OXFORD
INTERNATIONAL
AQA EXAMINATIONS

INTERNATIONAL GCSE

SCIENCES

Practical handbook

v2.0

International GCSE Biology (9201)

International GCSE Chemistry (9202)

International GCSE Physics (9203)

International GCSE Combined Science (9204)

CONTENTS

INTRODUCTION

Practical work is an essential element of all of our Oxford International AQA science specifications. Not only does it reinforces key scientific concepts but also provides insight into the scientific method.

Your students will need to carry out a series of required practicals for each of their science qualifications. This practical handbook suggests methods and activities for carrying out these required practicals to help you plan the best experience for your students.

There are 5 required practicals for each of the separate sciences - Biology, Chemistry and Physics. The 9 required practicals that are included in combined science have been selected from the separate science specifications. Required practicals that are unique to the Biology, Chemistry and Physics specifications are marked with B, C and P respectively.

This guide contains suggested methods for each of the required practicals including

- teachers' notes
- technical guidance
- student sheets

In your planning you should consider the leaning outcomes that you want for each of the required practicals. These might focus on specific investigative skills, scientific understanding or health and safety considerations. There are blank spaces in the student sheets for students to write down the learning outcomes for each required practical activity.

It should be noted that the procedures described are only suggestions and you are encouraged to develop activities, resources and contexts that provide the appropriate level of engagement and challenge for your students.

The experimental and investigative skills that your students develop through practical work will be assessed through exam questions rather than through coursework. This handbook also includes sample practical questions to help you prepare your students for the exams.

RISK ASSESSMENT

The practical methods in this guide have been suggested by teachers who have successfully carried them out in the lab. However it is the responsibility of the school or college to ensure that full risk assessments have been carried out in each case.

TRIALLING

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

WHY DO PRACTICAL WORK?

There are three separate, but interconnected, reasons for doing practical work in schools.

1. To support and consolidate scientific concepts:
   By doing practical work your students be able to make better sense of the knowledge an understanding that they gain throughout their course. They will also gain insights into the development of scientific thinking.

2. To develop investigative skills including:
   - devising and investigating testable questions
   - identifying and controlling variables
   - analysing, interpreting and evaluating data.

3. To build and master practical skills such as:
   - using specialist equipment to take measurements
   - handling and manipulating equipment with confidence and fluency
   - recognising hazards and planning how to minimise risk.

EXPERIMENTAL AND INVESTIGATIVE SKILLS

Science attempts to explain the world in which we live. It provides technologies that have had a great impact on our society and the environment. Scientists try to explain phenomena, using hypotheses and models, and to solve problems using evidence. Over this course, students should be encouraged to develop their understanding of the scientific process and the skills associated with scientific enquiry. The table below shows the key experimental and investigative skills that students will need to master over the course.

Scientific process and skill	
Designing a practical procedure	Design a practical procedure to answer a question, solve a problem or test a hypothesis.
	Comment on/evaluate plans for practical procedures.
	Select suitable apparatus for carrying out experiments accurately and safely.
Control	Appreciate that, unless certain variables are controlled, experimental results may not be valid.
	Recognise the need to choose appropriate sample sizes, and study control groups where necessary.
Risk assessment	Identify possible hazards in practical situations, the risks associated with these hazards, and methods of minimising the risks.
Collecting data	Make and record observations and measurements with appropriate precision and record data collected in an appropriate format (such as a
Analysing data	Recognise and identify the cause of anomalous results and suggest what should be done about them.
	Appreciate when it is appropriate to calculate a mean, calculate a mean from a set of at least three results and recognise when it is appropriate to ignore anomalous results in calculating a mean.
	Recognise and identify the causes of random errors and systematic errors.
	Recognise patterns in data, form hypotheses and deduce relationships.
	Use and interpret tabular and graphical representations of data.
Making conclusions	Draw conclusions that are consistent with the evidence obtained and support them with scientific explanations.
Evaluation	Evaluate data, considering its repeatability, reproducibility and validity in presenting and justifying conclusions.
	Evaluate methods of data collection and appreciate that the evidence obtained may not allow a conclusion to be made with confidence.
	Suggest ways of improving an investigation or practical procedure to obtain extra evidence to allow a conclusion to be made.

Your students will be assessed on aspects of the skills listed above, and may be required to read and interpret information from scales given in diagrams and charts, present data in appropriate formats, design investigations and evaluate information that is presented to them. Each of the sections describing the required practicals below is followed by a set of practical questions that exemplify how students will be assessed on practical skills in the exams.

BIOLOGY REQUIRED PRACTICALS

Investigate the effect of different concentrations of solutions separated by a semi permeable membrane.	Biology 3.1.5
Investigate how variables affect the rate of photosynthesis.	Biology 3.2.1 Combined 3.2.1
Investigate how different temperatures and pH affect the rate of digestion.	Biology 3.2.4
Investigate the effects of exercise on the human body.	Biology 3.2.6 Combined 3.2.5
Investigate the effect of disinfectants and antibiotics on uncontaminated cultures of microorganisms.	Biology 3.4.7 Combined 3.4.6

BIOLOGY REQUIRED PRACTICAL: OSMOSIS (B)

TEACHERS' NOTES

Required practical activity	Specification reference
Investigate the effect of different concentrations of solutions separated by a semi permeable membrane.	Biology 3.1.5

Investigate the effect of a range of concentrations of salt or sugar solutions on the mass of plant 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.

BIOLOGY REQUIRED PRACTICAL: OSMOSIS (B)

STUDENT SHEET

Investigate the effect of a range of concentrations of salt or sugar solutions on the mass of plant 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**

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

Read these instructions carefully before you start work.

1. Use a cork borer to cut five 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 10 cm^3 of the 1.0 M sugar solution and put into the first boiling tube. Label boiling tube as: 1.0. M sugar.

5. Repeat step 4 to produce the additional labelled boiling tubes containing solutions of 0.75 M, 0.5 M. and 0.25 M.

6. Measure 10 cm^3 of the distilled water and put into the fifth boiling tube. Label boiling tube as water.

7. Add one potato cylinder to each boiling tube. Make sure you know the length and mass of each potato cylinder in each boiling tube.

8. Record the lengths and masses of each potato cylinder in a table such as the one below.

	1.0 M sugar solution	**0.75 sugar solution**	**0.5 M sugar solution**	**0.25 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)					

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).

    Record your measurements in the table. Then calculate the changes in length and mass of each potato cylinder.

12. Plot a graph with:
    - 'Change in mass in g' on the y-axis
    - 'Concentration of sugar solution' on the x-axis

13. Plot another graph with:
    - 'Change in length in mm' on the y-axis
    - 'Concentration of sugar solution' on the x-axis.

    Compare the two graphs that you have drawn.

BIOLOGY REQUIRED PRACTICAL: PHOTOSYNTHESIS

TEACHERS' NOTES

Required practical activity	Specification reference
Investigate how variables affect the rate of photosynthesis.	Biology 3.2.1 Combined 3.2.1

Investigating the effect of light intensity on photosynthesis in an aquatic plant

MATERIALS

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

- a boiling tube
- freshly cut 10 cm piece of an aquatic plant
- a light source
- a ruler
- a test tube rack
- a stop watch
- 0.2% solution of sodium hydrogencarbonate solution
- a glass rod

TECHNICAL INFORMATION

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 $1/\text{distance}^2$. 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 plant when placed closest to the light source, cut a few millimetres off the end or, if necessary, use a new freshly-cut piece of plant.

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 hydrogencarbonate 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.

BIOLOGY REQUIRED PRACTICAL: PHOTOSYNTHESIS

STUDENT SHEET

Investigating the effect of light intensity on photosynthesis in an aquatic plant

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 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 the aquatic plant and a light source. The closer the light source the greater the light intensity.

Learning outcomes
1 **2**

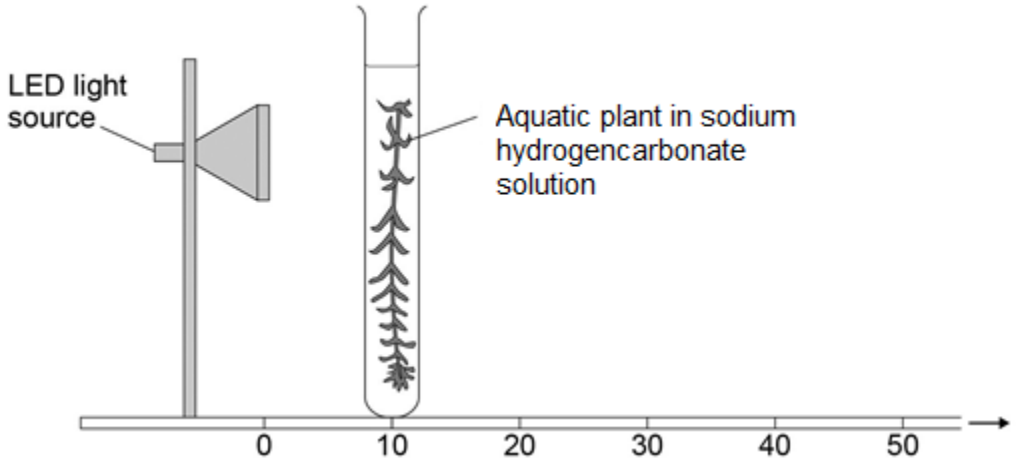
METHOD

You are provided with the following:

- a boiling tube
- freshly cut 10 cm piece of aquatic plant
- a light source
- a ruler
- a test tube rack
- a stop watch
- 0.2% solution of sodium hydrogencarbonate
- 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 hydrogencarbonate solution.
3. Place the piece of plant into the boiling tube with the cut end uppermost. Gently push the plant 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 plant 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.

BIOLOGY REQUIRED PRACTICAL: ENZYMES (B)

TEACHERS' NOTES

Required practical activity	Specification reference
Investigate how different temperatures and pH affect the rate of digestion.	Biology 3.2.4

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

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.

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

- Safety goggles should be worn in the presence of hot water in water baths.
- 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.
- 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.

BIOLOGY REQUIRED PRACTICAL: ENZYMES (B)

STUDENT SHEET

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

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.

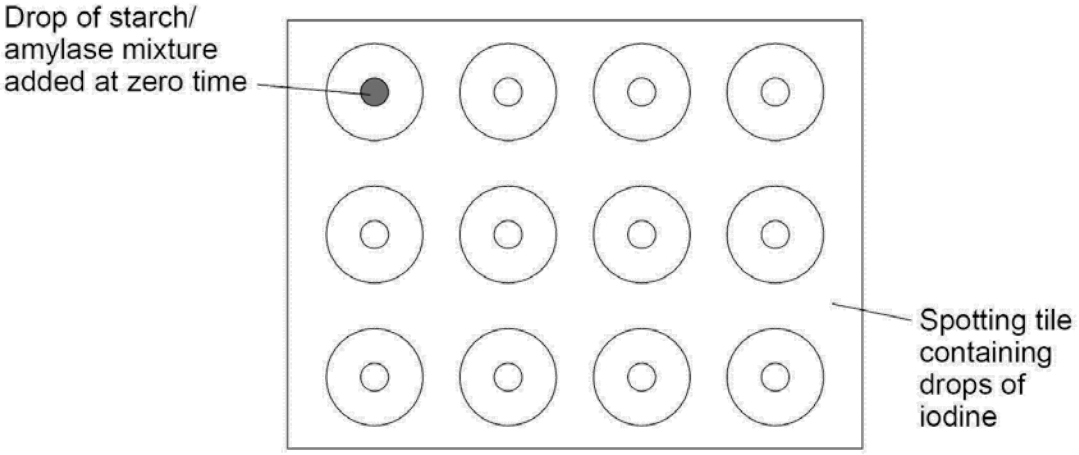
RISK ASSESSMENT

Safety goggles should be worn in the presence of hot water in water baths.

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.

BIOLOGY REQUIRED PRACTICAL: EXERCISE

TEACHERS' NOTES

Required practical activity	Specification reference
Investigate the effects of exercise on the human body.	Biology 3.2.6 Combined 3.2.5

Investigate whether the rate at which muscles work affects how long it takes for muscles become fatigued.

MATERIALS

- stopwatch
- hand exerciser

TECHNICAL INFORMATION

During exercise, if insufficient oxygen is reaching the muscles they use anaerobic respiration to obtain energy.

Anaerobic respiration is the incomplete breakdown of glucose and produces lactic acid.

If muscles are subjected to long periods of vigorous activity they become fatigued, ie they stop contracting efficiently.

ADDITIONAL INFORMATION

Judging when the exercise has become too painful is a subjective decision, and will vary from student to student. It would be useful to compile a set of class results and calculate means.

