. You need be able to shut the tap immediately after a single drop of acid causes the colour to become permanently red.
7. Read the burette scale carefully and record the volume of acid you added in the first blank space in the table below.

8. Repeat the whole investigation twice more and record the results of your repeats in the second and third blank spaces.

9. Calculate the mean value for the volume of acid needed to neutralise 25cm^3 of the sodium hydroxide solution. Record this value in the final space in the table.

Volume of dilute sulfuric acid required needed to neutralise 25cm^3 sodium hydroxide solution (cm^3)			
Trial 1	**Trial 2**	**Trial 3**	**Mean**

GCSE Chemistry required practical activity 7: Neutralisation (chemistry only)

Student sheet – Higher Tier

Required practical activity	Apparatus and techniques
Higher Tier only Determination of the concentration of one of the solutions in mol/dm3 and g/dm3 from the reacting volumes and the known concentration of the other solution.	AT 1, AT 8

Investigation to find the concentration of a dilute sulfuric acid solution using a sodium hydroxide solution of known concentration.

In this investigation you will use the colour change in an acid-base indicator to find the volume of dilute sulfuric acid of unknown concentration needed to exactly neutralise 25cm^3 of 0.5 mol/dm^3 sodium hydroxide solution. You will then calculate the concentration of the acid used in mol/dm^3 and g/dm^3.

Learning outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

Method

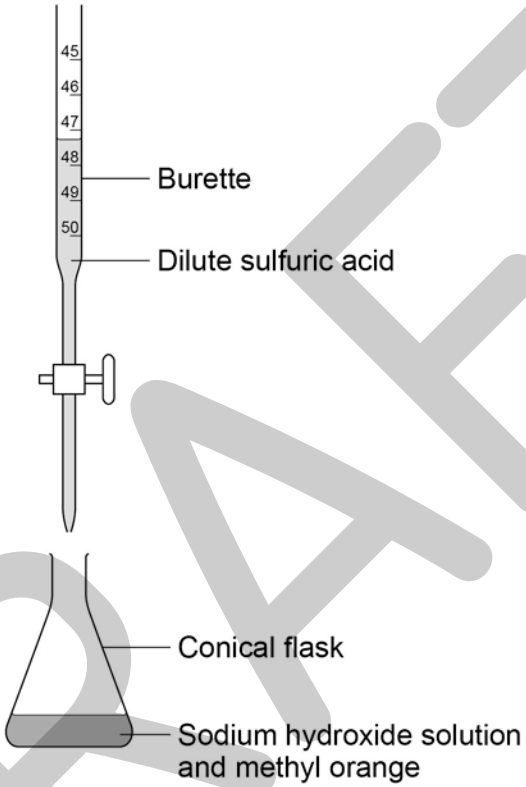
You are provided with the following:

- 25cm^3 volumetric pipette and pipette filler
- Burette, small funnel and clamp stand
- 250cm^3 conical flask
- White tile
- Dilute sulfuric acid of unknown concentration
- 0.1 mol/dm^3 sodium hydroxide solution
- Methyl orange indicator

Risk assessment

Safety goggles must be worn throughout.

You should read these instructions carefully before you start work.



1. Use the pipette and pipette filler to put exactly 25cm^3 sodium hydroxide solution into the conical flask. Your teacher will show you how to do this. Stand the flask on a white tile.
2. Clamp the burette vertically in the clamp stand about halfway up its length, so that there is just enough room underneath for the conical flask and tile.
3. Making sure the burette tap is closed; use the small funnel to carefully fill the burette with dilute sulfuric acid to the 0cm^3 line. You should do this at a low level so that you are not pouring acid from above head height – for example, with the clamp stand temporarily on a lab stool or the floor.
4. Put 5 – 10 drops of methyl orange indicator into the conical flask, swirl to mix and place under the burette with the tile.
5. Carefully open the tap so that sulfuric acid flows into the flask at a dropwise rate. Whilst adding acid, constantly swirl the flask and look for a colour change from yellow to red in the indicator.

6. When there are signs that the colour change is close to being permanent, use the tap to slow the drops down. You need be able to shut the tap immediately after a single drop of acid causes the colour to become permanently red.
7. Read the burette scale carefully and record the volume of acid you added in the first blank space in the table below.
8. Repeat the whole investigation twice more and record the results of your repeats in the second and third blank spaces.
9. Calculate the mean value for the volume of acid needed to neutralise 25cm^3 of the sodium hydroxide solution.
   Use your mean result to calculate the concentration of the acid in mol/dm^3 and g/dm^3 using the calculation steps below the table.

Volume of dilute sulfuric acid required needed to neutralise 25cm^3 sodium hydroxide solution (cm^3)			
Trial 1	**Trial 2**	**Trial 3**	**Mean**

Calculations

Concentration (mol/dm^3) = number of moles ÷ volume of solution (dm^3)

Step 1:

Moles of sodium hydroxide in $25cm^3$ = concentration x volume = 0.1 mol/dm^3 x (25 ÷ 1000) dm^3

= _____ moles

Step 2:

Equation: $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

This shows that **two** moles of sodium hydroxide neutralise **one** mole of sulfuric acid.

So moles of sulfuric acid used = (answer from step 1) ÷ 2

= _____ moles

Step 3:

Concentration of sulfuric acid (mol/dm^3) = moles ÷ mean volume of acid

= (answer from step 2) ÷ (mean volume from table ÷ 1000)

= _____ mol/dm^3

Step 4:

A_r (H) = 1; A_r (O) = 16; A_r (S) = 32

M_r (H_2SO_4) = _____ .

Concentration of sulfuric acid (g/dm^3) = (answer from step 3) x M_r (H_2SO_4)

= _____ g/dm^3

GCSE Chemistry Required practical activity 8: Identifying Ions (chemistry only)

Teachers' notes

Required practical activity	Apparatus and techniques
Use of chemical tests to identify the ions in unknown single ionic compounds covering the ions in sections.	AT 1, AT 8

Identify the ions in a single ionic compound using chemical tests

Materials

In addition to access to general laboratory equipment, each student needs:

- nichrome wire mounted in handle
- limewater
- 0.4M dilute hydrochloric acid
- 0.1M barium chloride solution
- 0.4M dilute nitric acid
- 0.05M silver nitrate solution
- 0.4M known labelled cation salt solutions: LiCl, NaCl, KCl, $CaCl_2$, $CuCl_2$
- 0.4M known labelled anion salt solutions: Na_2CO_3, Na_2SO_4, NaCl, NaBr, NaI
- 0.4M salt solution labelled 'unknown'.

Technical information

The unknown salt solution could be any soluble compound containing the anions and cations tested for. It is suggested that potassium sulfate will give good results as the unknown. It has the additional advantage that the halide test need not be done again if time is short, saving silver nitrate.

Nichrome wires can be mounted in lengths of glass capillary tube to form a handle. If nichrome wires are not available, soaked splints can be **briefly** heated to give acceptable results.

To prepare 0.4M dilute hydrochloric acid, consult CLEAPSS Recipe Book 43 and Guide L195.
To prepare 0.1M barium chloride solution, consult CLEAPSS Recipe Book 10 and Guide L195.
To prepare 0.4M dilute nitric acid, consult CLEAPSS Recipe Book 61 and Guide L195.
To prepare 0.05M silver nitrate solution, consult CLEAPSS Recipe Book 77 and Guide L195.

Additional information

Students will need practice and/or demonstration to show how to transfer small amounts of CO_2 to limewater using a pipette. Several withdrawals of CO_2 will be needed before the limewater turns cloudy.

Students will need to be told to label the test tubes in the rack clearly to avoid confusion.

The distinction between the three halide precipitates (white, cream and yellow) is slight. Students should be encouraged to compare these, side-by-side.

It is important to keep nichrome wires clean. They can be rubbed with fine emery paper to achieve this. Students at GCSE level should **not** be provided with concentrated hydrochloric acid in watch glasses to clean the wires in the traditional way. Contaminated wires or solutions can result in the intense sodium flame emission masking the other ions.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- Safety goggles should be worn throughout.
- 0.4M dilute hydrochloric acid (LOW RISK at this concentration) is covered by Hazcard 47A
- 0.1M barium chloride solution (HARMFUL) is covered by Hazcard 10A
- 0.4M dilute nitric acid (IRRITANT) is covered by Hazcard 67
- 0.05M silver nitrate (LOW RISK at this concentration) is covered by Hazcard 87
- The risks associated with the salt solutions and limewater should also be taken into consideration.

Trialling

The practical should be trialled before use with students.

Alternative practical

Outline method	Suggested apparatus	Suggested reagents
Addition of dilute NaOH solution dropwise and then in excess to solutions of compounds containing Cu^{2+}, Fe^{2+}, Fe^{3+}, Al^{3+}, Ca^{2+} and Mg^{2+}.	Pipettes, test tubes, rack, glass rods.	Dilute sodium hydroxide, soluble chlorides or sulfates of each cation.

GCSE Chemistry Required Practical activity 8: Identifying Ions (chemistry only)

Student sheet

Required practical activity	Apparatus and techniques
Use of chemical tests to identify the ions in unknown single ionic compounds covering the ions in sections.	AT 1, AT 8

Identify the ions in a single ionic compound using chemical tests

In this investigation you will analyse a range of known ionic compounds by flame testing and the addition of acids, barium chloride and silver nitrate. You will then apply the knowledge you gain to identify the ions in an unknown compound.

Learning outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

Method

You are provided with the following:

- Bunsen burner
- test tubes and test tube rack
- teat pipette
- nichrome wire mounted in handle
- limewater
- 0.4M dilute hydrochloric acid
- 0.1M barium chloride solution
- 0.4M dilute nitric acid
- 0.05M silver nitrate solution
- Known labelled solutions: chlorides of lithium, sodium, potassium, calcium and copper
- Known labelled solutions: sodium salts containing carbonate, sulfate, chloride, bromide and iodide
- Salt solution labelled ‘unknown’.

Risk assessment

Safety goggles must be worn throughout.

You should read these instructions carefully before you start work.

1. **Flame Tests:** Pour around 1cm depth of each of the **labelled chloride solutions** into five test tubes in the rack. Dip the nichrome wire into the first solution, and then hold the tip of the wire in a blue Bunsen burner flame. Clean the wire carefully between tests and test the other four solutions in the same way. Record your observation in **table 1** on the back of this sheet. Empty and clean the test tubes.
2. **Carbonate test:** Pour around 1cm depth of each of the **labelled sodium solutions** into five test tubes in the rack. Place 2cm depth of limewater in a sixth tube. Add 1cm depth **of dilute hydrochloric acid** to each sodium salt in turn. **If** (and only if) you see bubbles, **quickly** use the teat pipette to transfer the gas produced to the limewater. Your teacher may show you how to do this. You will need to take several pipettes of the gas to get a change in the limewater. Record your results in the first blank row of **table 2**. Empty and clean the test tubes.
3. **Sulfate test:** Pour around 1cm depth of each of the **labelled sodium solutions** into five test tubes in the rack. Add a few drops of **dilute hydrochloric acid** to each solution, followed by 1cm depth of **barium chloride** solution. Record your observations in the second blank row of **table 2**. Empty and clean the test tubes.
4. **Halide test:** Pour around 1cm depth of each of the **labelled sodium solutions** into five test tubes in the rack. Add a few drops of **dilute nitric acid** to each solution, followed by 1cm depth of **silver nitrate** solution. Again, record your observations in **table 2.**
5. **Unknown:** Repeat tests 1 to 4 on the unknown salt solution. Use your results from **test 1** and **table 1** to identify the positive metal ion in the unknown compound, and your results from **tests 2, 3 and 4** and **table 2** to identify the negative non-metal ion.

Table 1. Possible flame colours are green, crimson, lilac, yellow, red

metal ion	lithium	sodium	potassium	calcium	copper
flame colour					

Table 2. Possible outcomes are carbon dioxide release OR white, cream or yellow precipitates OR no reaction

non-metal ion	carbonate	sulfate	chloride	bromide	iodide
carbonate test					
sulfate test					
halide test					

GCSE Physics required practical activity 1: Specific heat capacity

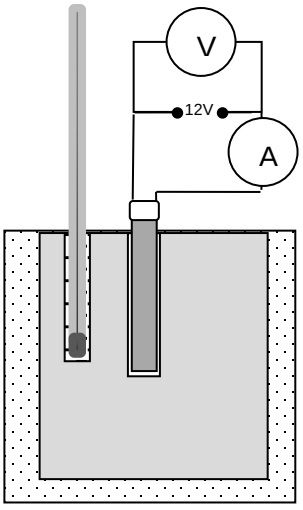
Teachers' notes

Required practical activity	Apparatus and techniques
An investigation to determine the specific heat capacity of one or more materials. The investigation will involve linking the decrease of one energy store (or work done) to the increase in temperature and subsequent increase in thermal energy stored.	AT 1, AT 5

What is the specific heat capacity of copper?