RISK ASSESSMENT

Students should be told to use common sense when deciding when the exercise has become too painful. Some students may want to show "bravado" regarding how much pain they can take!

TRIALLING

The practical should be trialled before use with students

BIOLOGY REQUIRED PRACTICAL: EXERCISE

STUDENT SHEET

Investigate whether the rate at which muscles work affects how long it takes for muscles become fatigued.

Learning outcomes
1 **2**

METHOD

You are provided with the following:

- a stopwatch
- a hand exerciser

You should read these instructions carefully before you start work.

1. Using your dominant hand, rest your elbow on a desk or other surface.
2. Using a hand exerciser, fully squeeze the handles in and out at the rate of 1 repetition every 3 seconds
3. Record the time it takes for your hand to get fatigued (i.e. when it becomes too painful to continue)
4. Rest for 5 minutes
5. Repeat this two more times and record in a table
6. Repeat steps 1 to 6 using the following rates of repetition:
    - 2 repetitions every 3 seconds
    - 3 repetitions every 3 seconds
    - 4 repetitions every 3 seconds
    - 5 repetitions every 3 seconds
7. Plot a graph of you collected data.

BIOLOGY REQUIRED PRACTICAL: MICROBIOLOGY

TEACHERS' NOTES

Required practical activity	Specification reference
Investigate the effect of disinfectants and antibiotics on uncontaminated cultures of microorganisms.	Biology 3.4.7 Combined 3.4.6

Investigating the effect of antiseptics on the growth of bacteria

MATERIALS

Teacher

In addition to access to general laboratory equipment teachers will need the following for demonstration purposes

- a nutrient agar plate
- a Bunsen burner
- a heatproof mat
- a disposable plastic pipette (sterile)
- a culture of bacteria (*E. coli– K12 or B strain*)
- a sterile glass spreader
- filter paper discs

Student

- three antiseptics (such as mouthwash, TCP, and antiseptic cream)
- 1% VirKon disinfectant
- forceps
- clear tape
- hand wash
- a wax pencil
- access to an incubator (set to maximum of 25°C).

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. Please note: when using *E.coli*, **penicillin will not produce clearing**.

You could use *Micrococcus luteus* instead of *E. coli* which is bright yellow and grows much better at 25 ^{o}C.

Plastic petri dishes should be used as these can be destroyed by melting in an autoclave or sterilising 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.

Plates should be secured with extra sticky tape before student viewing. It is important that condensation in the plates can still escape.

For sterilising glass pipettes or glass spreaders, wrap in greaseproof paper or foil and heat treat at 160^{o}C for 2 hours. Sterile plastic pipettes and spreaders can be purchased.

1% VirKon disinfectant should be used as they have validation of sterilisation.

If ethanol sterilisation is to be used, the ethanol should be kept well away from any naked flames.

The incubator should be kept secure, either in a locked prep room, or locked if it is in the lab.

DISINFECTION: all equipment and materials and work surfaces must be disinfected using excess 1% VirKon for at least 10 minutes. Pipettes and spreaders should be placed into a discard beaker of 1% VirKon immediately after use. An A4 piece of paper that has been laminated to make it waterproof (or a similar sized piece of plastic) is a suitable work surface. The work surface should be placed in a tray of 1% VirKon, so that it is fully covered, for 10 minutes. The surface should be blotted dry with a paper towel before use. Always wear eye protection when using VirKon solution.

Additional information

The aseptic techniques shown in the table below could be demonstrated to the students but they do not need to prepare the plates themselves or spread the lawn of the bacteria.

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
Placing drops of culture from the pipette onto the agar.	This needs to be done while carefully holding the lid over the plate.
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.

It is important to work carefully but quickly to minimise contamination.

Time can be saved by using commercially produced antibiotic discs rather than having the students prepare the discs themselves.

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.
- There should be facilities available in the laboratory for students to wash their hands thoroughly before and after handling microbes.
- Care should be taken if using ethanol in this experiment. Refer to Hazcard 40A.
- Students should ensure that their work spaces and hands are thoroughly disinfected with 1% VirKon before and after the experiment. Refer to technical notes regarding disinfection.

- 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. Tape plates with two/three small pieces of sticky tape so that lids remain attached to the base.
- 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.

BIOLOGY REQUIRED PRACTICAL: MICROBIOLOGY

STUDENT SHEET

Investigating the effect of antiseptics on the growth of bacteria

In this investigation you will measure the diameter of the 'clear zone' around the disc. This is where there is no bacteria growing. The larger the clear zone, the more effective the antiseptic.

Learning outcomes
1 **2** **3** **Teachers to add these with particular reference to working scientifically**

Risk assessment

- Ensure that your work spaces and hands are thoroughly cleaned before and after the experiment.
- 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

Method

You are provided with the following:

- a nutrient agar plate
- a heatproof mat
- filter paper discs
- three antiseptics (such as mouthwash, TCP, and antiseptic cream)
- disinfectant bench spray
- 1% VirKon disinfectant
- forceps
- clear tape
- hand wash
- a wax pencil

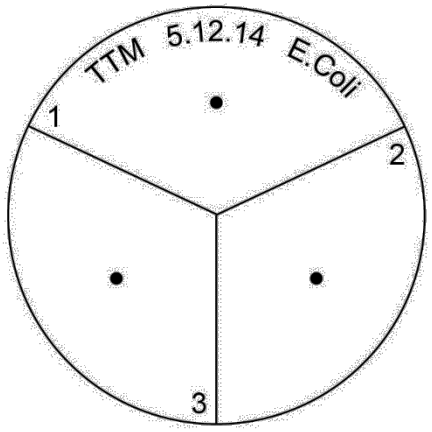
- access to an incubator (set to 25^{o}C).

Read these instructions carefully before you start work.

1. Spraying the bench where you are working with disinfectant spray. Then wipe with paper towels.

2. Mark the underneath of a nutrient agar plate (not the lid) with the wax pencil as follows (make sure that the lid stays in place to avoid contamination):

- divide the plate into three equal sections 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*)



3. Wash your hands with the antibacterial hand wash.

4. Put different antiseptics onto the three filter paper discs. This can be done by either soaking them in the liquid or spreading the cream or paste onto them.

5. Carefully lift the lid of the agar plate at an angle. Do not open it fully.

6. Use forceps to carefully put each disc onto one of the dots drawn on with the wax pencil.

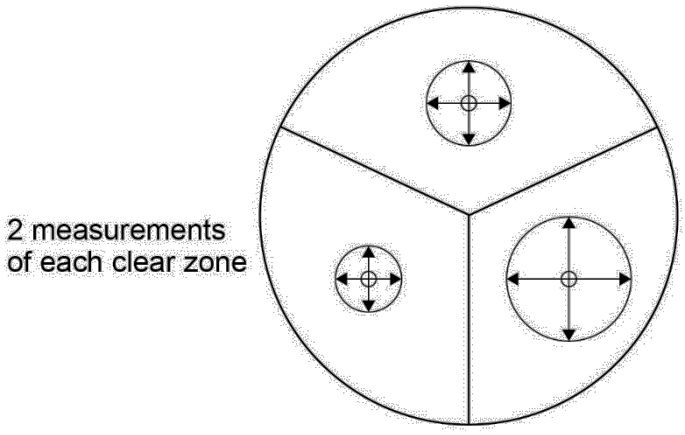
7. Make a note of which antiseptic is in each of the three numbered sections of the plate.

8. 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. Anaerobic conditions will prevent the E. coli bacteria from growing and can encourage some other very nasty bacteria to grow.

9. Incubate the plate at 25 °C for 48 hours.

10. 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.



11. 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)			

BIOLOGY PRACTICAL QUESTIONS

1 A student investigates the effect of different sugar solutions on potato tissue.

This is the method used.

1. Add 30 cm^3 of 0.8 mol dm^{-3} sugar solution to a boiling tube.
2. Repeat step 1 with equal volumes of 0.6, 0.4 and 0.2 mol dm^{-3} sugar solutions.
3. Use water to give a concentration of 0.0 mol dm^{-3}.
4. Cut five cylinders of potato of equal size using a cork borer.
5. Weigh each potato cylinder and place one in each tube.
6. Remove the potato cylinders from the solutions after 24 hours.
7. Dry each potato cylinder with a paper towel.
8. Reweigh the potato cylinders.

Table 1 shows the results.

Table 1

Concentration of sugar solution in mol dm^{-3}	Starting mass in g	Final mass in g	Change of mass in g	Percentage (%) change
0.0	1.30	1.51	0.21	16.2
0.2	1.35	1.50	0.15	**X**
0.4	1.30	1.35	0.05	3.8
0.6	1.34	1.28	−0.06	−4.5
0.8	1.22	1.11	−0.11	−9.0

1.1 Calculate the value of **X** in **Table 1**.

[2 marks]

Percentage change in mass = _____ %

1.2 Why did the student calculate the percentage change in mass as well as the change in grams?

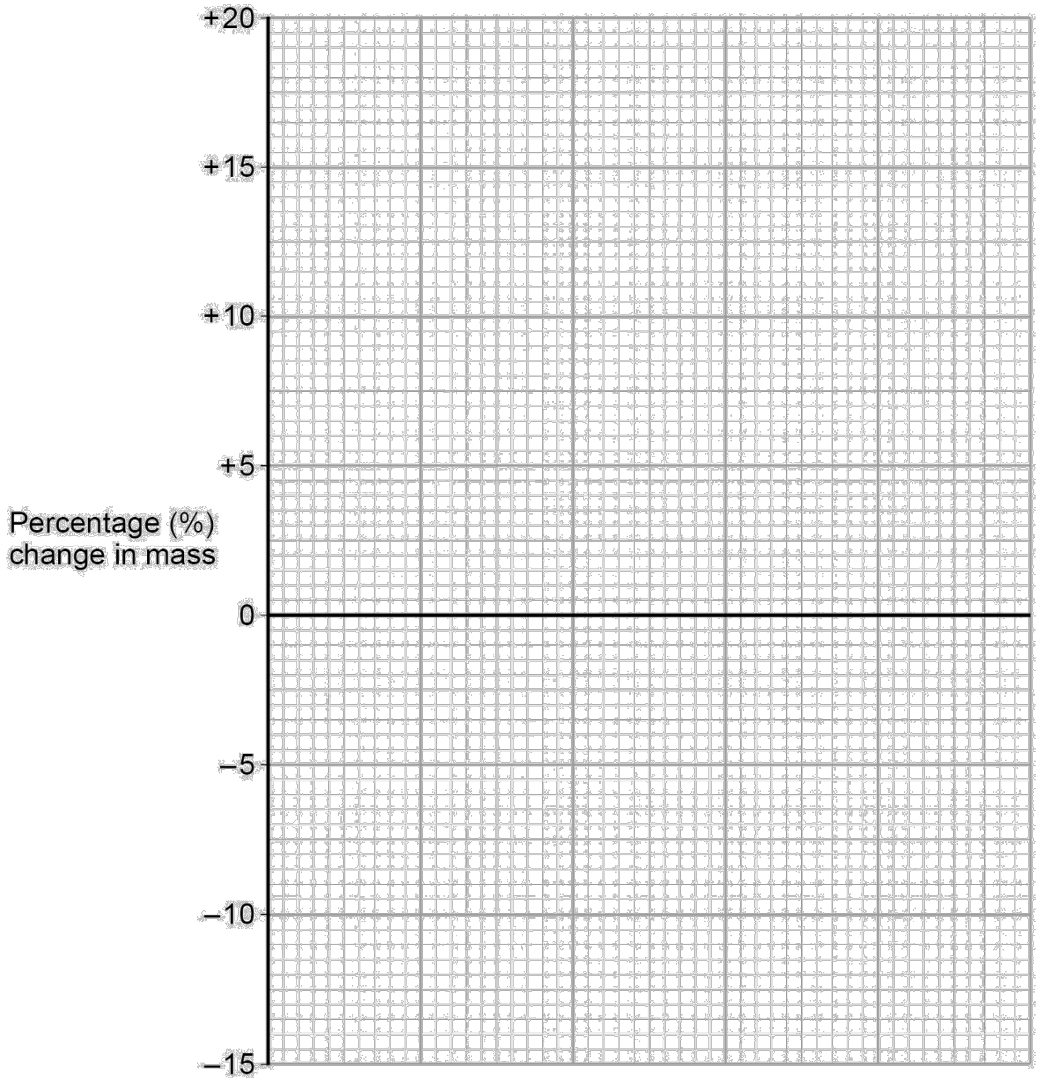
[1 mark]

1.3 Complete **Figure 1** using data from **Table 1**.

- Choose a suitable scale and label for the x-axis.
- Plot the percentage (%) change in mass.
- Draw a line of best fit.

[4 marks]

Figure 1



1.4 Use your graph in **Figure 1** to estimate the concentration of the solution inside the potato cells.

[1 mark]

Concentration =_____ mol dm^{-3}

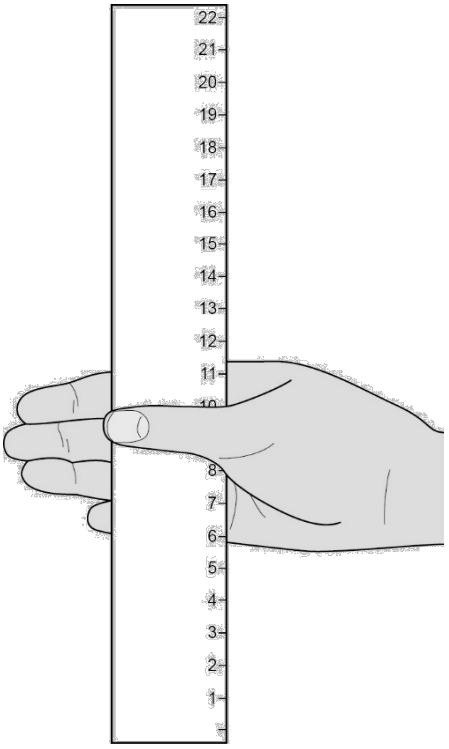
Question	Answers	Extra information	Mark
01.1	(0.15/1.35) × 100		1
	11.1 (%)	allow 11.1 (%) with no working shown for **2** marks	1
01.2	to allow results to be compared **or** they had different masses at the start		1
01.3	axis correct scale and labelled		1
	5 points correctly plotted	allow ecf from **05.1** allow **1** mark for 4 points correctly plotted	2
	line of best fit		1
01.4	0.5	allow 0.45–0.55	1

2 Two students investigated reflex action times.

This is the method used.

1. Student **A** sits with her elbow resting on the edge of a table.
2. Student **B** holds a ruler with the bottom of the ruler level with the thumb of Student **A**.
3. Student **B** drops the ruler.
4. Student **A** catches the ruler and records the distance, as shown in **Figure 2**.
5. Steps **1** to **4** were then repeated.

Figure 2



2.1 Suggest two ways the students could improve the method to make sure the test would give valid results.

[2 marks]

2.2 The mean distance the ruler was dropped is 116 mm.

Calculate the mean reaction time.

[3 marks]

Use the equation:

$$\text{reaction time (s)} = \sqrt{\frac{\text{mean drop distance (cm)}}{490}}$$

Mean reaction time = _____ s

Question	Answers	Extra information	Mark
02.1	any **two** from: • drop the ruler from the same height each time • let the ruler drop without using any force • same type / weight of ruler • thumb should be same distance from the ruler each time at the start • use the same hand to catch the ruler each time • carry out the experiment with the lower arm resting in the same way on the table	allow description of holding bottom edge of ruler opposite the catcher's thumb	2
02.2	$\sqrt{\frac{11.6}{490}}$ 0.1539 0.154	 allow 01539 with no working shown for **2** marks allow 0.154 with no working shown for **3** marks allow ecf as appropriate	1 1 1

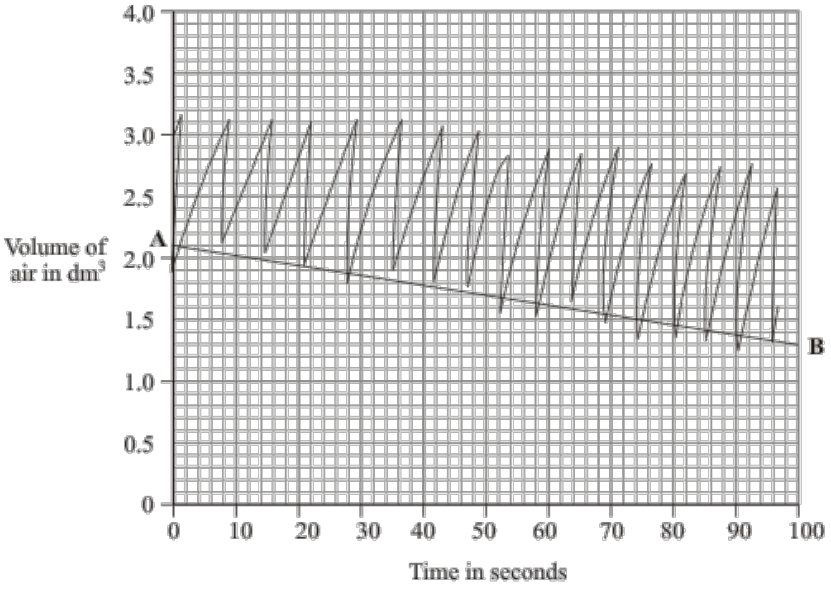
3 A student's breathing was monitored before and after vigorous exercise.

The student breathed in and out through a special apparatus.

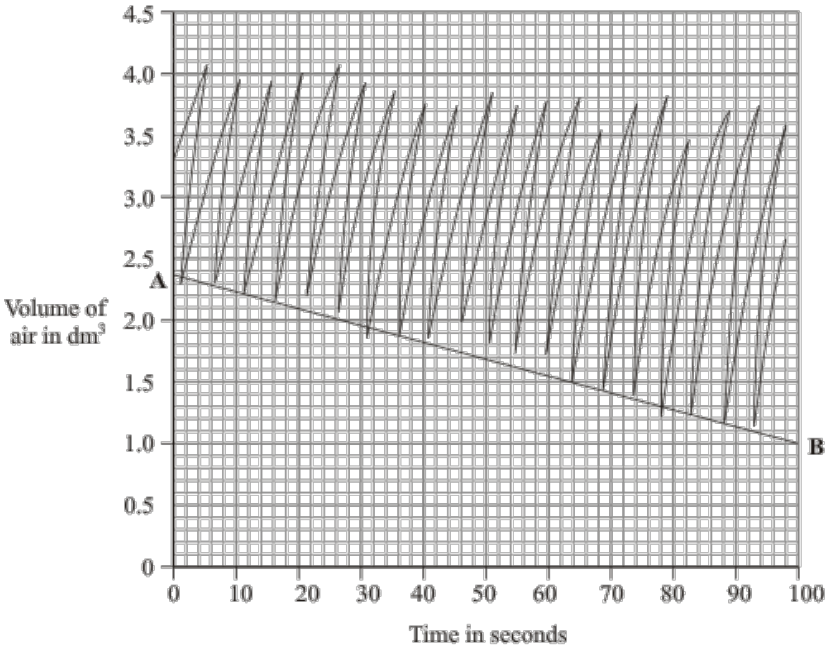
The graphs in Figure **3** show the changes in the volume of air inside the apparatus. Each time the student breathed in, the line on the graph dropped.

Each time the student breathed out, the line went up.

Figure 3



Before exercise



After exercise

3.1 How many times did the student breathe in per minute:

[1 mark]

before exercise? _____

after exercise? _____

3.2 On each graph, the line **A** – **B** shows how much oxygen was used. The rate of oxygen use before exercise was 0.5 dm^3 per minute. Calculate the rate of oxygen use after exercise.

[2 marks]

Rate of oxygen use after exercise = _____ dm3 per minute

3.3 The student suggested they should repeat the experiment twice more.

How would repeating the experiment improve the investigation?

[1 mark]

_____

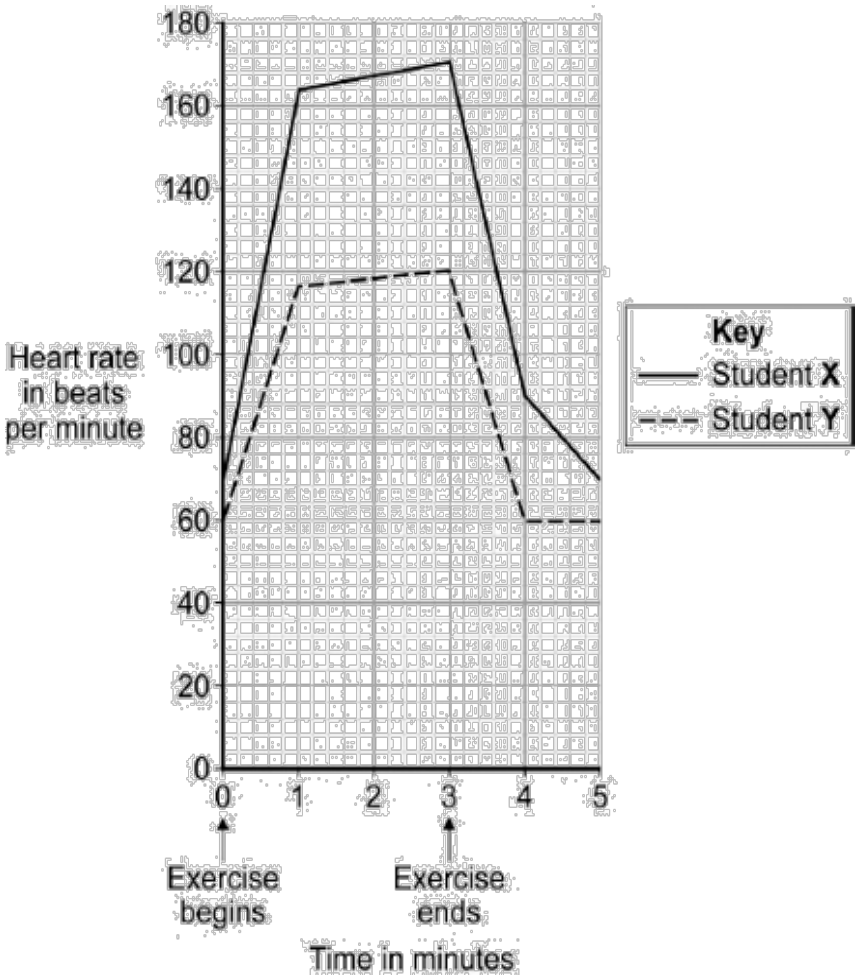
_____

Two other students did the same amount of vigorous exercise for 3 minutes.

One of the students was fit. The other student was unfit.

The graph in **Figure 4** shows how the students' heart rate changed during the exercise and after the exercise.

Figure 4



3.4 Use the information in the graph to suggest which student was the fitter.

Explain your choice.

[2 marks]

3.5 In order to compare the results of the two students they had to be matched for a number of factors.

State **two** of these factors.

[2 marks]

_____

_____

_____

3.6 Explain **two** advantages to the students of the change in heart rate during exercise.

[2 marks]

_____

_____

_____

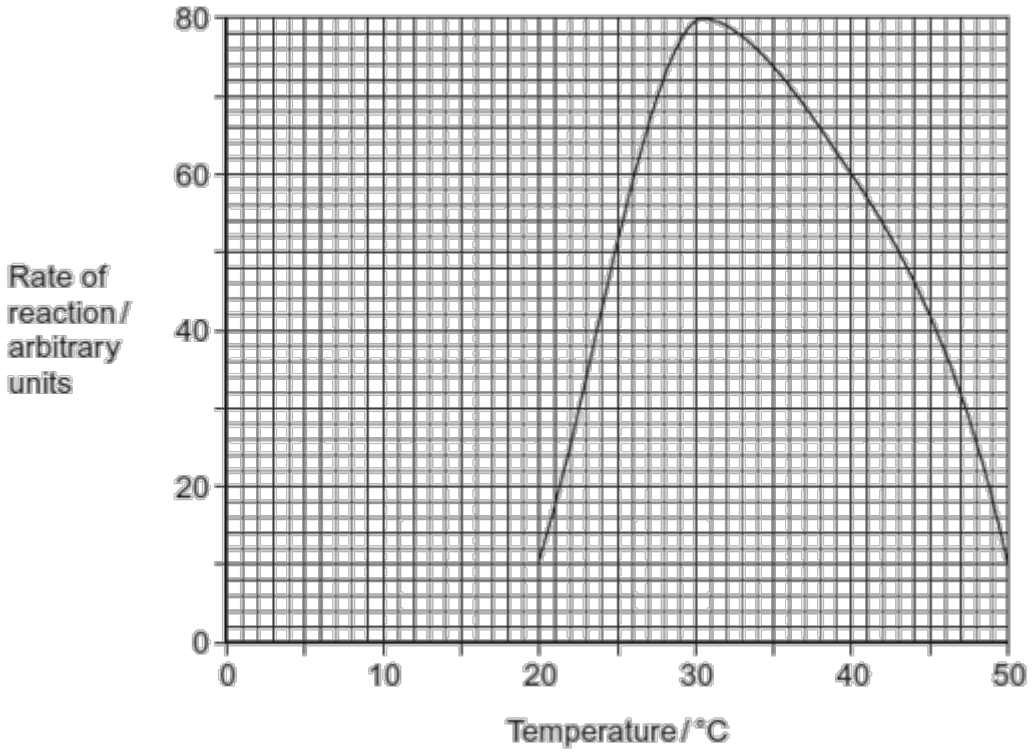
Question	Answers	Extra information	Mark
03.1	(before exercise) – 9 to 11 **and** (after exercise) – 12 **or** 13		1
03.2	*2.35 – 1.55* ***or*** $\frac{(2.35-1.0)\times 60}{100}$ 0.75 to 0.90		1 1
03.3	more representative / more reliable / can check 'repeatability' / see if get similar values / identify anomalies		1
03.4	(Student **Y**) because she/he had **any 2 from** • the lower resting heart rate • the lower heart rate increase • the quicker recovery time	*accept converse for Student **X***	2
03.5	any **two** from: • Age • Gender • Mass • Same diet prior to exercise or named dietary factor e.g. Caffeine/carbohydrate intake • Same amount of rest prior to exercise • Exercise done at the same time of day • Both in good health/not ill		2

03.6	any **two** from: • (the increased heart rate) increases rate of delivery of oxygen to the (respiring) muscles • and increases rate of delivery of glucose to the (respiring) muscles • and results in faster removal of carbon dioxide • and results in faster removal of lactic acid	allow 0.45–0.55	1

4 A protease is an enzyme that digests protein.

The graph in **Figure 5** shows how the activity of a protease varies with temperature.