Materials

In addition to access to general laboratory equipment, each student needs:



- 1 kg copper, iron and aluminium metal blocks, each with two holes – one for the heater and one for the thermometer
- thermometer
- pipette to put water in the thermometer hole
- 30 W, 12 V heater and power supply
- insulation to wrap around the blocks
- ammeter and voltmeter
- 4mm leads
- stop watch or stop clock
- balance (capable of measuring more than 1 kg) to determine the mass of the blocks.

Technical information

The method involves using the electric heaters to raise the temperature of the blocks. You may have blocks made for this experiment. The blocks usually have a mass of 1 kg and have holes that fit the heater and the thermometer. The heaters fit snugly but there is usually an air gap around the thermometer. A drop of water provides a better thermal contact. The blocks should be lagged to reduce heat loss to the surroundings.

The students will switch on the power supply and measure the current and potential difference. This is to obtain the power of the heater (power = IV) which should remain constant. Typically the

heaters are either about 30 W or 50 W. The students can be told the power of the heater rather than measure it if preferred. The students measure and record the temperature of the block every minute for about 10 minutes. They then plot a graph of temperature against work done by the heater.

There is some thermal inertia as the block warms up so the beginning of the student's graphs will not be linear if they start timing from when they switch on.

The student work sheet suggests comparing the specific heat capacities of three metals – aluminium, copper and iron. If you don't have all three types of block, the experiment can become a simple measurement of one of them.

Additional information

The heat capacity of a substance is the work done raising the temperature of the substance by 1 kelvin. Usually this is changed to 1°C, although 1 celsius degree would be more correct. Heat capacity depends upon the mass of substance. If it is measured for unit mass (ie 1 kg) it is called the specific heat capacity.

The students obtain values for current and potential difference (to work out the power), time and temperature. From the power and time they can work out the energy supplied, or work done by the heater. A graph of temperature against work done should be a straight line once the block has warmed a bit. Students use the gradient of this line and the mass of the block to work out the specific heat capacity. Having blocks of different materials allows students to see that specific heat capacities vary significantly, even between metals.

Metal	Copper	Aluminium	Iron	Lead
Specific heat capacity (J kg^{-1} K^{-1})	385	913	500	126

Using a 30 W heater for 10 minutes provides 30 × 60 × 10 = 18 000 J
This would be sufficient to raise the temperature of 1 kg of copper from room temperature to about 70 °C, aluminium to about 40 °C and iron to 55 °C. This supports the idea that 10 minutes is an adequate length of time for the experiment.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- The mains leads of the power supplies should be checked. The heater connections should also be checked. They will also get hot, particularly if left on without being in contact with the blocks.

Trialling

The practical should be trialled before use with students.

Alternative practicals

Outline method	Suggested apparatus	Outcomes
(a) The specific heat capacity of lead shot. Measure the temperature of some lead shot. Put it in a long tube and seal it. Turn the tube upside down so that the lead falls to the other end of the tube. Make sure the lead drops rather than slides. Repeat so that the lead drops the length of the tube 40 times. Pour out the lead and measure its temperature straight away. Avoid handling the shot.	Cardboard tube, about 50 cm to 100 cm long, sealed at one end and with a cap or bung to seal the other once the lead is in. About 500 g of lead shot. Plastic cup to hold the shot. Thermometer Ruler (to measure the length of the tube). Balance (to measure the mass of the lead – although you don't need to).	Work is done on the lead shot as you turn the tube over. This is transferred to thermal energy when the lead hits the bottom of the tube. The work done = mass of lead × g × length of tube × number of turns. The specific heat capacity = the work done/(mass of lead × the temperature rise) (Notice that the mass cancels). The temperature rise using a 1 metre tube, turned 40 times = 10 × 1 × 40/126 = 3 degrees.
(b) It is not recommended to put hot metal into water. You could try putting a cold coin (eg at 0 °C) into 100 ml hot water (at 80 °C) and measuring the equilibrium temperature.	Copper coin at 0 °C (eg placed in an ice/water mix). Insulated plastic cup (not a copper calorimeter) with lid and hole for thermometer, measuring cylinder and hot water. Tongs to handle the coin.	The hot water warms up the copper, the copper cools the water and they reach an equilibrium temperature. A 20 g copper coin put into 100 ml of 80 °C water: the mixture would reach about 70 °C if there were no energy losses.

GCSE Physics required practical activity 1: Specific heat capacity

Student sheet

Required practical activity	Apparatus and techniques
An investigation to determine the specific heat capacity of one or more materials. The investigation will involve linking the decrease of one energy store (or work done) to the increase in temperature and subsequent increase in thermal energy stored.	AT 1, AT 5

What is the specific heat capacity of copper?

In this investigation you will heat up a block of copper using an electric heater. You will measure the mass, the work done by the heater and the temperature. You will plot a graph of temperature against work done and use the gradient of this graph, and the mass of the block, to determine the specific heat capacity of copper.

Learning outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

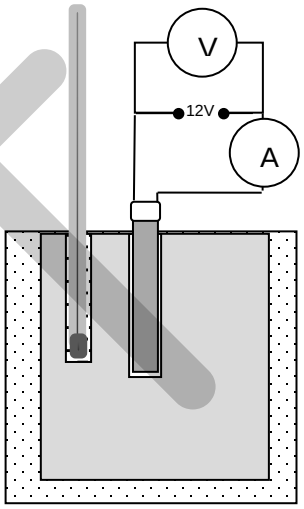
Method

You are provided with the following:

- copper block wrapped in insulation, with two holes for a thermometer and heater
- thermometer
- pipette to put water in the thermometer hole
- 30 W, 12 V heater and power supply
- insulation to wrap around the blocks
- ammeter and voltmeter
- five 4 mm leads
- stop watch or stop clock
- balance

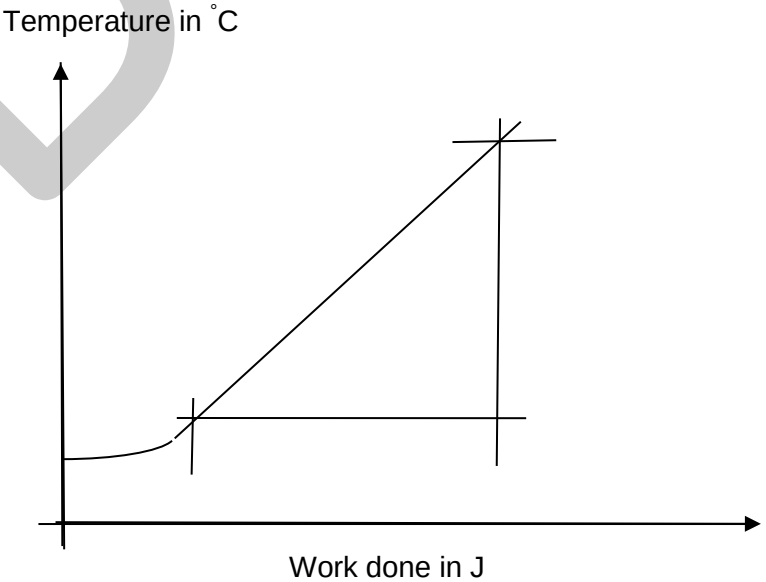
You should read these instructions carefully before you start work.

9. Measure and record the mass of the copper block, in kg.
10. Place a heater in the larger hole in the block. Connect the ammeter, power pack and heater in series.
11. Connect the voltmeter across the power pack.
12. Put a small amount of water in the other hole using the pipette.
13. Put the thermometer in this hole.
14. Switch the power pack to 12 V and switch it on.
15. Record the ammeter and voltmeter readings. These shouldn't change during the experiment.
16. Measure the temperature and switch on the stop clock.
17. Record the temperature every minute for 10 minutes. Your results table will need three columns. Notice that the time is measured in seconds, so the column will go 0, 60, 120, etc.



Time in seconds	Work done in J	Temperature in °C

18. Calculate the power of the heater in watts. To do this, multiply the ammeter reading by the voltmeter reading.
19. Calculate the work done by the heater. To do this, multiply the time in seconds by the power of the heater.



20. Plot a graph of temperature in ^{o}C against work done in J.
21. Draw a line of best fit. Take care as the beginning of the graph may be curved.
22. Calculate the gradient of the straight part of your graph.
23. The heat capacity of the block is 1/gradient.
24. The specific heat capacity is the heat capacity divided by the mass of the block in kg. Work out the specific heat capacity of the material of the block.
25. If you can, repeat this experiment for other blocks such as aluminium and iron. There is a suggestion that if metal blocks have the same mass, the bigger the volume: the bigger the specific heat capacity. Is this true for the blocks you tested?

GCSE Physics required practical activity 2: Resistance

Teachers' notes

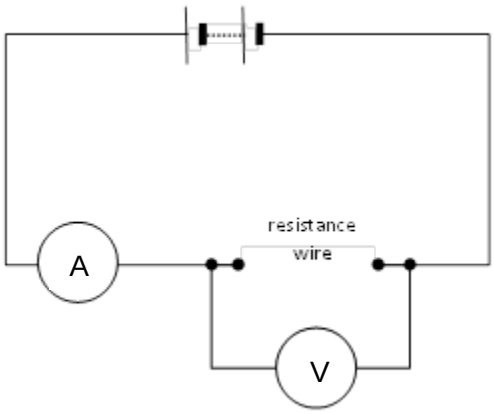
Required practical activity	Apparatus and techniques
Use circuit diagrams to set up and check appropriate circuits to investigate the factors affecting the resistance of electrical circuits. This should include: • the length of a wire at constant temperature • combinations of resistors in series and parallel.	AT 1, AT 6, AT 7

How does the resistance of a wire depend on its length?

Materials

In addition to access to general laboratory equipment, each student needs access to:

- a battery or suitable power supply
- ammeter or multimeter
- voltmeter or multimeter
- two crocodile clips
- resistance wire eg constantan of different diameters
- metre ruler
- connecting leads.



Technical information

The most straightforward way to investigate resistance is to use an ohmmeter. However, this practical requires the students to make a circuit, measure current and potential difference and calculate the resistance.

There are at least 5 different experiments that could be carried out: the circuit is the same in each case. However, this practical focuses on the variation of resistance with length.

Use a length of resistance wire (just over a metre of 22 swg constantan). Attach it to a metre ruler using tape. Attach a crocodile clip to one end (the zero end) of the material. Attach the other crocodile clip to the wire. The students vary the length of wire by moving this crocodile clip and record the length of wire, current and potential difference.

Additional information

The resistance of the wire is proportional to its length. A graph of resistance against length should be a straight line through the origin. This experiment is a good one to use to discuss zero error as it is hard to attach the crocodile precisely to the zero end of the wire, and there will be some contact resistances. The potential difference will not vary very much during the experiment. Use a low value of potential difference particularly for the short length of wire as the current will increase significantly and the wire can get quite hot. The wire should be fairly thin to give decent values of resistance.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- Short lengths of wire are likely to get hot. Use low values of potential difference. Switch off between readings.

Trialling

The practical should be trialled before use with students.

Alternative practicals

Outline method	Suggested apparatus	Outcomes
(a) Make a dimmer switch. Put a lamp in series with the resistance wire. Demonstrate the variation in resistance by showing the effect it has on the brightness of a lamp.	As above with a suitable lamp in series with battery eg a 6V lamp if a 6V battery is being used.	The brightness gives an indication of current. The current in the circuit is determined by the total resistance. As the length of wire changes, so does its resistance.
(b) Variation of resistance with diameter. Measure the resistance of several pieces of wire of the same length and material, but different diameters. If the length investigation has been done, time could be saved by using an ohmmeter.	As above 1 metre lengths of constantan of different diameters. Use a micrometer to measure the diameter and label each of the wires.	The resistance is inversely proportional to the area. A graph of resistance against 1/diameter^2 would give a straight line through the origin. As the wires get wider, it is similar to adding more resistors in parallel.
(c) The light dependent resistor If the length experiment has already been done, this experiment is probably best done with an ohmmeter. Simply attach the ohmmeter to the LDR and investigate different light levels.	LDR, two crocodile clips, two 4 mm leads and an ohmmeter.	The brighter the light level, the lower the resistance.
(d) Using a thermistor as a thermometer. Again, if the length experiment has been completed, use an ohmmeter. Pour some hot water in a beaker with a thermometer. Put in the thermistor, connected to the ohmmeter, and record the resistance and temperature as the water cools down. Plot a graph of resistance against temperature – a calibration curve.	Thermistor Two crocodile clips Two 4 mm leads and an ohmmeter Beaker Kettle Thermometer (alcohol in glass rather than digital may make a better contrast)	The graph is likely to be a curve, depending on the temperature range investigated. The greater the temperature, the lower the resistance (this is the opposite to a metal conductor, like the filament of a light lamp).