Figure 5



4.1 Protease digests protein. What is the product of the digestion of protein?

Tick **one** box.

[1 mark]

Amino acids ☐

Fatty acids ☐

Glucose ☐

4.2 Describe what the graph shows about the effect of temperature on the rate of reaction. Use data to support your answer.

[2 marks]

4.3 The student concluded the optimum temperature for protease was between 35°C and 40°C.

This conclusion may not be valid. Describe how the experiment could be improved to find a more precise value for the optimum temperature.

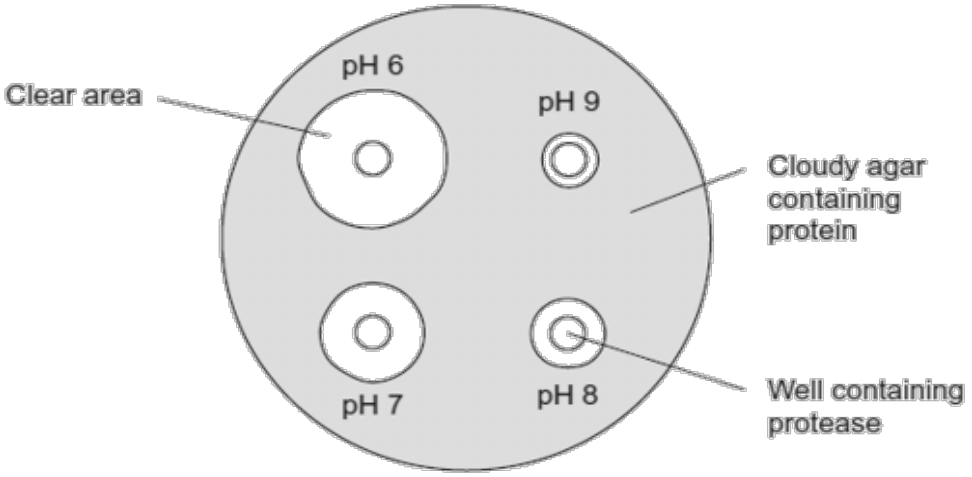
[2 mark]

Students investigated the effect of pH on the activity of the protease.

- The students used agar plates containing protein. The protein made the agar cloudy.
- They made four wells of equal size in the agar of each plate.
- They added a drop of protease solution to each of the wells. The protease solution in each well was at a different pH.
- The students incubated the agar plates for 4 hours at a constant temperature.

The diagram in **Figure 6** shows the agar plates after they were incubated and the pH of the protease solution in each well.

Figure 6



4.4 Describe how the student could have used these results to compare the activity of the enzyme at different pH values.

[2 marks]

4.5 Describe a control that would be necessary for this investigation.

[2 marks]

4.6 Use the graph to suggest a suitable temperature for incubating the agar plates.

Explain your answer.

[1 mark]

Question	Answers	Extra information	Mark
04.1	amino acids		1
04.2	rate of reaction increases then decreases peak at 35°C		1 1
04.3	(repeat the experiment) using more temperatures/intermediate values testing between 20 and 40 °C		1 1
04.4	Measure diameter / radius / area of clear zone; Detail of method e.g. determine mean diameter of each clear zone / use of graph paper to determine area		1 1
04.5	use of denatured / boiled enzyme at all pH values		1 1
04.6	35°C maximum rate / optimum temperature		1

CHEMISTRY REQUIRED PRACTICALS

Investigating the products formed at the anode and cathode in the electrolysis of copper sulfate solution.	Chemistry 3.3.2
Identify the metal ion in an unknown compound using flame testing techniques	Chemistry 3.4.3 Combined 3.10.2
Establish the concentration of an unknown strong acid through titration with strong base.	Chemistry 3.6.4 Combined 3.12.4
Investigate factors affecting the rate of a reaction.	Chemistry 3.8.1 Combined 3.14.1
Test for the presence of a double bond in an unknown hydrocarbon.	Chemistry 3.10.1.3

CHEMISTRY REQUIRED PRACTICAL: ELECTROLYSIS (C)

TEACHERS' NOTES

Required practical activity	Specification reference
Investigating the products formed at the anode and cathode in the electrolysis of copper sulfate solution.	Chemistry 3.3.2

Investigating the products formed at the anode and cathode in the electrolysis of copper sulfate solution.

MATERIALS

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

- 0.5 mol/dm^3 copper(II) sulfate solution
- Petri dish lid with bored holes
- Two carbon rod electrodes with support bungs
- Two crocodile / 4mm plug leads
- Low voltage power supply

TECHNICAL INFORMATION

To prepare 0.5 mol/dm^3 copper(II) sulfate solution, consult CLEAPSS Recipe Book 31 and Guide L195.

Small petri dish lids fit 100 cm^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

Longer times will be needed to collect enough oxygen for testing. If a Hofmann voltameter is available, it could be set up at the beginning of the lesson. This will usually produce enough oxygen 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

- Safety goggles must be worn throughout.
- Risk assessment and risk management are the responsibility of the centre.
- 0.5 mol/dm^3 copper(II) sulfate solution is covered by Hazcard 27C

TRIALLING

The practical should be trialled before use with students.

CHEMISTRY REQUIRED PRACTICAL: ELECTROLYSIS (C)

STUDENT SHEET

Investigating the products formed at the anode and cathode in the electrolysis of copper sulfate solution.

In this investigation you will use a low voltage power supply and carbon rod electrodes to pass a current through copper sulfate solution. You will identify the products formed at the positive and negative electrode in each case.

Learning outcomes
1
2

METHOD

You are provided with the following:

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

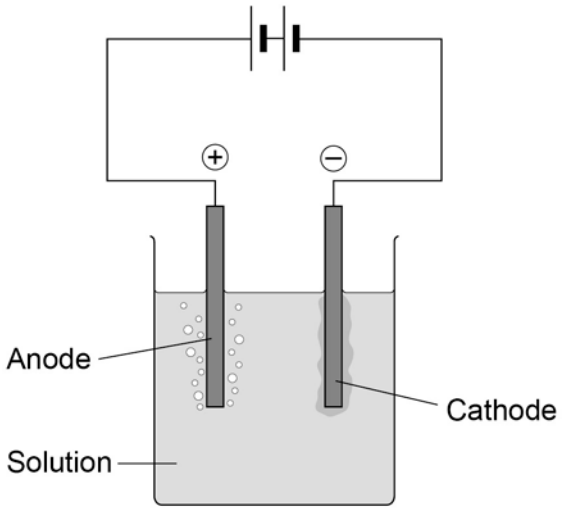
RISK ASSESSMENT

Safety goggles must be worn throughout.

You should read these instructions carefully before you start work.

1. Pour copper(II) sulfate solution into the beaker to about 50 cm^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. 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.

ADDITIONAL INFORMATION:

If a gas is produced at the positive electrode hydroxide ions from water are discharged forming oxygen. The amounts produced are usually too small to identify by testing.

If a gas is produced at the negative electrode hydrogen ions from water are discharged forming hydrogen. The amounts produced are usually too small to identify by testing.

Positive electrode (anode)		**Negative electrode (cathode)**	
Observations	**Element formed**	**Observations**	**Element formed**

CHEMISTRY REQUIRED PRACTICAL: IDENTIFYING IONS

TEACHERS' NOTES

Required practical activity	Specification reference
Identify the metal ion in an unknown compound using flame testing techniques	Chemistry 3.4.3 Combined 3.10.2

Identify the metal ion in an unknown compound using flame testing techniques

MATERIALS

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

- nichrome wire mounted in handle
- 0.4 mol/dm^3 known labelled cation salt solutions: LiCl, NaCl, KCl, $CaCl_2$, $CuCl_2$
- 0.4 mol/dm^3 salt solution labelled 'unknown'.

TECHNICAL INFORMATION

The unknown salt solution could be any soluble compound containing one of the cations tested for.

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.

ADDITIONAL INFORMATION

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

It is important to keep nichrome wires clean. They can be rubbed with fine emery paper to achieve this. Students 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.
One way to avoid this is to allocate one or two nichrome wires for exclusive use with each salt solution. Individuals or groups of students can move from one solution to the next to perform the flame test.

RISK ASSESSMENT

- Safety goggles should be worn throughout.
- Risk assessment and risk management are the responsibility of the centre.

TRIALLING

The practical should be trialled before use with students.

CHEMISTRY REQUIRED PRACTICAL: IDENTIFYING IONS

STUDENT SHEET

Identify the metal ion in an unknown compound using flame testing techniques

In this investigation you will analyse a range of metal ions in a compound by flame testing. You will then apply the knowledge you gain to identify the ions in an unknown compound.

Learning outcomes
1
2

METHOD

You are provided with the following:

- Bunsen burner
- test tubes and test tube rack
- nichrome wire mounted in handle
- Known labelled solutions: chlorides of lithium, sodium, potassium, calcium and copper
- Salt solution labelled 'unknown'.

RISK ASSESSMENT

Safety goggles must be worn throughout.

You should read these instructions carefully before you start work.

1. Pour around 1 cm depth of each of the **labelled chloride solutions** into five test tubes in the rack.
2. Dip the nichrome wire into the first solution, and then hold the tip of the wire in a blue Bunsen burner flame.
3. Clean the wire carefully between tests and test the other four solutions in the same way.
4. Record your observation in **Table 1**.

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

metal ion	**lithium**	**sodium**	**potassium**	**calcium**	**copper**
flame colour					

CHEMISTRY REQUIRED PRACTICAL: NEUTRALISATION

TEACHERS' NOTES

Required practical activity	Specification reference
Establish the concentration of an unknown strong acid through titration with strong base.	Chemistry 3.6.4 Combined 3.12.4

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

MATERIALS

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

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

TECHNICAL INFORMATION

To prepare 0.08 mol/dm^3 dilute sulfuric acid, consult CLEAPSS Recipe Book 98 and Guide L195.

To prepare 0.1 mol/dm^3 sodium hydroxide solution, consult CLEAPSS Recipe Book 85 and Guide L195.

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

25 cm^3 0.1 mol/dm^3 NaOH is neutralised by 15.6 cm^3 mol/dm^3 H_2SO_4. Therefore it should be possible to complete all three titrations using one fill of a standard 50 cm^3 burette. However, the student sheet assumes for simplicity that the burette is refilled each time to 0 cm^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

- Safety goggles must be worn throughout.
- Risk assessment and risk management are the responsibility of the centre.
- 0.08 mol/dm^3 dilute sulfuric acid is covered by Hazcard 98A
- 0.1 mol/dm^3 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.