GCSE Physics required practical activity 2: Resistance

Student sheet

Required practical activity	Apparatus and techniques
Use circuit diagrams to set up and check appropriate circuits to investigate the factors affecting the resistance of electrical circuits. This should include: • the length of a wire at constant temperature • combinations of resistors in series and parallel.	AT 1, AT 6, AT 7

How does the resistance of a wire depend on its length?

A dimmer switch allows you to control the brightness of a lamp. In this experiment you will investigate how the dimmer switch works. You will construct a circuit to measure the potential difference across a wire and the current in the wire. You will do this for different lengths of wire.

Learning outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

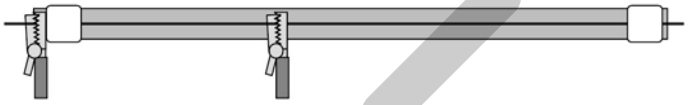
Method

You will use the following:

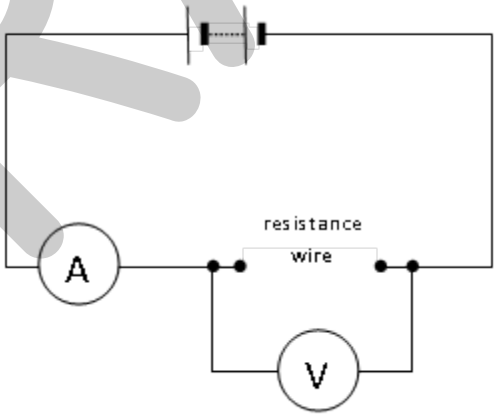
- a battery or suitable power supply
- ammeter or multimeter
- voltmeter or multimeter
- two crocodile clips
- resistance wire eg constantan of different diameters attached to a metre ruler
- connecting leads.

You should read these instructions carefully before you start work.

1. Connect the circuit. It may be helpful to start at the positive side of the battery or power supply. This may be indicated by a red socket.
2. Connect a lead from the red socket to the positive side of the ammeter.
3. Connect a lead from the negative side of the ammeter (this may be black) to the crocodile clip at the zero end of the ruler.



4. Connect a lead from the other crocodile clip to the negative side of the battery. The main loop of the circuit is now complete. Use this lead as a switch to disconnect the battery between readings.
5. Connect a lead from the positive side of the voltmeter to the crocodile clip the ammeter is connected to.
6. Connect a lead from the negative side of the voltmeter to the other crocodile clip.



7. Record the length of the wire between the crocodile clips, and the readings on the ammeter and voltmeter in a suitable table. You will need just four columns in total.

Length of wire in cm	Potential difference in V	Current in A	Resistance in Ω

8. Move the crocodile clip and record the new ammeter and voltmeter readings. Note that the voltmeter reading may not change. Repeat this to obtain several pairs of meter readings for different lengths of wire.
9. Calculate and record the resistance for each length of wire using the equation:

$$\text{resistance in } \Omega = \frac{\text{potential difference in V}}{\text{current in A}}$$

10. Plot a graph of resistance in Ω against length.
11. You should be able to draw a straight line of best fit although it may not go through the origin. Can you account for the extra resistance?

GCSE-Physics required practical activity 3: V-I Characteristics

Teachers' notes

Required practical activity	Apparatus and techniques
Use circuit diagrams to construct appropriate circuits to investigate the V – I characteristics of a variety of circuit elements including a filament lamp, a diode and a resistor at constant temperature.	AT 6, AT 7

What happens to the current through a component when the p.d across it changes?

Materials

In addition to access to general laboratory equipment, each student needs access to:
For the regular shaped solid objects:

- ammeter and milliammeter, or multimeter
- voltmeter or multimeter
- component holders
- 12 V, 24 W lamp e.g. a ray box lamp
- resistor, for example 100 Ω, 1 W
- diode and protective resistor (eg 10 Ω)
- rheostat eg 10 Ω, 5 A
- connecting leads.

Technical information

There are many different electricity kits available and the students should use what is familiar to them. If using multimeters it may be helpful to tape over the connections not in use.

When using the diode, the students will need to use a protective resistor. They should still be able to connect the voltmeter across the diode (ie the resistor and diode should not be soldered together). This resistor should be labelled 'P' to distinguish it from the other resistor.

If a lab pack is used for the power supply this can remove the need for the rheostat as the pd can be varied directly.

The voltage should not be allowed to get so high as to damage the components.

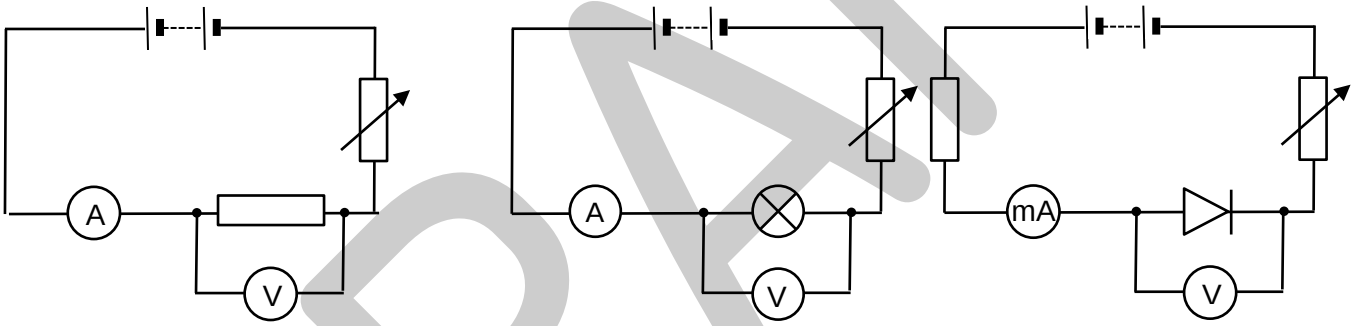
Additional information

There are three separate experiments.

The exception is the diode as it will need to be protected to prevent the current through it getting too big. It also behaves differently depending on the polarity of the supply. Due to the low currents through it, a milliammeter will need to be used.

The students will record the current through each component for different values of p.d. The p.d. will be varied using a rheostat, although a variable power supply may be used.

The students will plot a graph of current against pd. This is what is meant by a characteristic. There is a tendency for some to think that the gradient of this graph is the resistance. In fact the resistance at any point on the graph is the inverse of the gradient of a line from that point to the origin.



Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- Care should be taken as components, particularly lamps, are likely to get quite hot. The mains lead should be checked for damage before a lab pack is used by a student.

Trialling

The practical should be trialled before use with students.

Alternative practicals

Outline method	Suggested apparatus	Outcomes
Enclose the component in a black box with two sockets, although this may be difficult for the diode. Students have to measure its characteristic and determine what is in the box.	As above, but with each component soldered into a box with two connections.	The students would have to identify the component from its characteristic.

GCSE Physics required practical activity 3: V-I Characteristics

Student sheet

Required practical activity	Apparatus and techniques
Use circuit diagrams to construct appropriate circuits to investigate the V-I characteristics of a variety of circuit elements including a filament lamp, a diode and a resistor at constant temperature.	AT 6, AT 7

What happens to the current through a component when the pd across it changes?

There are three activities. In each one you are going to measure electric current in a component as you change the potential difference (pd) across it. You will then plot a graph of current in A against potential difference in V. You will investigate the behaviour of a resistor, a lamp and a diode.

Learning outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

Method

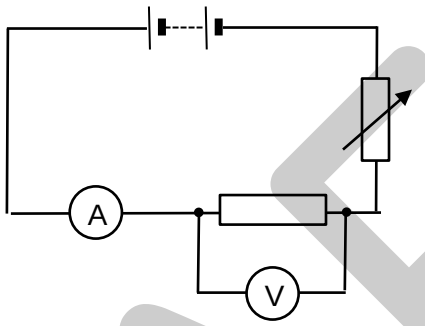
You have access to the following:

- ammeter and milliammeter, or multimeter
- voltmeter or multimeter
- component holders
- 12 V, 24 W lamp eg a ray box lamp
- resistor
- diode and protective resistor (eg 10 Ω)
- rheostat eg 10Ω, 5A
- connecting leads.

You should read these instructions carefully before you start work.

Activity 1: The characteristic of a resistor.

1. Connect the circuit. It may be helpful to start at the positive side of the battery or power supply. This may be indicated by a red socket.
2. Connect a lead from the red socket to the positive side of the ammeter.

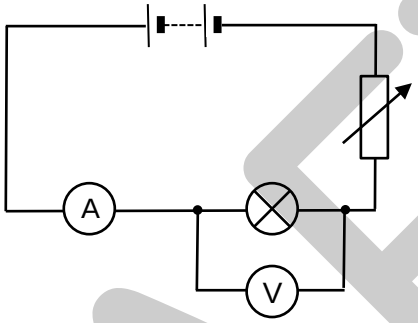


3. Connect a lead from the negative side of the ammeter (this may be black) to one side of the resistor.
4. Connect a lead from the other side of the resistor to the variable resistor.
5. Connect a lead from the other side of the variable resistor to the negative side of the battery. The main loop of the circuit is now complete. Use this lead as a switch to disconnect the battery between readings.
6. Connect a lead from the positive side of the voltmeter to the side of the resistor the ammeter is connected to.
7. Connect a lead from the negative side of the voltmeter to the other side of the resistor.
8. Record the readings on the ammeter and voltmeter in a suitable table.
9. Adjust the variable resistor and record the new ammeter and voltmeter readings. Repeat this to obtain several pairs of readings.
10. Swap the connections on the battery so that the ammeter is now connected to the negative terminal and variable resistor to the positive terminal. The readings on the ammeter and voltmeter should now be negative.
11. Continue to record pairs of readings of current and potential difference with the battery reversed.
12. Plot a graph of current in A against potential difference in V. As the readings include negative values the origin of your graph will be in the middle of the graph paper.
13. You should be able to draw a straight line of best fit through the origin. This is the characteristic of a resistor.

Activity 2: the characteristic of a lamp.

You should read these instructions carefully before you start work.

1. Swap the leads on the battery back to their original positions.
2. Replace the resistor with the lamp. If you are starting the circuit from the beginning, follow the instructions above, inserting the lamp for the resistor.

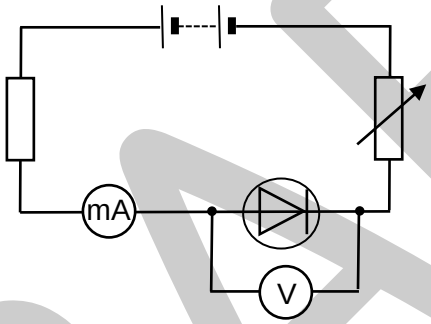


3. The lamp will get hot. Take care not to touch it.
4. Follow the procedure for the resistor, swapping the leads on the battery to obtain negative readings.
5. Plot a graph of current in A against potential difference in V. Again the origin will be in the middle of the paper. Draw a curved line of best fit for your points.

Activity 3: the characteristic of a diode.

You should read these instructions carefully before you start work.

1. Swap the leads on the battery back to their original positions.
2. If you can, reduce the battery potential difference to less than 5 V.
3. Remove the lead from the positive side of the battery and connect it to the extra resistor labelled P.
4. Connect the other end of P to the positive side of the battery.
5. Replace the ammeter with a milliammeter or change the setting on the multimeter.



6. Replace the lamp with the diode. Connect the positive side of the diode to the milliameter.
7. Repeat steps 1 – 6 above to obtain pairs of readings of potential difference and current for the diode.
8. Plot the graph of current in A against potential difference in V. The origin will probably be in the middle of the bottom of your graph paper. There should not be any negative values of current.

GCSE Physics required practical activity 4: Density

Teachers' notes

Required practical activity	Apparatus and techniques
Use appropriate apparatus to make and record the measurements needed to determine the densities of regular and irregular solid objects and liquids. Volume should be determined from the dimensions of a regularly shaped object and by a displacement technique for irregularly shaped objects. Dimensions to be measured using appropriate apparatus such as a ruler, micrometre or Vernier callipers	AT 1

Using density to identify what something is made from.