CHEMISTRY REQUIRED PRACTICAL: NEUTRALISATION

STUDENT SHEET

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 25 cm^3 of 0.1 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

METHOD

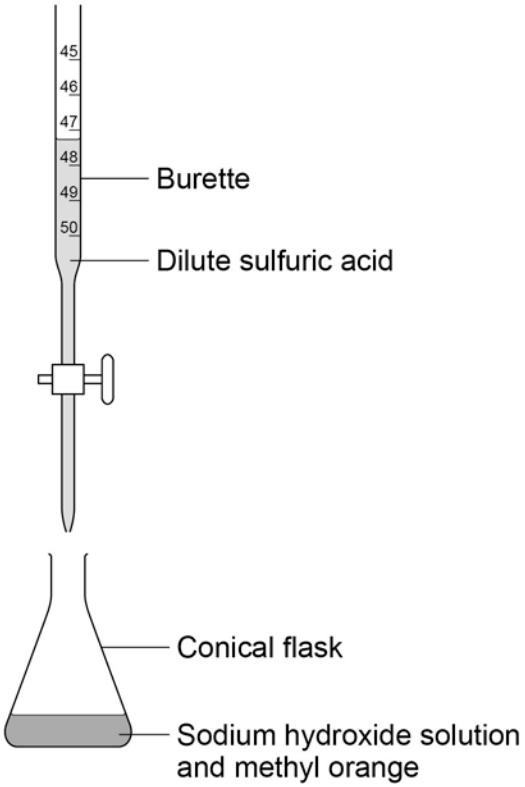
You are provided with the following:

- 25 cm^3 volumetric pipette and pipette filler
- Burette, small funnel and clamp stand
- 250 cm^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 25 cm^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 0 cm^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 25 cm^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 to neutralise 25 cm^3 sodium hydroxide solution (cm^3)			
Trial 1	**Trial 2**	**Trial 3**	**Mean**

Calculation

1. The equation for the reaction is:

   $$2NaOH(aq) + H_2SO_4(AQ) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

2. Moles of NaOH dissolved in 25 cm^3

3. Moles of H_2SO_4 that reached with 25 cm^3 of NaOH(aq)

4. Concentration of H_2SO_4 in mol/dm^3

5. Concentration of H_2SO_4 in g/dm^3

CHEMISTRY REQUIRED PRACTICAL: RATES OF REACTION

TEACHERS' NOTES

Required practical activity	Specification reference
Investigate factors affecting the rate of a reaction.	Chemistry 3.8.1 Combined 3.14.1

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:

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

TECHNICAL INFORMATION

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

To prepare 2.0 mol/dm^3 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

- Safety goggles should be worn throughout.
- Risk assessment and risk management are the responsibility of the centre.
- 40 g/dm3 sodium thiosulfate (LOW RISK) is covered by Hazcard 95C
- 2.0 mol/dm^3 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.

CHEMISTRY REQUIRED PRACTICAL: RATES OF REACTION

STUDENT SHEET

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**

METHOD

You are provided with the following:

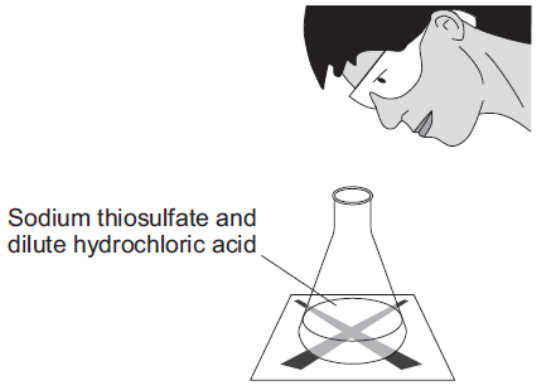
- 40 g/dm^3 sodium thiosulfate solution.
- 2.0 mol/dm^3 dilute hydrochloric acid
- 10 cm^3 and 100 cm^3 measuring cylinders
- 100 cm^3 conical flask
- printed black paper cross
- stopclock

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 10 cm^3 sodium thiosulfate solution into the conical flask. Again using a measuring cylinder, dilute this by adding 40 cm^3 water. This will make a solution of thiosulfate with a concentration of 8 g/dm^3. Put the conical flask on the black cross.
2. Put 10 cm^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:

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

CHEMISTRY REQUIRED PRACTICAL: TEST FOR ALKENES(C)

TEACHERS' NOTES

Required practical activity	Specification reference
Test for the presence of a double bond in an unknown hydrocarbon.	Chemistry 3.10.1.3

MATERIALS

- test tubes + stoppers
- bromine water in a dropping bottle
- samples of the following substances:
    a) Cyclohexene
    b) Cyclohexane
    c) Hexene
    d) Hexane

These substances should be made available to students in bottles labelled **A**, **B**, **C** and **D**.

These bottles should also carry the symbol for flammable and toxic substance.

Access to a fume cupboard is also required.

TECHNICAL INFORMATION

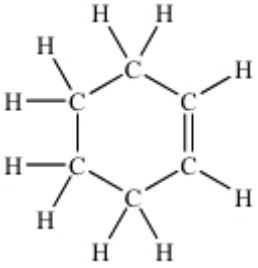
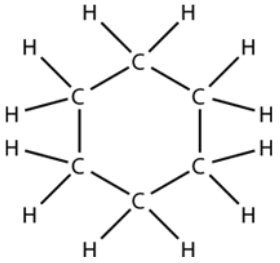
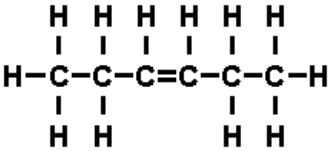
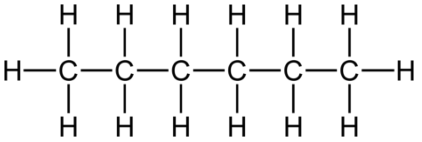
Alkanes are saturated hydrocarbons that do not contain a double bond.

Alkenes are unsaturated hydrocarbons that contain a double bond.

Bromine water can be used to tell the difference between an alkane and an alkene. An alkene will turn orange bromine water colourless as it reacts with the double bond. Bromine water remains orange in the presence of an alkane as there is no double bond.

ADDITIONAL INFORMATION

The following diagrams show the structure of the four compounds.

Cyclohexene	C_6H_{10}	
Cyclohexane	C_6H_{12}	
Hexene	C_6H_{12}	
Hexane	C_6H_{14}	

RISK ASSESSMENT

- Risk assessment and risk management are the responsibility of the centre.
- Safety goggles should be worn throughout.
- All the alkenes and alkanes listed above are colourless, flammable liquids. Centres should check the appropriate Hazcard available from CLEAPSS.
- Bromine water – Hazcard 15B
- Hydrocarbons, saturated – Hazcard 45B
- Hydrocarbons, unsaturated – Hazcard 45C

TRIALLING

The practical should be trialled before use with students

CHEMISTRY REQUIRED PRACTICAL: TEST FOR ALKENES

STUDENT SHEET

Test for the presence of a double bond in an unknown hydrocarbon.

In this experiment you will test a number of unknown substances to find out if they contain double bonds.

When bromine water is shaken with an unsaturated hydrocarbon, the reaction mixture turns colourless.

When a saturated hydrocarbon and bromine water are mixed the orange colour of the bromine water remains.

Learning outcomes
1
2

METHOD

You are provided with the following:

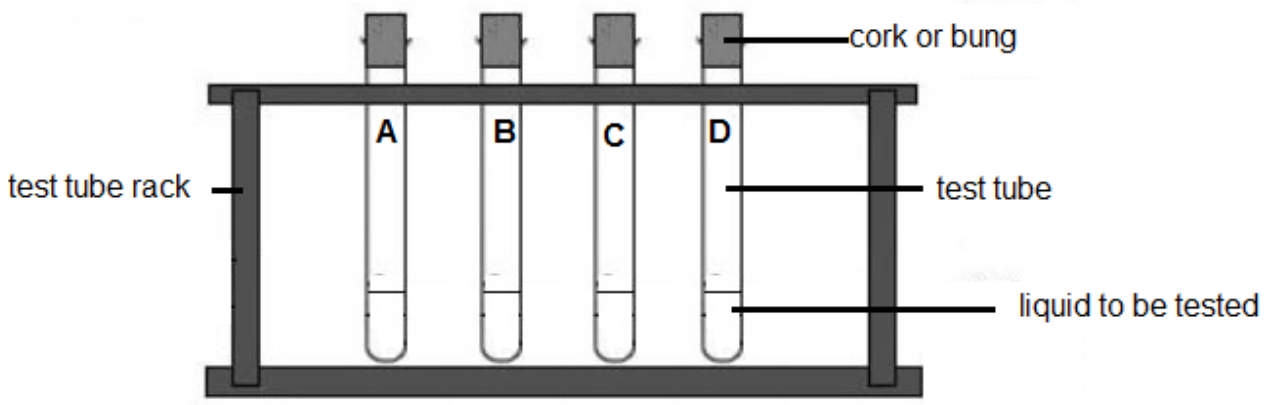
- four test tubes, with stoppers
- marker pen for labelling the test tubes
- a test tube rack
- four unknown liquids, labelled **A**, **B**, **C** and **D**. **TAKE CARE!** These are flammable and toxic.
- dropping pipettes
- a dropping bottle containing bromine water.
- safety goggles
- protective gloves

RISK ASSESSMENT

Safety goggles should be worn throughout.

You should read these instructions carefully before you start work.

1. Put 4 of the test tubes in the test tube rack.
2. Use the marker pen to label the tubes **A**, **B**, **C** and **D**.
3. Use a dropping pipette to put 1 cm^3 of each of the four liquids into the corresponding test tube.
4. Put a cork or bung in each of the tubes.
5. Take each tube in turn to a fume cupboard. Briefly remove the bung and add 5 drops of bromine water.
6. Replace the bung and shake the tube for 5 seconds.
7. Observe whether the orange colour of the bromine water has remained or disappeared.
8. Record your results.



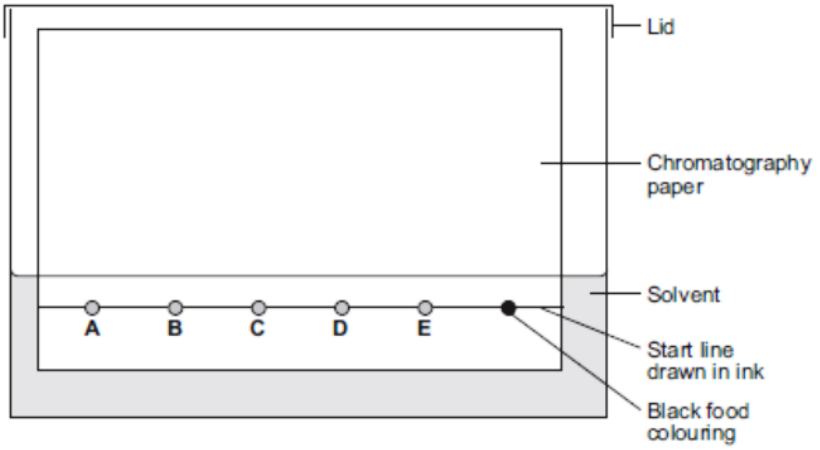
CHEMISTRY PRACTICAL QUESTIONS

1 Chromatography can be used to separate components of a mixture.

A student used paper chromatography to analyse a black food colouring. The student placed spots of known food colours, **A**, **B**, **C**, **D** and **E**, and the black food colouring on a sheet of chromatography paper.

The student sets up the apparatus as shown in **Figure 1**.

Figure 1



The student made **two** errors in setting up the apparatus.

0 1 . 1 Identify the **two** errors and describe the problem each error would cause.

[4 marks]

Error:.....

Problem:.....

.....

.....

Error:.....

Problem:.....

.....

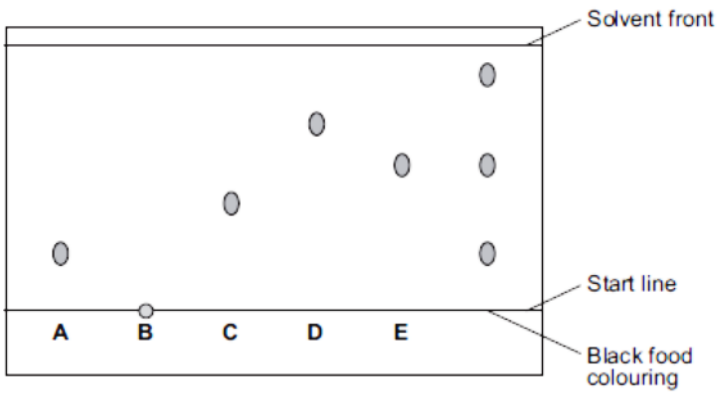
.....

.....

A different student set up the apparatus without making any errors.

The chromatogram in **Figure 2** shows the student's results.

Figure 2



0 1 . 2 What do the results tell you about the composition of the black food colouring?

[2 marks]

0 1 . 3 Take measurements from **Figure 2** to complete **Table 1**.

[2 marks]

Table 1

	Distance in mm
Distance from start line to solvent front	.....
Distance moved by food colour **C**	.....

0 1 . 4 Use your answers in part **2.3** to calculate the Rf value for food colour **C**.

[1 mark]

Rf value = _____

Table 2 gives the results of chromatography experiments that were carried out on some known food colours, using the same solvent as the students.