Materials

In addition to access to general laboratory equipment, each student needs access to:
For the regular shaped solid objects:

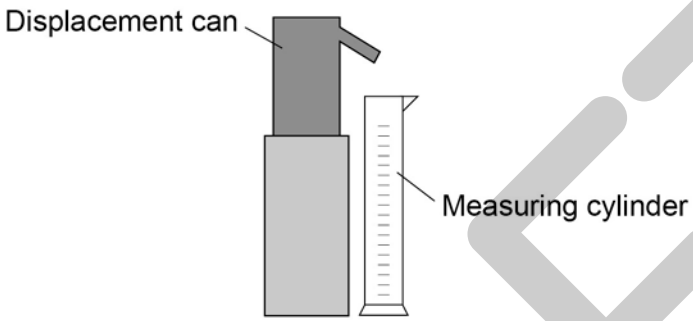
- 30 cm ruler marked off in mm
- digital balance
- materials kits ie various regular shaped objects made of iron, copper, aluminium.

For the irregular shaped solid objects:

- digital balance
- displacement can and something to stand it on (eg a brick)
- measuring cylinders
- 250 ml beaker of water and an extra empty beaker
- paper towels
- cotton or thin string
- various irregular shaped objects

For the liquids:

- digital balance
- 250 ml beaker
- suitable liquid eg sugar solution.



Ideally the digital balance should have a range of 1 kg in 1 g steps.

The experiments are relatively straightforward although the measurement of the densities of the liquids and the irregular objects may create a bit of a mess.

The experiments may be best done as part of a circus – so that everyone uses the different density measuring techniques.

You may want to label the solid objects for easy identification.

The displacement can spout is likely to be too low to fit a measuring cylinder underneath it; use a brick or something similar to stand the displacement can on. Alternatively they can tip the measuring cylinder so that it goes under the spout, but they may knock the spout when moving it.

Additional information

There are three separate experiments. The density of regular objects focuses on the use of a millimetre scale ruler and the calculations of volume and density. Students use their value of density to identify the material of the object being measured.

In the second experiment students measure the volume by displacement. This can be done by lowering the object into a sufficiently large measuring cylinder and noting the change in volume reading. However, a displacement can allows the use of narrower and therefore more precise measuring cylinders to measure the volume. The students should choose a measuring cylinder and justify their choice.

The density of liquid experiment does not make use of specific gravity bottles. It is a basic technique and students identify a liquid from its density.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- There are no serious issues related to these activities.

Trialling

The practical should be trialled before use with students.

Alternative practicals

Outline method	Suggested apparatus	Outcomes
If a 100 rivets have a density of 8 g /cm^3 what is the density of one rivet? Use the displacement can to measure the density of different numbers of rivets.	Apparatus for irregular objects.	The idea is to show that the density of a material does not depend on how much of it you have.
Neutral buoyancy – measure the density of an object and make a solution of the same density. Choose an object with a density not much greater than water. Determine its density using the previous methods. Calculate the amount of sugar that would be added to water to make it have the same density, and make up the solution. Test it by placing the object in the solution.	Object with density similar to, but greater than, water. Apparatus as before.	When placed in the solution, the object should not sink or float but just stay wherever it is put.

GCSE Physics required practical activity 4: Density

Student sheet

Required practical activity	Apparatus and techniques
Use appropriate apparatus to make and record the measurements needed to determine the densities of regular and irregular solid objects and liquids. Volume should be determined from the dimensions of a regularly shaped object and by a displacement technique for irregularly shaped objects. Dimensions to be measured using appropriate apparatus such as a ruler, micrometre or Vernier callipers.	AT 1

Identifying a substance from its density.

There are three activities. In each one you are going to measure the density of something and use the value to find out what the substance is. You will be expected to work as accurately as possible.

In one activity you will determine the density of a regular shaped object using a ruler and balance. In another activity you will measure the mass of an object in the same way, but you will measure its volume from the amount of water it displaces.

In the third activity you will find the density of a liquid.

Learning outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

Activity 1: Regular shaped objects

Method

You have access to the following:

- 30 cm ruler marked off in mm
- digital balance
- regular shaped objects

You should read these instructions carefully before you start work.

1. Measure the length, width and height of each of the objects.
2. Record your results in a table. Include columns for volume, mass, density and substance.
3. Measure the mass of each object using the digital balance, and record the results.
4. Calculate and record the volumes (length x width x height).
5. Calculate and record the densities (mass ÷ volume).
6. Use this table to identify the substance each object is made from.

Substance	**aluminium**	**zinc**	**iron**	**copper**	**gold**
Density g/cm^3	2.7	7.1	7.9	8.9	19.3

Activity 2: Irregular shaped objects.

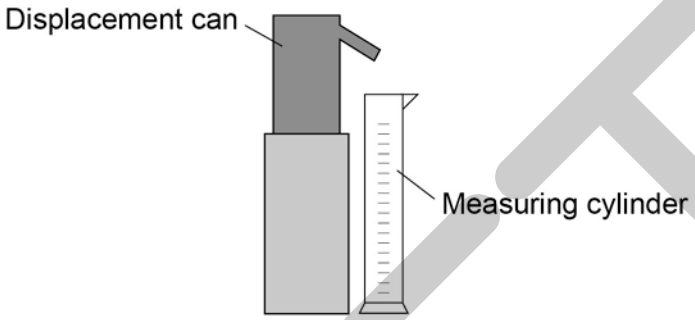
Method

You have access to the following:

- digital balance
- displacement can and something to stand it on (eg a brick)
- various measuring cylinders
- beaker of water and an extra empty beaker
- paper towels
- cotton or thin string
- irregularly shaped objects

You should read these instructions carefully before you start work.

1. Measure the mass of one of the irregular shaped objects.



2. Record your result in a table. It will need extra columns for the volume, density and substance.
3. Place a displacement can on a brick. Put an empty beaker under the spout and fill the can with water. Water should be dripping from the spout.
4. When the water has stopped dripping, place a measuring cylinder under the spout. Choose the measuring cylinder you think will give the most precise reading.
5. Tie the object to a piece of cotton and very carefully lower it into the displacement can so that it is completely submerged. Collect all of the water that comes out of the spout in the measuring cylinder.
6. Measure and record the volume of the collected water; this is equal to the volume of the object.
7. Calculate and record the density of the object. Try to find out what substance it is made from.
8. Repeat for some of the other objects. Remember to refill the can each time.

Activity 3 – liquids

Method

You have access to the following:

- digital balance
- 250 ml beaker
- 100ml measuring cylinder
- suitable liquid eg sugar solution.

You should read these instructions carefully before you start work.

1. Measure the mass of the empty beaker.
2. Record your results in a table. Your table will also need columns for the mass of the beaker with the liquid in, the mass of the liquid, the volume of the liquid and the density.
3. Pour about 100 ml of liquid into the measuring cylinder. Measure and record the volume.
4. Pour this liquid into the beaker. Measure and record the mass of the beaker and liquid.
5. Calculate and record the volume of the liquid.
6. Calculate the density of the liquid.
7. The density of water is 1 g/cm^3. Determine the mass of sugar per cm^3 dissolved in the water, assuming the sugar does not affect the volume of the water.

GCSE Physics required practical activity 5: Force and Extension

Teachers' notes

Required practical activity	Apparatus and techniques
Investigate the relationship between force and extension for a spring.	AT 1, AT 2

Making and calibrating a spring-balance (newtonmeter).

Materials

In addition to access to general laboratory equipment, each student needs:

- a spring of a suitable stiffness (eg capable of extending more than 1 cm under a load of 1 N) with loops at each end
- metre ruler
- suitable pointer – eg splint and tape
- weight stack appropriate for the spring – eg 10 N in steps of 1 N.
- clamp stand, 2 clamps and bosses
- g clamp or weight to prevent the apparatus tipping over the edge
- object, eg stone attached to string, to weigh.

Technical information

If you are using new springs you should extend them under a suitable load for a short while. The pointer should be attached so that it doesn't slip or change angle. It is probably best attached to the bottom of the spring. The students will measure the extension ie the increase in length. Many are likely to think that this is the incremental increase – in fact it is the total increase (ie from the original length). The students align the top of the ruler with the top of the spring – this isn't essential but it may help emphasise this point about the extension.

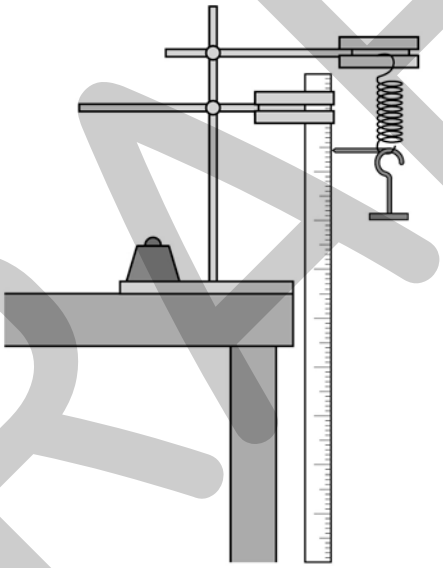
Students may need to be told how to convert the mass (in grammes) written on the weight stack into a weight in newtons. (Using the equation W = mg, 100 g has a weight of 1 N). This practical can be used to emphasise the difference between mass and weight.

The weight of the stone should be within the range of weights used. The length of the spring shouldn't exceed one metre when fully stretched.

Additional information

The relationship between force and extension is given by Hooke's Law. This is an opportunity to investigate the life and work of Robert Hooke who was a contemporary of Isaac Newton.

The students will record the reading on the metre ruler (which will be the length of the spring if set up that way) as the weights are added. They will then calculate the extension (ie the increase from the original reading). The extension should increase in proportion to the weight. A graph of extension against weight will be a straight line through the origin. The gradient of the line is 1/stiffness or 1/spring constant. (ie the graph for a stiffer spring will have a lower gradient). To determine the weight of the stone, students measure the extension and either use their graphs (read off the weight directly) or use 1/gradient multiplied by the extension to give the weight.



Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- The springs should be checked so that the loops at the ends don't unravel when the greatest weight is used.
- It is likely that the spring will extend below the edge of the bench. The clamp stand should be secure so as not to tip. Put something under the spring and weight to protect the floor in case things slip.

Trialling

The practical should be trialled before use with students.

Alternative practicals

Outline method	Suggested apparatus	Outcomes
(a) Testing springs in series. Connect two identical springs by threading the bottom loop of one through the top loop of the other. Set up the apparatus as described and work out the spring constant for two (and more) springs in series.	As above. 3 or 4 identical springs	As you add more springs in series the stiffness decreases ie you get a greater extension for the same force. In fact stiffness = stiffness of one spring/number of springs.
(b) Use a rod (eg a nail) clamped horizontally. Hang two identical springs from the rod. Place a second rod through the loops at the bottom of the springs and hang weights from this rod. Measure the spring constant for two (and more) springs in parallel.	As above 2 stiff rods (eg nails) to suspend the springs and weights.	As you add more springs in parallel the stiffness increases. In fact stiffness = stiffness of one spring × number of springs.
(c) Investigate what happens if more weight is added so that the spring extends beyond its elastic limit	Disposable springs, more weights (and more care!)	The graph will no longer be linear, and when the weights are removed the spring will not return to its original length.

GCSE Physics required practical activity 5: Force and Extension

Student sheet

Required practical activity	Apparatus and techniques
Investigate the relationship between force and extension for a spring.	AT 1, AT 2

Making and calibrating a spring balance (newtonmeter)

In this activity you will investigate the relationship between the weight hung from a spring and how much longer the spring gets (the extension). You will plot a graph of extension against weight and use your graph to find the weight of a mystery object.

Learning outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

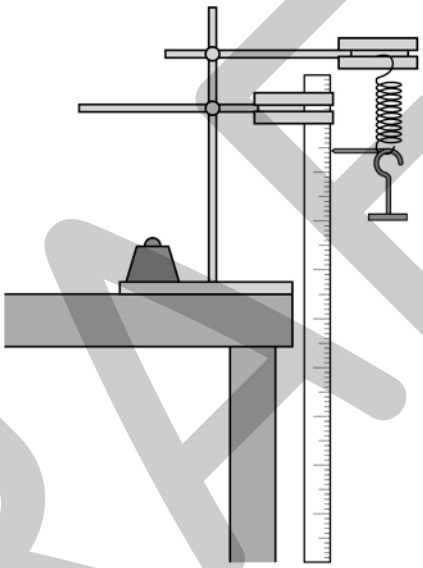
Method

You are provided with the following:

- a spring
- a metre ruler
- a splint and tape to act as a pointer
- a 10 N weight stack.
- a clamp stand, and two clamps and bosses
- a heavy weight to prevent the apparatus tipping over.
- a mystery object to weigh.

You should read these instructions carefully before you start work.

1. Attach the two clamps to the clamp stand using the bosses. The top clamp should be further out than the lower one.
2. Place the clamp stand near the edge of a bench so that the ends of the clamps stick out beyond the bench.
3. Place a heavy weight on the base of the clamp stand to stop the clamp stand tipping over.



4. Hang the spring from the top clamp.
5. Attach the ruler to the bottom clamp with the zero on the scale at the top of the ruler. (If there are two scales going in opposite directions you will have to remember to read the one that increases going down.)
6. Adjust the ruler so that it is vertical, and the zero on the scale is at the same height as the top of the spring.
7. Attach the splint securely to the bottom of the spring. Make sure that the splint is horizontal and that it rests against the scale of the ruler.
8. Take a reading on the ruler – this is the length of the unstretched spring.
9. Carefully hook the base of the weight stack onto the bottom of the spring. This weighs 1.0 newton (1.0 N).
10. Take a reading on the ruler – this is the length of the spring when a force of 1.0 N is applied to it.
11. Add further weights, measuring the length of the spring each time.

12. Record your results in a suitable table. You will need a third column for the extension. This is the amount the string has stretched. To calculate this you subtract the length of the unstretched spring from each of your length readings.

Weight in N	Length of spring in cm	Extension of spring in cm

13. Do not put the apparatus away yet. Plot a graph of extension against weight.

14. Hang the unknown object on the spring. Measure the extension and use your graph to determine the object's weight. Check it with a newtonmeter.

GCSE Physics required practical activity 6: Acceleration

Teachers' notes

Required practical activity	Apparatus and techniques
Investigate the effect of varying the force on the acceleration of an object of constant mass and the effect of varying the mass of an object on the acceleration produced by a constant force.	AT 1, AT 2, AT 3

Investigating acceleration using an air track and light gates

Materials

In addition to access to general laboratory equipment, each student needs access to:

- linear air track and gliders
- bench pulley, string and small weight stack e.g. 1 N in steps of 0.2 N
- card 10 cm x 5 cm
- two clamp stands, clamps and bosses
- two light gates, interface and computer software
- blutak or similar to attach the weights to the glider.

Technical information

The air track provides a cushion of air for the gliders to 'float' on, thus reducing friction to almost zero. Air is often provided by a vacuum cleaner in 'blow' mode. The air track should be level. This can be achieved by adjusting the legs. There are two adjustments: one to make sure that the air track isn't leaning to one side. The other to make sure it is horizontal. Place a glider in the middle of the air track and switch on the vacuum cleaner. Adjust the legs so that the glider rests on the cushion of air without moving or touching the sides of the air track.

The card is attached to the glider. Using the clamp stands, the light gates are positioned so that the card interrupts the light beam as the glider moves along the air track. The time is measured automatically. The software usually requires you to input the length of the card (10 cm in this case). The force is provided by the weight stack, string and pulley. Attach the pulley to the bench at the far end of the air track. Hang the weight stack on the string, pass it over the pulley and attach it to the glider. Check that, when the vacuum cleaner is switched on, the weight starts to fall and the glider to accelerate. It is important that the card passes through the second light gate before the weight stack hits the ground.

When varying the force, the total mass of the system should stay constant. The mass of the system is the mass of the glider plus the mass of the weight stack. The 'unused' weights should therefore be attached to the sides of the glider (with the Blutak).

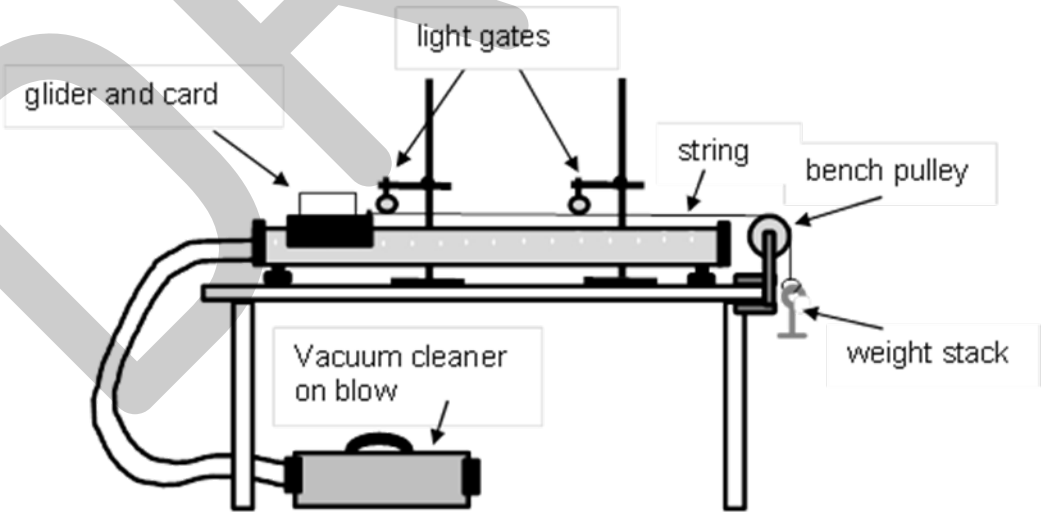
The experiment is best controlled with the vacuum cleaner mains switch. When everything is ready simply switch it on and the glider will go. When the weight stack hits the ground, switch it off and the glider stops. Pull the glider back into position with the vacuum cleaner off.

Additional information

The relationship between force, mass and acceleration is given by Newton's Second Law of Motion. The acceleration of the glider is usually worked out automatically by the software that comes with the light gates provided the length of the card is input into the system. Students should understand how the calculation is done:

$$acceleration = \frac{\left(\frac{length\ of\ card}{interrupt\ time\ 2} - \frac{length\ of\ card}{interrupt\ time\ 1}\right)}{time\ between\ interruptions}$$

The students will record the values of acceleration for constant mass as the force is varied. They can plot a graph of acceleration against force and get a straight line through the origin.



Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- Check the mains cable to the vacuum cleaner.
- Do not use large weights on the weight stack. The glider can cause the air track to fall off the bench if it hits the end moving quickly.

Trialling

The practical should be trialled before use with students.

Alternative practicals

Outline method	Suggested apparatus	Outcomes
(a) The same experiments can be carried out using other equipment, depending on what is available. eg Make a velocity-time graph out of ticker tape and measure the acceleration from the slope.	Replace air track: friction compensated (ie sloping) ramp and dynamics trolleys. Replace light gates: ticker tape timers or camera or accelerometer. Replace weights and pulley: elastic pulled to the same length.	The outcome should be the same.
(b) The variation of acceleration with mass can be investigated. Use the 1 N weight stack and add gliders (using magnets or Blutak), increasing the total mass each time.	Equipment as before, with extra gliders of known mass. It would be worth measuring and writing down the mass of each glider and sticking it on each one.	For a constant force, the acceleration will decrease as the mass increases. In fact, they will be inversely proportional. A graph of acceleration against 1/mass will be a straight line through the origin.

GCSE Physics required practical activity 6: Acceleration

Student sheet

Required practical activity	Apparatus and techniques
Investigate the effect of varying the force on the acceleration of an object of constant mass and the effect of varying the mass of an object on the acceleration produced by a constant force.	AT 1, AT 2, AT 3

Investigating acceleration using an air track and light gates

In this activity you will investigate the relationship between the acceleration of an object and the size of the force acting upon it. You will use an air track. This produces a cushion of air which allow gliders to move almost friction free.

Learning outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

Method

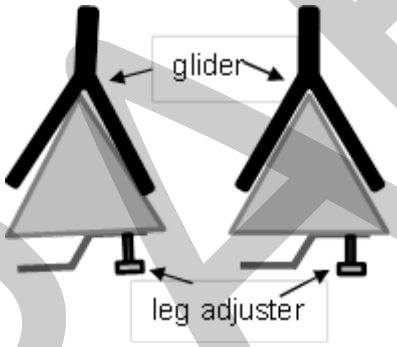
You have access to the following:

- linear air track and gliders
- bench pulley, string and small weight stack eg 1 N in steps of 0.2 N
- card 10 cm x 5 cm
- two clamp stands, clamps and bosses
- two light gates, interface and computer
- Blutak or similar to attach the weights to the glider.

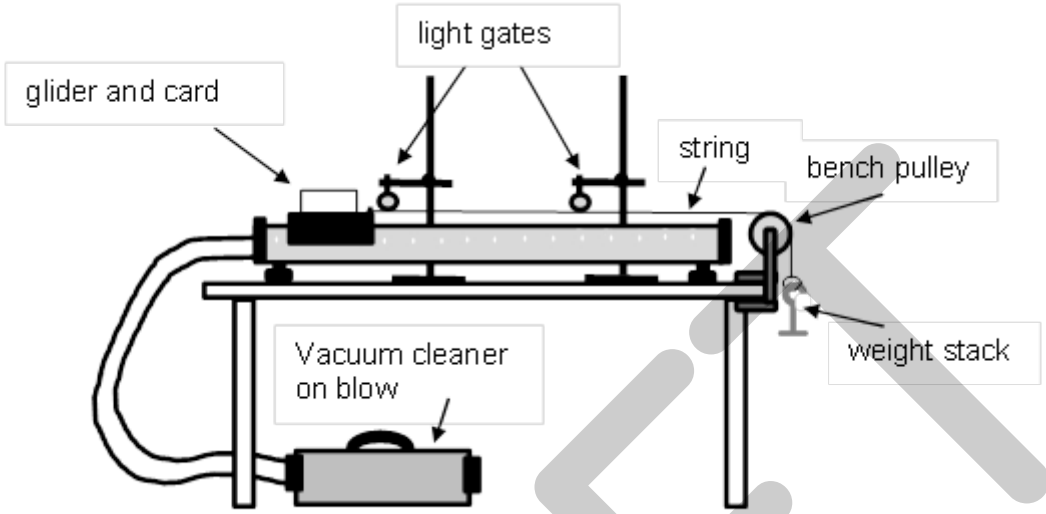
You should read these instructions carefully before you start work.

1. Place the air track on a bench and attach it to the vacuum cleaner, set on ‘blow’.
2. Place a glider on the air track and switch on the vacuum cleaner. The glider should lift up off the air track and be free to move.
3. Adjust the legs of the air track so that the glider moves without touching and the air track is horizontal. There are two separate adjustments to make. With the vacuum cleaner on:

    - place the glider above the adjuster that tilts the air track from side to side. Adjust the length of the leg until the glider does not touch the sides;
    - then place the glider in the middle of the air track and adjust the other leg until the glider does not move when released.



4. Cut out a piece of card measuring 5 cm x 10 cm and place it, with the long side horizontal, in the groove on the glider.
5. Clamp the two light gates horizontally and place them above the air track so that the card passes through them as the glider moves.
6. Connect the light gates to the interface and computer. Start the software for timing. You should have the opportunity to choose acceleration using two light gates. Type in the length of the card (10 cm) when asked by the software.
7. Check the movement of the glider by gently pushing it along the track with the software running. The acceleration should be close to zero. Switch off the vacuum cleaner.
8. Attach the bench pulley to the end of the air track away from the vacuum cleaner.
9. Tie a length of string to the glider, pass the string over the pulley and attach the weight stack to the free end. Make sure the string is horizontal and is in line with the air track.
10. Switch on the vacuum cleaner. The glider should accelerate through the light gates as the weight falls to the ground.
11. If necessary, move the second light gate so that the glider passes through it before the weight hits the ground. Otherwise the glider will stop accelerating too early.



12. The first experiment will investigate how the acceleration depends upon the force. The force is provided by the weight stack. Attach the full weight stack (1 N) to the end of the string, switch on the software, make sure the glider is in position and switch on the vacuum cleaner. The glider should accelerate through the light gates towards the bench pulley. Record the acceleration. Repeat. If the two values are not similar, repeat again. Record your readings in a suitable table, and calculate the mean.

Force in N	**acceleration in cm/s^2**			
	first go	**second go**	**third (if necessary)**	**mean**

13. Remove one weight (0.2 N) and attach that to the glider. This will keep the total mass constant. (The weight stack is being accelerated too.)
14. Repeat the experiment for a force of 0.8 N, 0.6 N, 0.4 N and 0.2 N. Remember to attach each weight to the glider as it is removed from the weight stack.
15. Plot a graph of acceleration in m/s^2 against force in N.

GCSE Physics required practical activity 7: Waves

Teachers' notes

Required practical activity	Apparatus and techniques
Investigate the suitability of apparatus to measure the frequency, wavelength and speed of waves in a ripple tank and waves in a metal rod.	AT 4

This activity is likely to be a teacher demonstration or form part of a 'circus' of experiments for students to perform.