Table 2

Name of food colour	Distance from start line to solvent front in mm	Distance moved by food colour in mm	R_f value
Ponceau 4R	62	59	0.95
Carmoisine	74	45	0.61
Fast red	67	27	0.40
Erythrosine	58	17	0.29

0 1 . 5 Which of the food colours in **Table 2** could be food colour **C** from the chromatogram?

[1 mark]

Question	Answers	Extra information	Mark
01.1	start line drawn in ink		1
	(so) line would run		1
	start line below solvent level		1
	(so) samples would wash off		1
01.2	it is made up of two other colours present on the chromatogram		1
	A and E		1
01.3	distance from start line to solvent front 44 ±1		1
	distance moved by C 13 ±1		1
01.4	0.27 to 0.33		1
01.5	Erythrosine		1

2 A student had a colourless solution.

The student thought the solution was dilute hydrochloric acid.

The student added universal indicator to this solution.

0 2 . 1 What colour would the universal indicator change to if the solution is hydrochloric acid?

[1 mark]

_____

0 2 . 2 Describe how the student could show that there are chloride ions in this solution.

[2 marks]

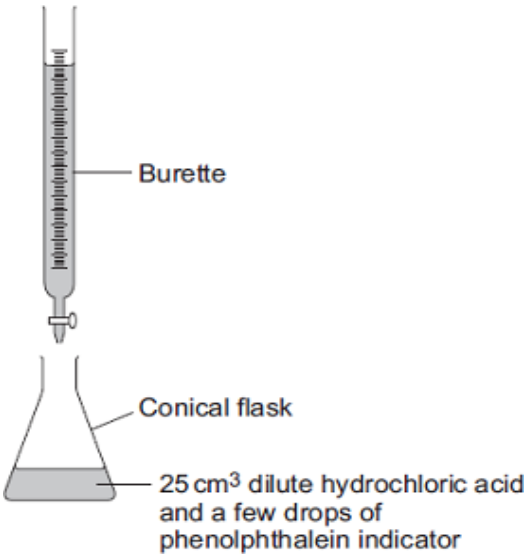
_____

_____

_____

_____

The results of a titration can be used to find the concentration of an acid.



0 2 . 3 Describe how to use the apparatus to do a titration using 25 cm^3 of dilute hydrochloric acid.

In your answer you should include:

- how you will determine the end point of the titration
- how you will make sure the result obtained is accurate.

[4 marks]

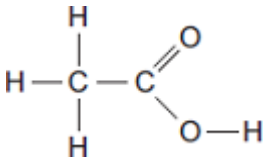
0 2 . 4 Hydrochloric acid is a strong acid.

Ethanoic acid is a *weak acid.*

What is meant by the term *weak acid*?

[1 mark]

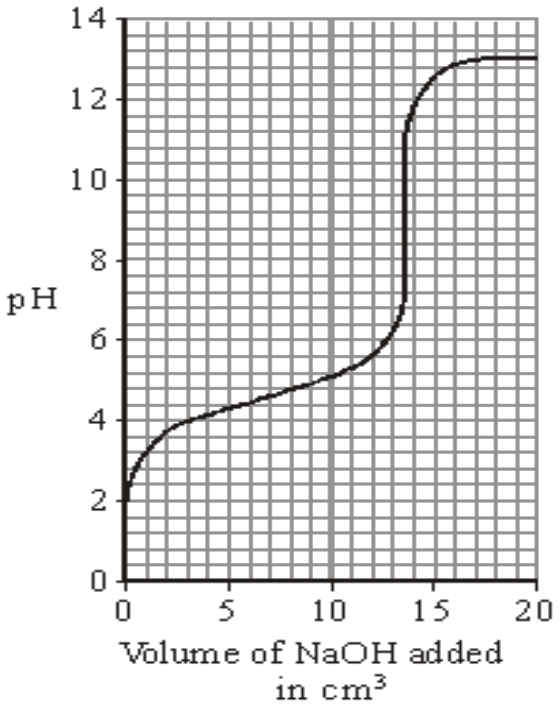
The displayed formula of ethanoic acid is:



0 2 . 5 On the formula, draw a circle around the functional group in ethanoic acid.

[1 mark]

The graph shows how the pH of the solution changes during a titration between a weak acid and sodium hydroxide.



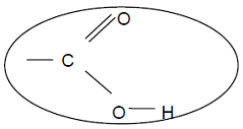
0 2 . 6 A student has two indicators:

Phenolphthalein changes colour between pH 8.2 and pH 10.0.

Methyl orange changes colour between pH 3.2 and pH 4.4.

Suggest why she chose phenolphthalein to use in this titration.

[1 mark]

Question	Answers	Extra information	Mark
02.1	red	ignore pink	1
02.2	add silver nitrate (solution) white precipitate	ignore addition of another acid	1 1
02.3	suitable named alkali / sodium hydroxide solution in burette add alkali solution until (indicator) becomes pink / red any **two** from: • wash / rinse equipment • add dropwise or slowly (near end point) • swirl / mix • read (meniscus) at eye level • white background • read start and final burette levels / calculate the volume needed • repeat		1 1 2
02.4	does not ionize / dissociate completely	allow <u>for acids of the same concentration</u>, weak acids have a higher pH or fewer hydrogen ions	1
02.5	Ring around COOH 		1
02.6	(methyl orange) would have changed colour (well) before the end-point / pH7 / neutral Phenolpthalein changes colour when the acid is neutralised		1 1

3 A student is investigating electroplating of metal objects. She wants to test the hypothesis
'The mass of metal deposited depends on the time the current is flowing.'

This is the student's method:

1. Take a metal object and measure its mass
2. Connect the object to a negative pole of a battery
3. Dip in a solution of copper sulfate
4. Let the electricity flow for 1 minute
5. Remove the metal object from the solution and measure its mass
6. Put the electrode back in the copper sulphate solution. Reconnect the metal object to the battery and let the electricity flow for a further minute
7. Repeat steps 5 and 6 for a further 5 times

0 3 . 1 The student has made no notes about which variable she would need to control.

Give two variables that the student should control to make this a fair test.

[2 marks]

1. _____

2. _____

The student collected the following results

Time, in minutes	Increase in mass of object, in grams
1	2.4
2	3.4
3	4.2
4	4.7
5	4.9
6	4.9
7	4.9

0 3 . 2 Draw a sketch graph of the student's results on the axes below.

[2 marks]

0 3 . 3 Describe the student's results and explain whether or not the results support the student's hypothesis that 'The mass of metal deposited depends on the time the current is flowing.'

[2 marks]

0 3 . 4 Describe two ways the student's method could be improved to make the results more accurate.

[2 marks]

0 3 . 5 When doing a similar investigation another student noticed the reading on the balance was 0.11 g when nothing was on it.

Describe **two** ways the student could overcome this error.

[2 marks]

Question	Answers	Extra information	Mark
03.1	any **two** from: • concentration of copper sulfate • volume of copper sulphate • area/size/length of metal object submerged • current/voltage of electricity supply or same battery		2
03.2	correctly labeled axes correct profile of graph – The line should slope from bottom left to top right and level off 1	time must be on x axis	1 1
03.3	as time increases for first five minutes the mass deposited increases after 5 minutes the mass no longer increases		1 1
03.4	any **two** from: • dry electrodes before weighing • dip electrodes in propanone • increase resolution of balance • change battery for power pack • simultaneously starting the current flow and stopwatch		2
03.5	any **two** from: zero the balance then repeat the readings subtract 0.11g from the readings obtained change balance for one reading		2

4 Magnesium reacts with dilute sulfuric acid in a reaction that makes hydrogen gas.

magnesium + sulfuric acid → magnesium sulfate + hydrogen

Mg + 1 → 2 + 3

0 4 . 1 Which are the correct formulae for the missing substances in the equation above?

[1 mark]

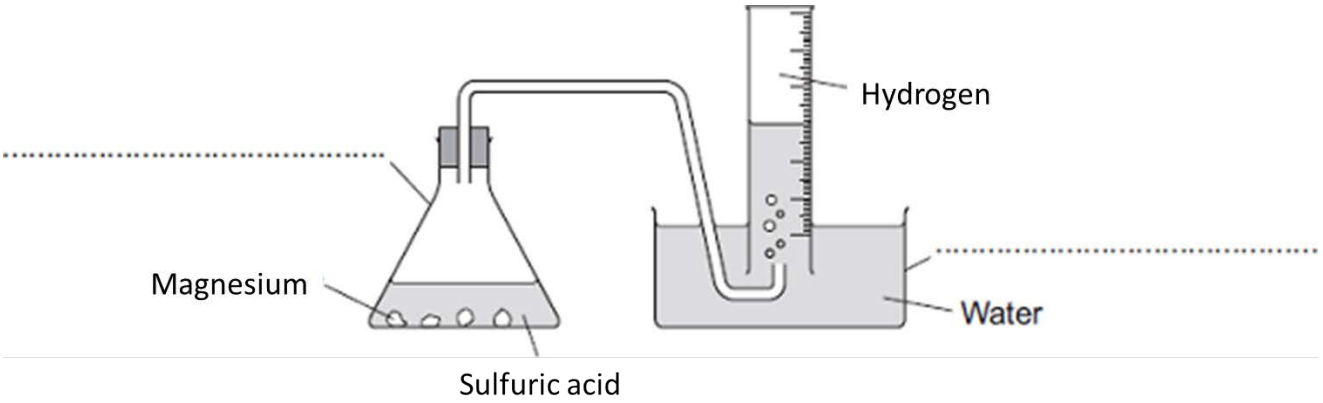
	1	**2**	**3**
A	H_2SO_3	$MgSO_3$	H_2
B	H_2SO_4	$MgSO_4$	2H
C	HSO_4	$MgSO_4$	H
D	H_2SO_4	$MgSO_4$	H_2

Answer: ……..

A student wanted to investigate the rate of this reaction.

He added an unknown mass of magnesium to an excess of sulfuric acid.

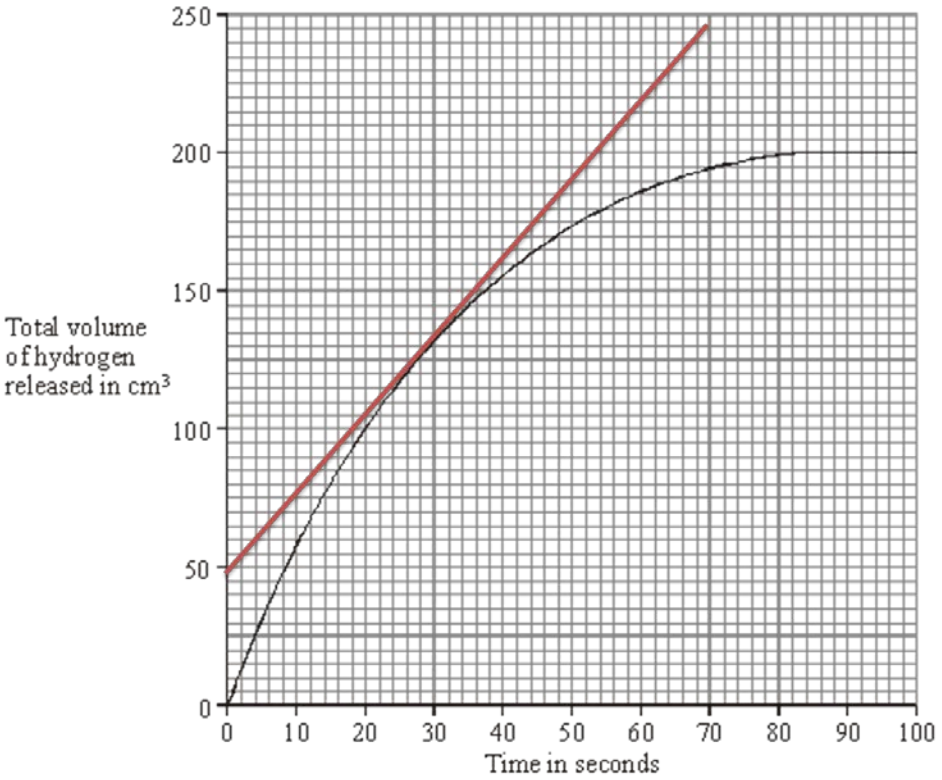
He measured the volume of hydrogen given off every 10 seconds using the apparatus shown below:



0 4 . 2 Complete the **two** labels for the apparatus on the diagram.

[2 marks]

The student's results are shown on the graph.



0 4 . 3 The rate of reaction can be calculated from the gradient of the tangent to the line of best fit through the data.

Calculate from the tangent shown on the graph the rate of reaction at 30 seconds. Give your answer to 2 decimal places.