The activity is split into two parts;

- observing water waves in a ripple tank;
- observing waves on a stretched string or elastic cord.

Activity 1: Observing waves in a ripple tank

Materials

- ripple tank plus accessories
- suitable low voltage power supply
- metre ruler.

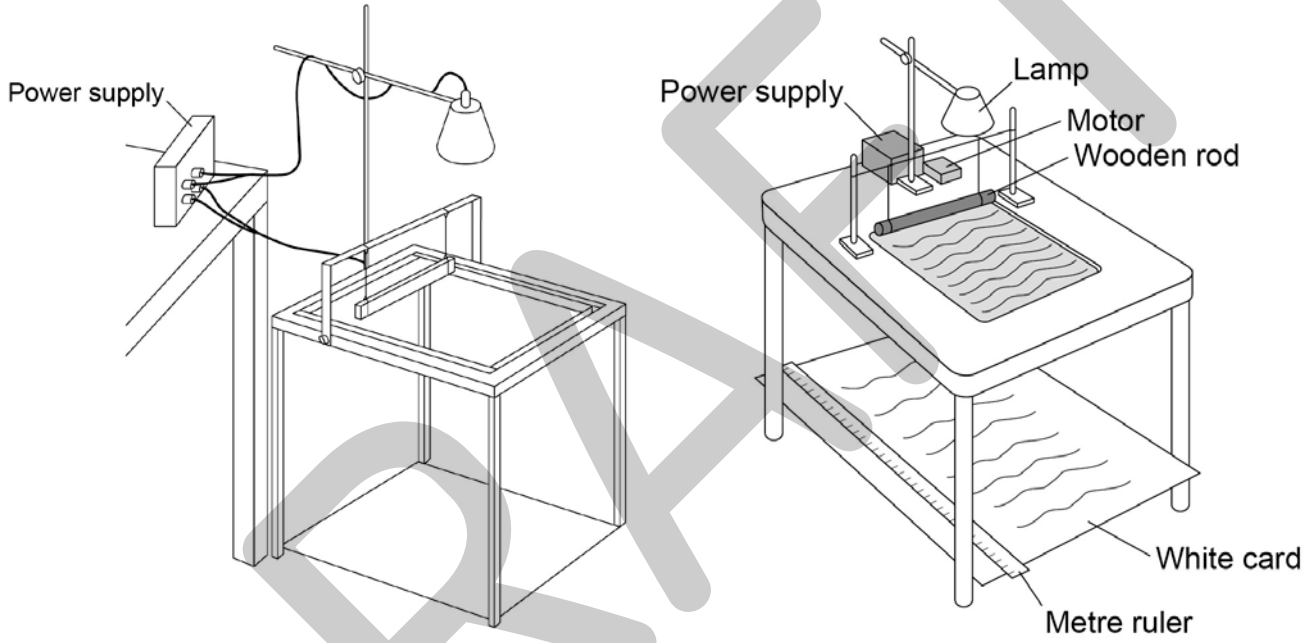
Technical information

The design of ripple tanks varies slightly from one manufacturer to another. The following is given for general guidance.

The depth of water in the ripple tank should be about 5 mm.

To produce plain (straight) waves, a wooden rod should be used (usually one of the accessories supplied with the ripple tank). When stationary the wooden rod should just touch the water surface. A single low voltage power supply may be used for both the motor attached to the wooden rod and the lamp (usually a power supply designed specifically for use with a ripple tank). Alternatively, a fixed power supply can be used for the lamp and a single 1.5 V cell with a variable resistor (in series) as a variable supply to the motor.

The ripple pattern can be viewed either on a large sheet of white card placed on the floor directly below the ripple tank or on the ceiling. To view the floor, have the lamp above the ripple tank. To view the ceiling, have the lamp below the ripple tank. If viewing the pattern on the floor students should look from the side directly at the card and not look from above through the water in the ripple tank. The position of the lamp should be adjusted to give a clear image. Some ripple tanks are designed to sit on top of an overhead projector. If one of these is used the students will be able to view a large image projected onto a wall.



Additional information

A darkened laboratory may make it easier to observe the wave pattern.

Students should observe the wave pattern and then decide how the wavelength, frequency and speed should be measured.

Wavelength – it is likely that a metre ruler positioned at right angles to the projected wave fronts will be used. Measure across as many waves as possible then divide the total length by the number of waves.

Frequency – it is likely that no apparatus will be used. If the motor is rotating slowly so the frequency is low it should be possible to count the number of waves passing a point in the pattern over a given time (say 10 seconds). Then divide the number of waves counted by 10. If this is a demonstration experiment have several students count the waves and then calculate the mean value. Using a stroboscope may be suggested. This will 'freeze' the pattern. The frequency of the stroboscope is then the frequency of the waves.

Speed – this will be calculated using the equation:

wave speed = frequency x wavelength

Risk assessment

- Water is easily spilt onto the floor. Mop up all spills straight away.
- Place any power supply used on a laboratory bench and not on the floor.
- The frequency of a stroboscope can trigger an epileptic fit. Although this method may be suggested by students it is therefore NOT advisable to use a stroboscope with the class.

Trialling

Obtaining a clear pattern from a ripple tank is not easy. It is advisable to trial the experiment and if possible have the ripple tank set up and ready for use before the class starts.

Activity 2: Observing waves on a stretched string or elastic cord

This method uses resonance to set up a standing wave on a vibrating string. The theory of resonance and standing waves does not need to be covered.

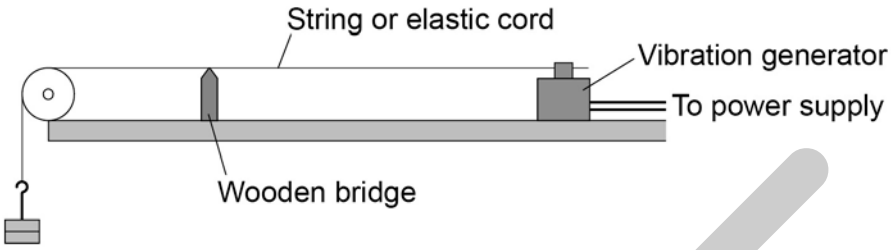
Materials

- vibration generator
- suitable power supply (variable frequency)
- suitable string or elasticated cord
- set of 100g masses and hanger
- set of 10g masses and hanger
- wooden bridge
- pulley on a clamp

Technical information

To achieve the conditions necessary for resonance the following can be adjusted:

- the frequency at which the generator vibrates (adjust the frequency of the power supply)
- the length of string allowed to vibrate (move the wooden bridge)
- the tension in the string (add or remove masses).



For a quick demonstration use an elasticated cord attached to the vibration generator. Then simply stretch the cord until it resonates and a standing wave pattern is seen.

Students should observe the wave pattern and then decide how the wavelength, frequency and speed should be measured.

- Wavelength – it is likely that a metre ruler will be used to measure across as many half wavelengths as possible. Then divide the total length by the number of half waves. Multiplying this number by two will give the wavelength.
- Frequency – it is likely that no apparatus will be used. The frequency will be the frequency of the power supply. It may be suggested that a stroboscope is used. This will 'freeze' the pattern to show a transverse wave. The frequency of the stroboscope is then the frequency of the waves.
- Speed – this will be calculated using the equation:

wave speed = frequency x wavelength

Risk assessment

- Students sitting close to the vibrating string should wear safety goggles or sit behind a safety screen.
- The frequency of a stroboscope can trigger an epileptic fit. Although this method may be suggested by students it is therefore NOT advisable to use a stroboscope with the class.

Trialling

The practical should be trialled before use with students to ensure a standing wave can be set up and seen.

Extension

Using the same apparatus, the relationship between the tension in the string and speed of the wave could be investigated.

GCSE Physics required practical activity 7: Waves

Student sheet

Required practical activity	Apparatus and techniques
Make observations to identify the suitability of apparatus to measure the frequency, wavelength and speed of waves in a ripple tank and waves in a solid and take appropriate measurements.	AT 4

The activity is split into two parts:

- observing water waves in a ripple tank;
- observing waves on a stretched string or elastic cord.

Your teacher may complete both parts of this activity as a class demonstration.

Activity 1: Observing waves in a ripple tank

Learning outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

Method

You will use the following:

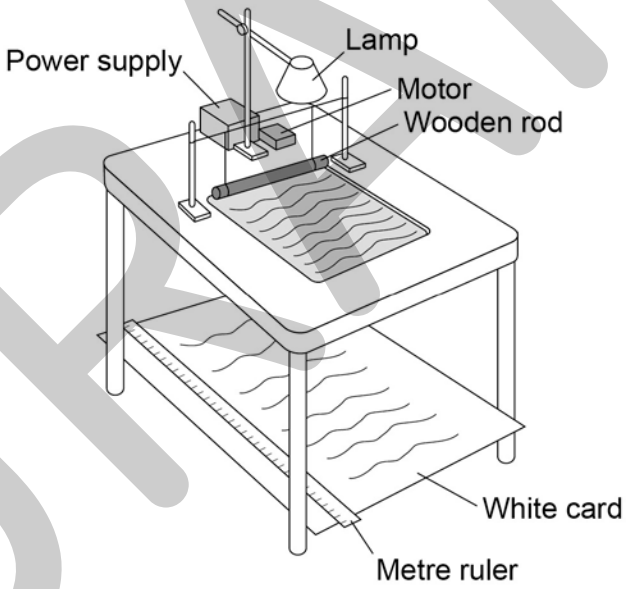
- ripple tank plus accessories
- suitable low voltage power supply
- metre ruler

You should read these instructions carefully before you start work.

1. Set up the ripple tank with a large sheet of white card or paper on the floor under the tank.
2. Pour water to a depth of about 5 mm into the tank.

3. Adjust the height of the wooden rod so that it just touches the surface of the water.
4. Switch on both the overhead lamp and the electric motor.
5. Adjust the speed of the motor so that low frequency water waves are produced.
6. Adjust the height of the lamp so that the pattern can be clearly seen on the card on the floor.
7. Place a metre ruler at right angles to the waves shown in the pattern on the card. Measure across as many waves as possible then divide that length by the number of waves. This gives the wavelength of the waves.
8. Count the number of waves passing a point in the pattern over a given time (say 10 seconds). Then divide the number of waves counted by 10. This gives the frequency of the waves.
9. Calculate the speed of the waves using the equation:

wave speed = frequency x wavelength



Activity 2: Observing waves on a stretched string or elastic cord

Learning outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

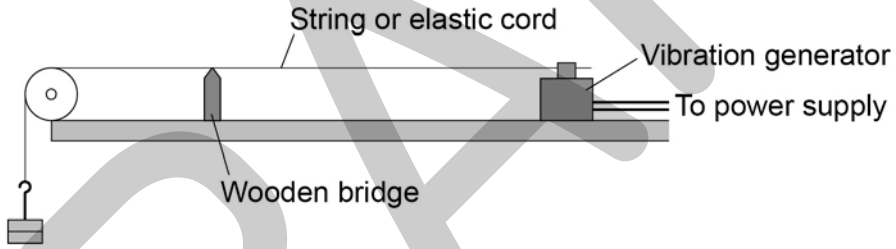
Method

You will use the following:

- vibration generator
- suitable power supply (variable frequency)
- suitable string or elasticated cord
- set of 100 g masses and hanger
- set of 10 g masses and hanger
- wooden bridge
- pulley on a clamp.

You should read these instructions carefully before you start work

1. Set up the apparatus as shown.



2. Switch on the vibration generator. The string (or elasticated cord) should start to vibrate.
3. Adjust the tension in the string or move the wooden bridge to adjust the length of the string until a clear wave pattern can be seen. The waves should look like they are stationary.
4. Use a metre ruler to measure across as many half wavelengths as possible (a half wavelength is one loop). Then divide the total length by the number of half waves. Multiplying this number by two will give the wavelength.
5. The frequency is the frequency of the power supply.
6. Calculate the speed of the wave using the equation:

wave speed = frequency x wavelength

GCSE Physics required practical activity 8: Radiation and absorption

Teachers' notes

Required practical activity	Apparatus and techniques
Investigate how the amount of infrared radiation absorbed or radiated by a surface depends on the nature of that surface.	AT 1, AT 4

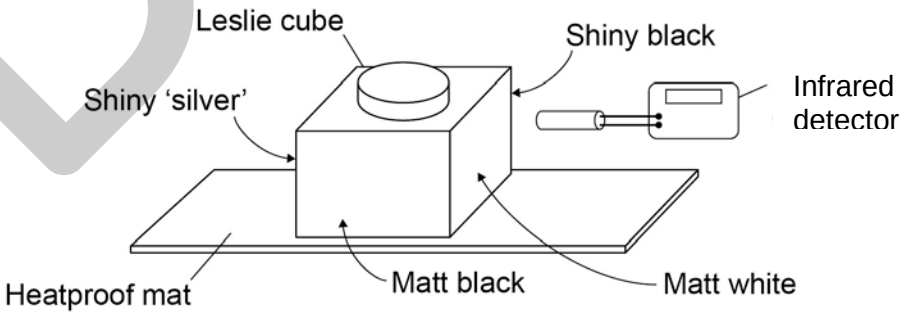
Investigate the amount of infrared radiation emitted by different surfaces

Materials

- Leslie cube
- kettle
- infrared detector
- heatproof mat

Technical information

If a Leslie cube is not available or a class set is required then a simple 'home-made' version could be used. Take a large empty metal can and lid, for example a coffee tin. Remove any outside paper labels so that only the bare metal is seen. Paint one section with a matt white paint and another with a matt black paint. Leave one section as a shiny 'silver' surface.



The detector may be an infrared detector with a suitable meter, an infrared thermometer or a liquid-in-glass thermometer with the bulb painted matt black. The last option is likely to have the least resolution.

Additional information

Before filling with boiling (or very hot) water the Leslie cube should be placed on a heatproof mat.

Risk assessment

Risk assessment and risk management are the responsibility of the centre.
Care must be taken when boiling (or very hot) water is used. Students should not carry containers of hot water across the laboratory.

Trialling

The practical should be trialled before use with students.

Alternative practicals

Outline method	Suggested apparatus	Outcomes
(a) Investigate how the type of surface affects the amount of infrared radiation absorbed by a surface. Place two metal sheets an equal distance from a source of infrared radiation. Attach a small coin to the side of the sheets that face away from the infrared source.	Two sheets of metal. One side of one sheet painted matt black. One side of the other sheet to be left shiny. A source of infrared radiation (filament lamp, radiant heater, Bunsen burner). Two retort stands and clamps. Candle wax and two small coins.	The coin that drops off first will be the one attached to the sheet that was the better absorber of infrared radiation.
(b) Investigate how the type of surface affects the amount of infrared radiation absorbed by a surface. Use two identical beakers. Fill one with water and the other with an equal volume of very strong black coffee. Put both beakers in a sunny position (or an equal distance from an infrared heater). Measure the temperature of each liquid over a period of time.	Two 250 ml beakers (plastic if they are not to be placed near an infrared heater). Coffee granules. Two thermometers.	The temperature of the water with the coffee granules added (black) will increase faster than the clear water.

GCSE Physics required practical activity 8: Radiation and absorption

Student sheet

Required practical activity	Apparatus and techniques
Investigate how the amount of infrared radiation absorbed or radiated by a surface depends on the nature of that surface.	AT 1, AT 4

Investigating the amount of infra-red radiation emitted by different surfaces

Learning outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

Your teacher may complete this investigation as a class demonstration or include it in a 'circus' of experiments.

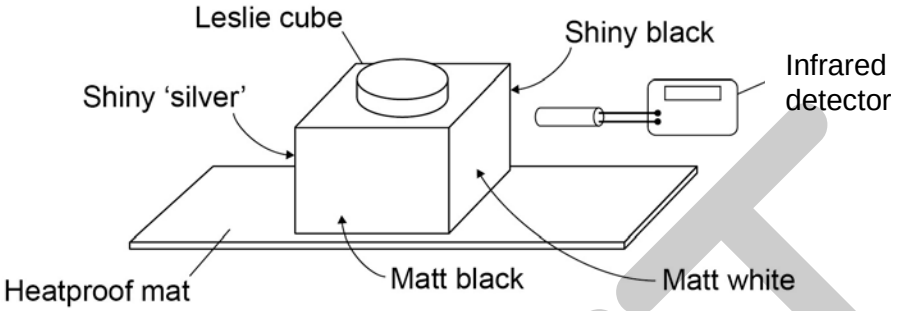
Method

You will use the following:

- Leslie cube kettle
- infra-red detector
- heat proof mat

You should read these instructions carefully before you start work

1. Place the Leslie cube on to a heat proof mat.
2. Fill the cube with very hot water and replace the lid of the cube.



3. Use the detector to measure the amount of infrared radiated from each surface. Make sure that before a reading is taken the detector is the same distance from each surface.
4. Draw a bar chart to show the amount of infrared radiated against the type of surface.

GCSE Physics required practical activity 9: Thermal insulation (physics only)

Teachers' notes

Required practical activity	Apparatus and techniques
Investigate the effectiveness of different materials as thermal insulators and the factors that may affect the thermal insulation properties of a material.	AT 1, AT 5

This investigation is divided into two parts:

1. Investigating the effectiveness of different materials as thermal insulators.

In this part of the experiment students will measure the rate of cooling of a beaker of hot water when insulated with different materials.

They will plot cooling curves to determine which is the best thermal insulator.

2. Investigating factors that may affect the thermal insulation properties of a material.

In this part of the experiment students will measure the rate of cooling of a beaker of hot water when insulated with different thicknesses of the same materials.

They will plot cooling curves to determine which is the best thermal insulator.

Materials

In addition to access to general laboratory equipment, each student needs:

- 100 ml beaker (×5)
- 250 ml beaker (×5)
- 800 ml beaker (×5)
- thermometer (×5)
- kettle to heat water
- piece of cardboard
- scissors
- stopwatch
- insulating material, eg newspaper, corrugated cardboard, bubble wrap, sawdust, polystyrene granules
- rubber bands.

Technical information

Constantan resistance wire is an alloy made of 56% copper and 44% nickel. Its value in this experiment is that its resistance changes very little over a wide range of temperatures. Constantan wire of diameter 0.27 mm (32 SWG) has a resistance of about 11.8 ohms per metre. This means that if a p.d. of 6 volts is applied across the ends of a 1 metre length, the current will be approximately 0.5 amps.

Additional information

If time is short, class results may be pooled so that each student has a complete set of results. It is important however that each student carries out the experiment for at least one type of insulator in part 1 and at least one thickness of insulator in part 2.

Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- Care should be taken when using boiling water.

Trialling

The practical should be trialled before use with students.

Alternative practicals

As an alternative to using a thermometer and stopwatch, students could use a temperature probe and data logger.

GCSE Physics required practical activity 9: Thermal insulation (physics only)

Student sheet

Required practical activity	Apparatus and techniques
Investigate the effectiveness of different materials as thermal insulators and the factors that may affect the thermal insulation properties of a material.	AT 1, AT 5

1. Investigating the effectiveness of different materials as thermal insulators.

In this part of the experiment you will measure the rate of cooling of a beaker of hot water when insulated with different materials.

You will plot cooling curves to determine which is the best thermal insulator.

Learning outcomes
1
2
Teachers to add these with particular reference to working scientifically

Method

You are provided with the following:

- large beaker (eg 800 ml)
- small beaker (e.g. 250 ml)
- thermometer
- kettle to heat water
- piece of cardboard
- scissors
- stopwatch
- selection of insulating materials, eg polystyrene granules, sawdust, bubble wrap, newspaper.

Risk assessment

Take great care when pouring the near-boiling water from the kettle. If you splash any on yourself, immediately wash the affected area with cold water.

You should read these instructions carefully before you start work.

21. Use the kettle to boil water and then put 80 ml of this hot water into a 100 ml beaker.
22. Place the small 100 ml beaker inside the large beaker.
23. Use a piece of cardboard, with a hole for the thermometer, as a lid for the large beaker.
24. Insert the thermometer through the hole in the cardboard lid so that its bulb is in the hot water.
25. Record the temperature of the water and start the stopwatch.
26. Record the temperature of the water every 5 minutes for 20 minutes.
27. Repeat steps 1 to 6, but this time fill the space between the small and the large beaker with an insulating material. Make sure that you use the same volume of water each time.
28. Draw cooling curve graphs by plotting temperature against time for each insulator.
29. From your graphs, determine which material is the best insulator.
30. Record your results in a table such as the one below.
31. Plot a cooling curve for each type of material used.

Material used for insulation	Temperature in °C				
	At the start	after 5 minutes	after 10 minutes	after 15 minutes	after 20 minutes

Note: If you are working on your own in this investigation, you should be provided with at least 5 beakers of each size, and 5 thermometers. This will enable you to set up the equipment for all of the different insulators at the same time.

Alternatively, your teacher may decide to pool the class results so that you only need to set up the equipment for one of the insulators.

2. Investigating factors that may affect the thermal insulation properties of a material.

In this part of the experiment you will measure the rate of cooling of a beaker of hot water when insulated with different thicknesses of the same materials.

You will plot cooling curves to determine which is the best thermal insulator.

Method

You are provided with the following:

- beaker (eg 250 ml)
- thermometer
- kettle to heat water
- piece of cardboard
- scissors
- stopwatch
- insulating material, eg newspaper, corrugated cardboard, bubble wrap
- rubber bands.

Risk assessment

Take great care when pouring the near-boiling water from the kettle. If you splash any on yourself, immediately wash the affected area with cold water.

You should read these instructions carefully before you start work.

1. Use the kettle to boil water and then put 200 ml of this hot water into a 250 ml beaker.
2. Use a piece of cardboard, with a hole for the thermometer, as a lid for the beaker.
3. Insert the thermometer through the hole in the cardboard lid so that its bulb is in the hot water.
4. Record the temperature of the water and start the stopwatch.
5. Record the temperature of the water every 5 minutes for 20 minutes.
6. Repeat steps 1 to 5, but this time insulate the beaker by wrapping one or more layers of insulating material around the beaker. The insulating material may be held in place by using rubber bands. Make sure that you use the same volume of water each time.
7. Draw cooling curve graphs by plotting temperature against time for each number of different layers of insulation.
8. From your graphs, write a conclusion about the effect of changing the number of layers of insulation.
9. Record your results in a table such as the one below.
10. Plot a cooling curve for each type of material used.

Number of layers of material used for insulation	Temperature in °C				
	At the start	after 5 minutes	after 10 minutes	after 15 minutes	after 20 minutes

Note: If you are working on your own in this investigation, you should be provided with at least 5 beakers and 5 thermometers. This will enable you to set up the equipment for all of the different numbers of layers of insulation at the same time.

Alternatively, your teacher may decide to pool the class results so that you only need to set up the equipment for one particular number of layers.

GCSE Physics required practical activity 10: Light (physics only)

Teachers' notes

Required practical activity	Apparatus and techniques
Investigate the reflection of light by different types of surface and the refraction of light by different substances.	AT 4, AT 8

What happens to the direction of light after hitting the surface of different materials?

Materials

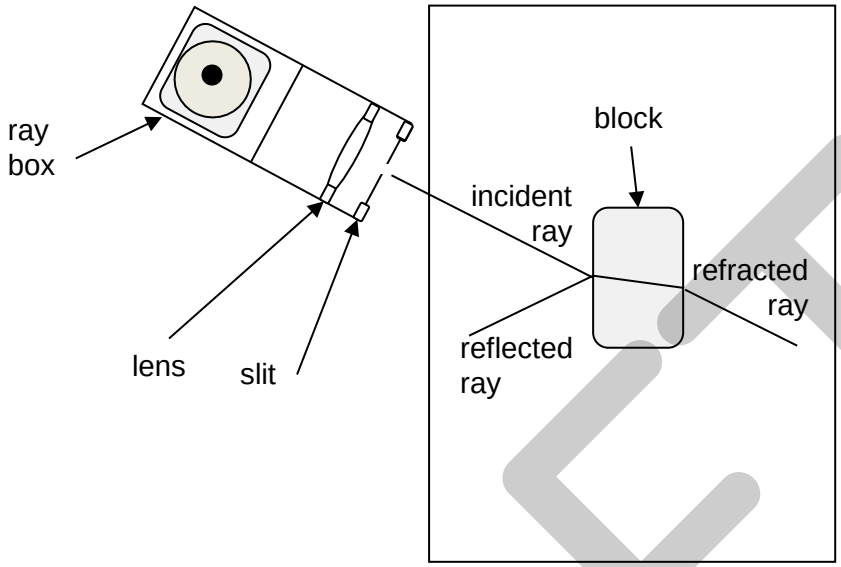
In addition to access to general laboratory equipment, each student needs:

- ray box and suitable power supply
- collimating slit and lens
- rectangular transparent blocks – preferably of different materials eg glass, Perspex
- 30 cm ruler
- protractor
- sheets of plain A3 paper.