[2 marks]

Rate ..... cm^3/s

0 4 . 4 Write down the rate of reaction at a time of 90 seconds.

[1 mark]

Rate ..... cm^3/s

0 4 . 5 Calculate the number of moles of hydrogen produced by the reaction at completion.

1 mole of a gas occupies 24,000 cm^3

[2 marks]

volume ..... cm^3

0 4 . 6 Calculate the mass of magnesium used in the experiment using your answer to question 8.5. Give your answer to 2 significant figures.

[2 marks]

Question	Answers	Extra information	Mark
04.1	D		1
04.2	(conical) flask trough / water bath / beaker		1 1
04.3	(250-50) / 70 = 2.86 Answer to 1 or 2 d.p.		1 1
04.4	zero / 0		1
04.5	200/24000 $=8.3x10^{-3}$ / 0.0083		1 1
04.6	0.0083 x 24 = 0.20 answer to 2 sf		1 1

PHYSICS REQUIRED PRACTICALS

Investigate the relationship between force and extension for a spring.	Physics 3.1.1 Combined 3.17.1
Investigate the reflection of light by different types of surface and the refraction of light by different substances.	Physics 3.3.5 Combined 3.19.1
Investigating the cooling curve of stearic acid.	Physics 3.4.1
Investigating the V – I characteristics of a filament lamp, a diode and a resistor at constant temperature.	Physics 3.5.1
Investigate the factors that determine the strength of an electromagnet.	Physics 3.5.2 Combined 3.21.2

PHYSICS REQUIRED PRACTICAL: FORCE AND EXTENSION

TEACHERS' NOTES

Required practical activity	Specification reference
Investigate the relationship between force and extension for a spring.	Physics 3.1.1 Combined 3.17.1

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.

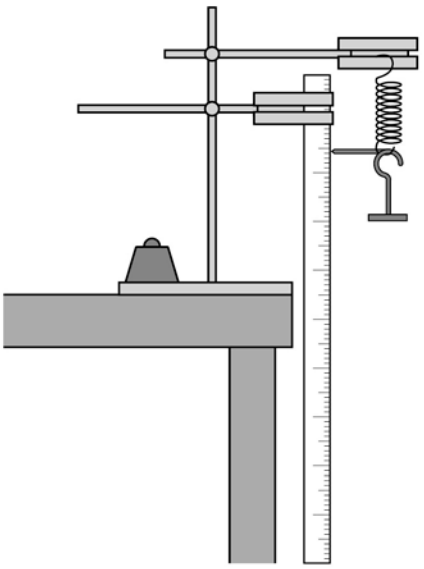
Students may need to be told how to convert the mass (in grammes) written on the weight stack into a weight in newtons. (Using the equation W = mg, 100 g has a weight of 1 N). This practical can be used to emphasise the difference between mass and weight.

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.

PHYSICS REQUIRED PRACTICAL: FORCE AND EXTENSION

STUDENT SHEET

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**

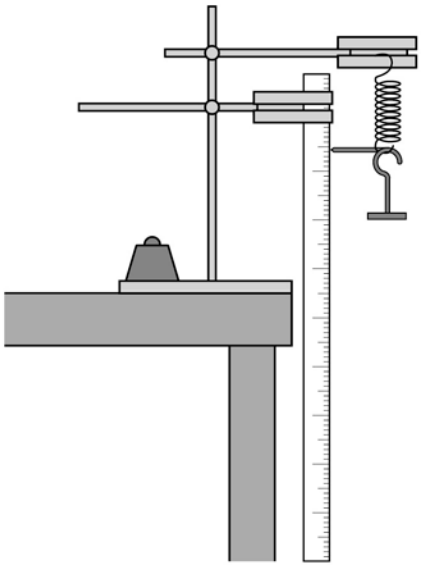
METHOD

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.

PHYSICS REQUIRED PRACTICAL: LIGHT

TEACHERS' NOTES

Required practical activity	Specification reference
Investigate the refraction of light by different substances.	Physics 3.3.5 Combined 3.19.1

What happens to the direction of light as it passes through different materials?

MATERIALS

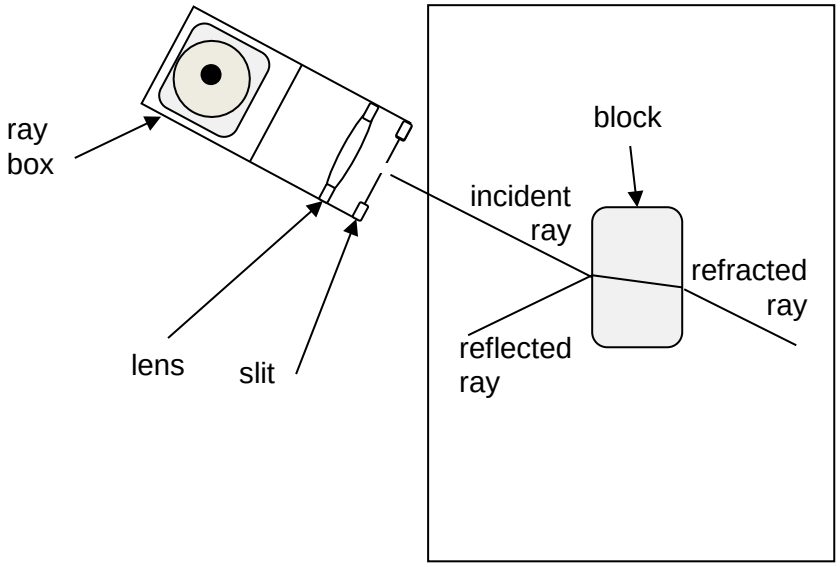
In addition to access to general laboratory equipment, each student needs:

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

TECHNICAL INFORMATION

In this experiment, students trace the path of light refracted through blocks of different materials. They will use a ray box to produce a narrow ray of light. They will compare the light refracted by 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 refracted rays will be faint. The experiment will have to be carried out in low light conditions.



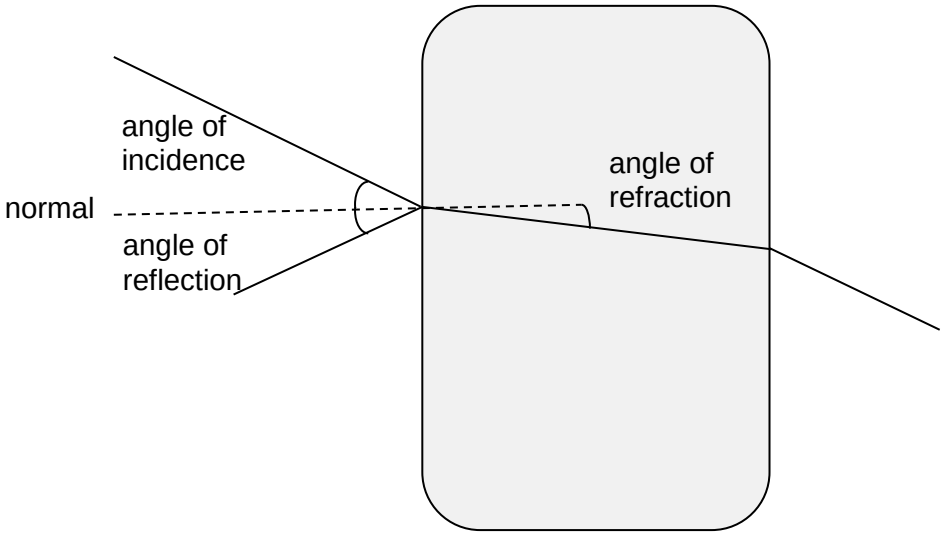
ADDITIONAL INFORMATION

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 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 refraction.

A graph can be drawn of the sine of the angle of incidence, sin (***i***) against the sine of the angle of refraction, sin (***r***). This is a straight line. The gradient of this line is the refraction index, *n* for the material.



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.

PHYSICS REQUIRED PRACTICAL: LIGHT

STUDENT SHEET

What happens to the direction of light as it passes through different materials?

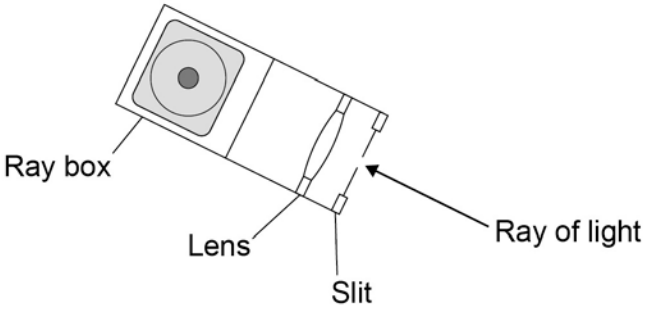
When light hits a surface it can be reflected, transmitted (refracted) and absorbed. In this experiment, you will investigate what happens to light when it is refracted by two different materials.
You will use a ray box to direct a ray of light onto the surface of a transparent block. You will then mark the path of the ray that 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**

METHOD

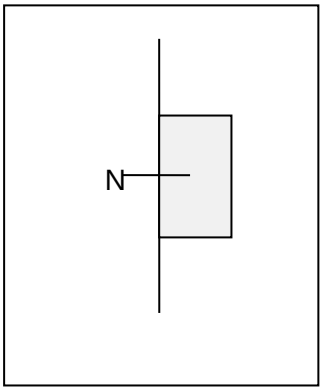
You are provided with the following:

- 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 and Perspex
- 30 cm ruler
- protractor
- sheets of plain A3 paper.

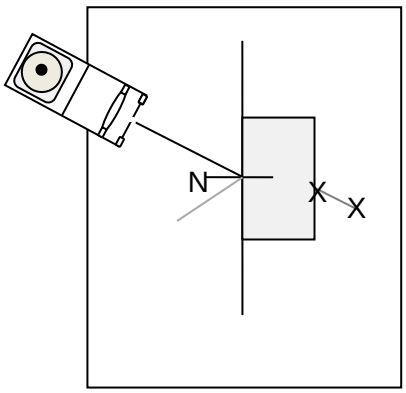


You should read these instructions carefully before you start work

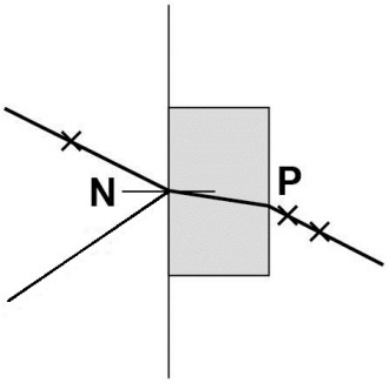
1. Before the room is darkened, set up the ray box, slit and lens so that a narrow ray of light is produced.
2. The ray box will get hot – be careful when you move it and switch it off when you don't need it.
3. Place the ruler near the middle of the A3 paper and draw a straight line parallel to its 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 glass 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 emerging from the opposite side of the block.

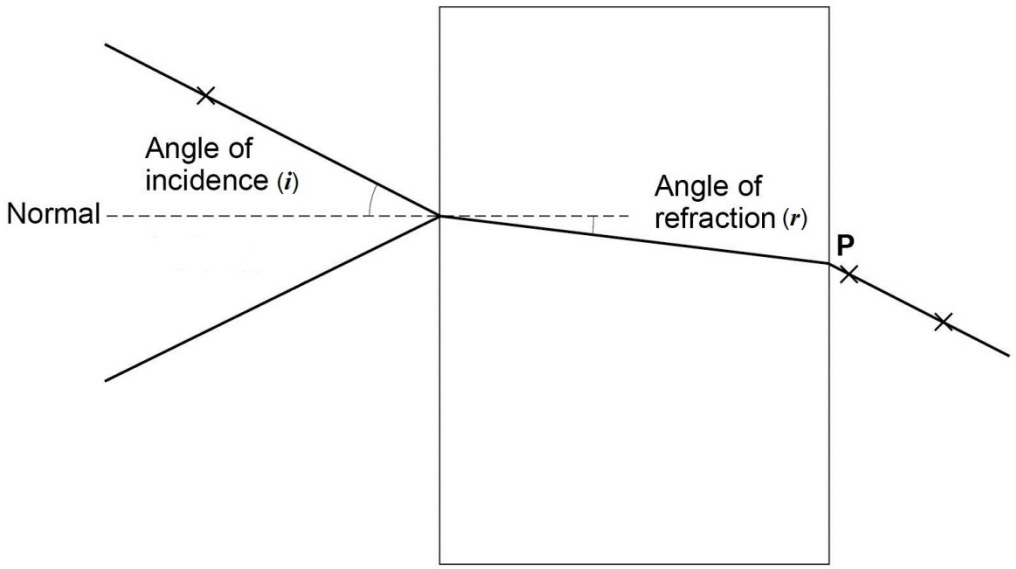


9. Mark the path of the incident ray with a cross. If the ray is wide, make sure the centre of the cross is in the centre of the ray.
10. Mark the path of the ray that leaves the block (the transmitted ray) with two crosses, one near the block and the other further away.
11. Draw the transmitted ray 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’.
12. 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.