Technical information

In this experiment, students trace the path of light refracted through and reflected from blocks of different materials. They will use a ray box to produce a narrow ray of light. They will compare the light reflected and refracted for the two materials.

The ray is produced using a single narrow slit placed in the jaws of the ray box. The ray is likely to broaden as it leaves the slit so a cylindrical convex lens can be used to help produce a narrow, bright ray. The reflected and refracted rays will be faint. The experiment will have to be carried out in low light conditions.



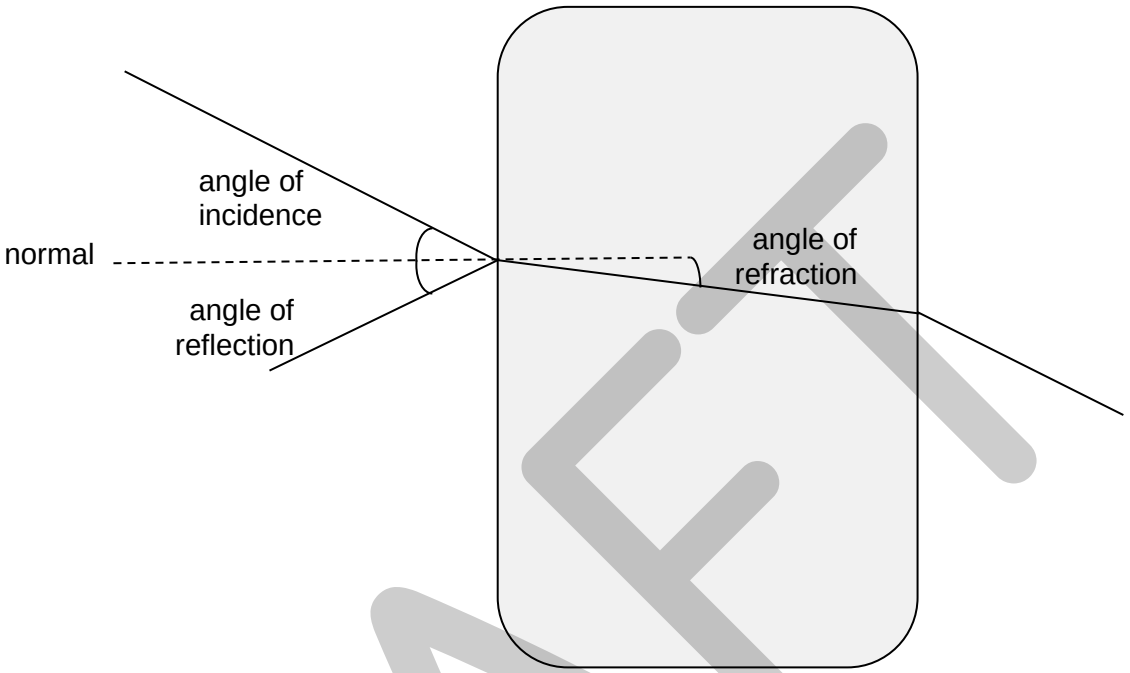
Additional information

A ray shows the path of the light wave. The angle of the ray at the surface of a material is conventionally measured to the ‘normal’. This is a line drawn at right angles to the surface.

The angle of the incident ray (the angle of incidence) and the angle of the reflected ray (the angle of reflection) are equal. This does not depend on the material.

The path of the refracted ray within the block is found by marking its path as it leaves the block and joining the start of this to the end of the path of the incident ray. The angle the ray makes to the normal (the angle of refraction) within the block depends on the material.

The investigation is designed to demonstrate the effect the material has on the angles of reflection and refraction.



Risk assessment

- Risk assessment and risk management are the responsibility of the centre.
- The ray box will get hot. It should be switched off when not in use.
- The experiment will have to be carried out in reduced lighting. Care should be taken so that students can still be supervised to minimise the risk of accidents.

Trialling

The practical should be trialled before use with students.

Alternative practicals

Outline method	Suggested apparatus	Outcomes
(a) The refractive index of the two materials can be measured. This is achieved by measuring the angle of refraction (using the method described in the pupil sheet) for different angles of incidence.	As before	A graph of sin (angle of incidence) on the y-axis against sin (angle of refraction) on the x – axis should give a straight line through the origin. The gradient of this line is the refractive index.
(b) A reflection experiment (with a little more to it than just 'angle of incidence = angle of reflection') is to set up a mirror at right angles to the incident ray so that it just bounces straight back. Then turn the mirror through an angle, and measure the angle between incident ray and reflected ray. (The context of this work could be reflecting sunlight off a watch face).	Ray box etc. as before. Mirror and system to mount it vertically (eg plasticine). Protractor. A3 paper.	The angle between the incident ray and reflected should be double the angle the mirror is moved through.

GCSE Physics required practical activity 10: Light (physics only)

Student sheet

Required practical activity	Apparatus and techniques
Investigate the reflection of light by different types of surface and the refraction of light by different substances.	AT 4, AT 8

What happens to the direction of light after hitting the surface of different materials?

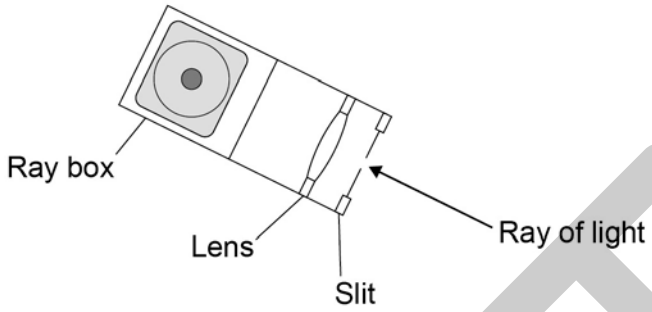
When light hits a surface it can be reflected, transmitted and absorbed. In this experiment, you will investigate what happens to light when it is reflected and transmitted using two different materials. You will use a ray box to direct a ray of light onto the surface of a transparent block. You will then mark the path of the ray that is reflected from the surface of the block and the ray that passes through the block. You will use the ray box to produce a narrow ray of light and perform the experiment in a darkened room, so that the paths of the rays can be marked precisely. You will then repeat the experiment using a different block and compare the results.

Learning outcomes
1 **2** **Teachers to add these with particular reference to working scientifically**

Method

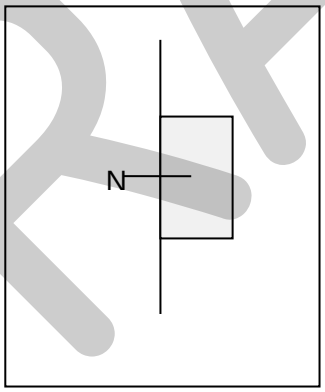
You are provided with the following:

- Ray box and suitable power supply
- a slit and lens that fit the ray box and can be used to make a narrow ray
- two rectangular transparent blocks of different materials eg glass, Perspex
- 30 cm ruler
- protractor
- sheets of plain A3 paper.

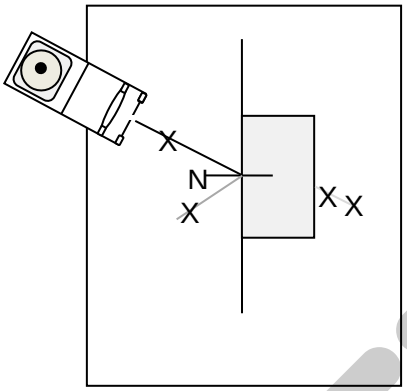


You should read these instructions carefully before you start work

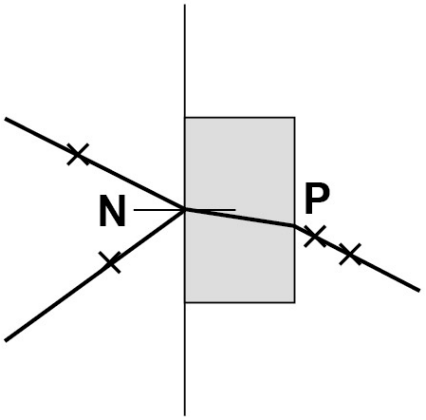
1. Before the room is darkened, set up the ray box, slit and lens so that a narrow ray of light is produced.
2. The ray box will get hot – be careful when you move it and switch it off when you don't need it.
3. Place the ruler near the middle of the A3 paper and draw a straight line parallel to its long side.
4. Use the protractor to draw a second line at right angles to this line. Label this line with an 'N' for 'normal'.



5. Place the longest side of the block against the first line, with the largest face of the block on the paper. The normal should be near the middle of the block.
6. Without moving the block, carefully draw around it.
7. Use the ray box to direct a ray of light at the point where the normal meets the block. This is called the incident ray.
8. The angle between the normal and the incident ray is called 'the angle of incidence'. Move the ray box or paper to change the angle of incidence until you see a clear ray reflected from the surface of the block and another clear ray leaving the opposite face of the block. You will probably have to do this with the room darkened.

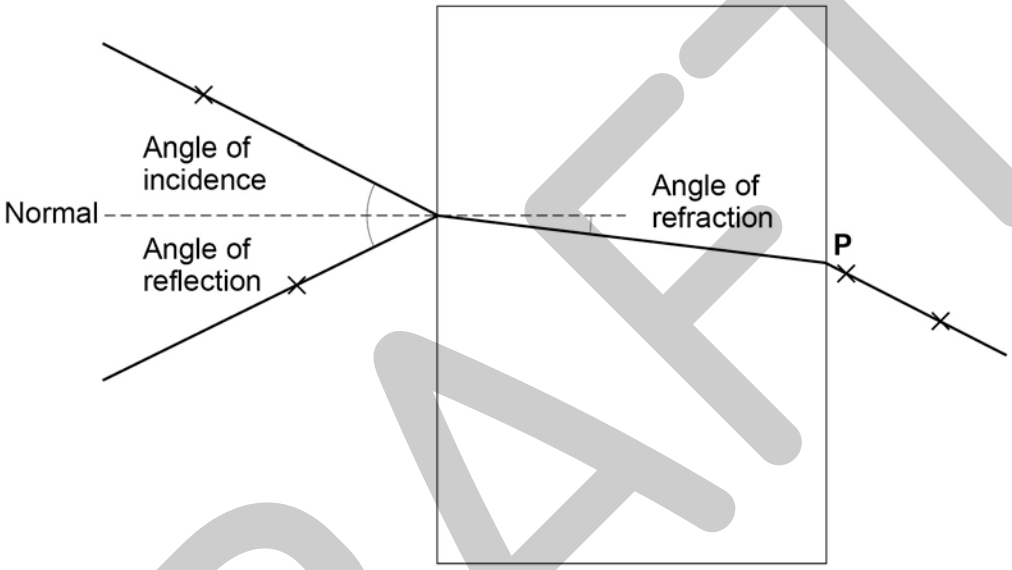


9. Mark the path of the incident ray with a cross. If the ray is wide, make sure the centre of the cross is in the centre of the ray.
10. Mark the path of the reflected ray with another cross.
11. Mark the path of the ray that leaves the block (the transmitted ray) with two crosses, one near the block and the other further away.
12. Switch on the room lights, switch of the ray box and remove the block.
13. Draw in the incident ray by drawing a line through your first cross to the point where the normal meets the block.
14. Draw the reflected ray by drawing a line through your second cross to the point where the normal meets the block.
15. Draw the transmitted ray by drawing a line through the two crosses on the other side of the block to that side of the block. Label this point with a ‘P’.
16. Draw a line that represents the path of the transmitted ray through the block. Do this by drawing a line from point P to the point where the normal meets the block.



17. Use the protractor to measure:

    a. the angle between the incident ray and normal. This is the angle of incidence.
    b. the angle between the reflected ray and normal. This is the angle of reflection.
    c. the angle between the ray inside the block and the normal. This is the angle of refraction.



18. Record your measurements in a suitable table. You are going to need three rows and five columns.

angle of incidence in degrees	first block		second block	
	angle of reflection in degrees	angle of refraction in degrees	angle of reflection in degrees	angle of refraction in degrees

19. Now repeat this for the other block. Place the other block on the A3 paper.
20. Line up the long side of the block as before.
21. If the block is not the same size as the first one, carefully draw around it without moving it.
22. Use your ray box to send in an incident ray along the same line as before. Again you may have to work in a darkened room.
23. Look at the directions of the reflected and transmitted rays.
24. If they are not the same as before, mark their paths using crosses.

25. Remove the block, switch off the ray box, and switch on the room lights.
26. Draw in the reflected and refracted rays.
27. Measure the angle of reflection and the angle of refraction and record them in your table.
28. Physics theory suggests that the angles of reflection should be the same, but the angles of refraction should be different. How well do your results support this theory?