13. 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.



14. Repeat the measurements for different angles of incidence. Record your measurements in a suitable table.

Angle of incidence, (*i*) in degrees	**Angle of refraction, (*r*) in degrees**	**sin(*i*)**	**sin(*r*)**

15. Plot a graph of sin(*i*) on the *y*-axis, against sin(*r*) on the *x*-axis.
16. Calculate the gradient of this line. This is the refractive index.
17. Now repeat this process for the Perspex block.

PHYSICS REQUIRED PRACTICAL: COOLING CURVES (P)

TEACHERS' NOTES

Required practical activity	Specification reference
Investigating the cooling curve of stearic acid.	Physics 3.4.1

MATERIALS

In addition to the standard heating equipment of Bunsen burner, tripod, gauze and heat resistant mat, each student needs:

- a boiling tube
- a thermometer (0-100 °C)
- a beaker (250 cm^3)
- a stopwatch
- a stand, boss and clamp
- safety goggles

TECHNICAL INFORMATION

Stearic acid, also called octadecanoic acid, has the formula $CH_3(CH_2)_{16}COOH(s)$. It is a waxy solid at room temperature, with a melting point of approximately 70°C, although impurities will often cause this figure to be lower.

ADDITIONAL INFORMATION

Students will melt the stearic acid by placing a boiling tube containing the stearic acid in a beaker of nearly boiling water. They will then remove the boiling tube from the hot water and record the temperature of the stearic acid at 30 second or one minute intervals until the temperature is close to room temperature.

RISK ASSESSMENT

- Safety goggles should be worn throughout.
- Risk assessment and risk management are the responsibility of the centre.

PHYSICS REQUIRED PRACTICAL: COOLING CURVES (P)

STUDENT SHEET

Investigating the cooling curve of stearic acid.

In this experiment you will record the temperature of a sample of stearic acid as it cools down from about 90 °C. Make a note of the temperature at which you think the stearic acid just starts to solidify.

Learning outcomes
1 **2**

METHOD

You are provided with the following:

- a boiling tube
- a thermometer (0-100 °C)
- a beaker (250 cm^3)
- a stopwatch
- a stand, boss and clamp
- Bunsen burner, tripod and gauze
- safety goggles

RISK ASSESSMENT

Safety goggles must be worn throughout.

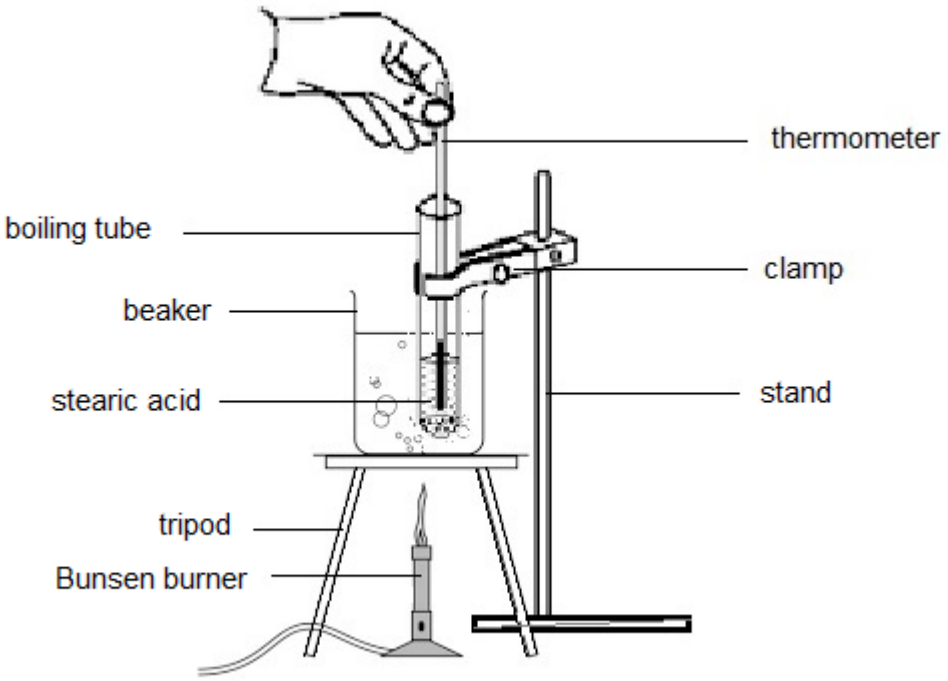
You should read these instructions carefully before you start work.

1. Carefully clamp the boiling tube containing the stearic acid onto the lab stand.
2. Half fill the 250 cm^3 beaker with water, place it on the tripod and gauze, and use the Bunsen burner to bring the water to the boil.
3. When the water is boiling, turn off the Bunsen burner.
4. Now carefully move the stand so that the boiling tube containing the stearic acid is in the hot water in the beaker.
5. When all of the stearic acid has melted (you may need to reheat the water) use the stand to lift the boiling tube out of the water.
6. Place a thermometer in the stearic acid and record the temperature.
7. Continue to record the temperature every 30 seconds until the stearic acid is nearly at room temperature.

8. Plot a graph of your results.

DO NOT attempt to pull the thermometer out of the solidified stearic acid when you have finished.

The diagram shows how to set up the equipment.



PHYSICS REQUIRED PRACTICAL: V-I CHARACTERISTICS (P)

TEACHERS' NOTES

Required practical activity	Specification reference
Investigating the V – I characteristics of a filament lamp, a diode and a resistor at constant temperature.	Physics 3.5.1

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.

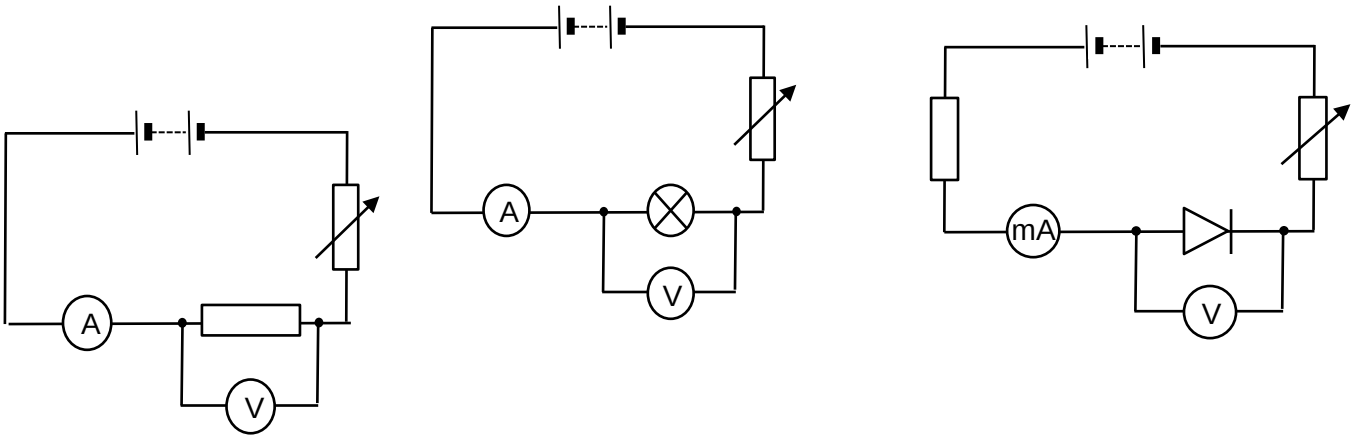
ADDITIONAL INFORMATION

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.

PHYSICS REQUIRED PRACTICAL: V-I CHARACTERISTICS (P)

STUDENT SHEET

Investigating the V – I characteristics of a filament lamp, a diode and a resistor at constant temperature.

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**

METHOD

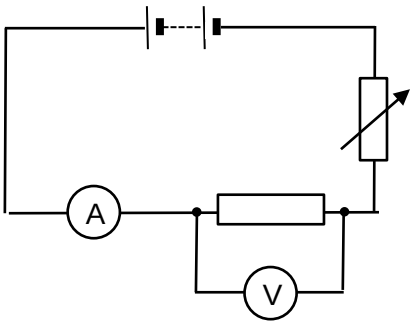
You have access to the following:

- 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 V-I 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.

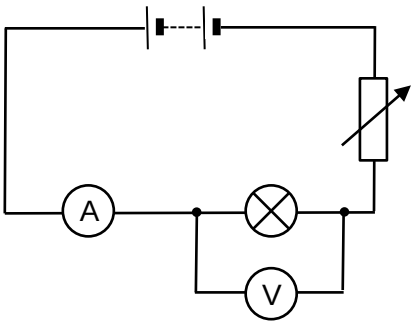


3. Connect a lead from the negative side of the ammeter (this may be black) to one side of the resistor.
4. Connect a lead from the other side of the resistor to the variable resistor.
5. Connect a lead from the other side of the variable resistor to the negative side of the battery. The main loop of 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 V-I 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.

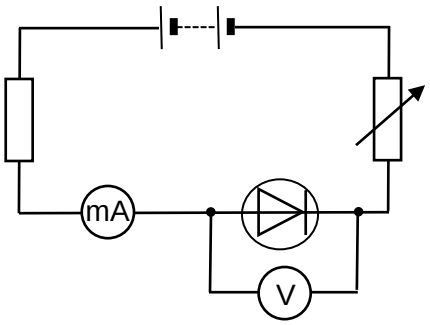


3. The lamp will get hot. Take care not to touch it.
4. Follow the procedure for the resistor, swapping the leads on the battery to obtain negative readings.
5. Plot a graph of current in A against potential difference in V. Again the origin will be in the middle of the paper. Draw a curved line of best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

Activity 3: the V-I 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.

PHYSICS REQUIRED PRACTICAL: ELECTROMAGNETS

TEACHERS' NOTES

Required practical activity	Specification reference
Investigating the factors that determine the strength of an electromagnet.	Physics 3.5.2 Combined 3.21.2

In this experiment you will investigate at least two factors that may affect the strength of an electromagnet.

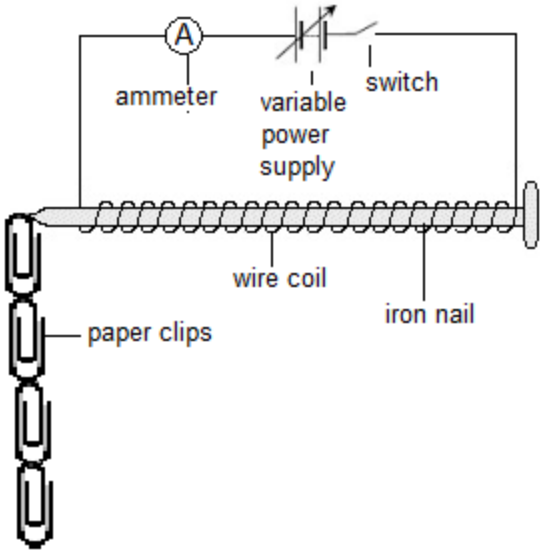
(i) Does the value of the electric current passing through a fixed number of turns on the coil affect the strength of an electromagnet?

(ii) Does the number of turns on the coil, for a fixed value of the current flowing, affect the strength of an electromagnet?

The same basic set-up may be used for both investigations.

MATERIALS

- iron nail (15 cm)
- length of insulated wire
  for investigation **(i)** plastic covered 26 swg wire is suitable
  for investigation **(ii)** enamel coated 36 swg wire is suitable
- variable power supply (0 – 6 volts)
- ammeter
- a supply of paper clips
- connecting leads with plugs
- a switch
- crocodile clips
- stand, boss and clamp
- access to a top pan balance



TECHNICAL INFORMATION

The nail should be made of soft iron and not steel. Steel will retain its magnetism when the current is switched off, but soft iron will not.

RISK ASSESSMENT

- Risk assessment and risk management are the responsibility of the school or college.
- Care should be taken to ensure that the coil does not overheat.
- Safety goggles should be used if iron filings are used rather than paper clips.

TRIALLING

The practical should be trialled before use with students

PHYSICS REQUIRED PRACTICAL: ELECTROMAGNETS

STUDENT SHEET

Investigate the factors that determine the strength of an electromagnet.

In this experiment you will investigate at least two factors that may affect the strength of an electromagnet.

(i) Does the value of the electric current passing through a fixed number of turns on the coil affect the strength of an electromagnet?

Learning outcomes
1
2

METHOD

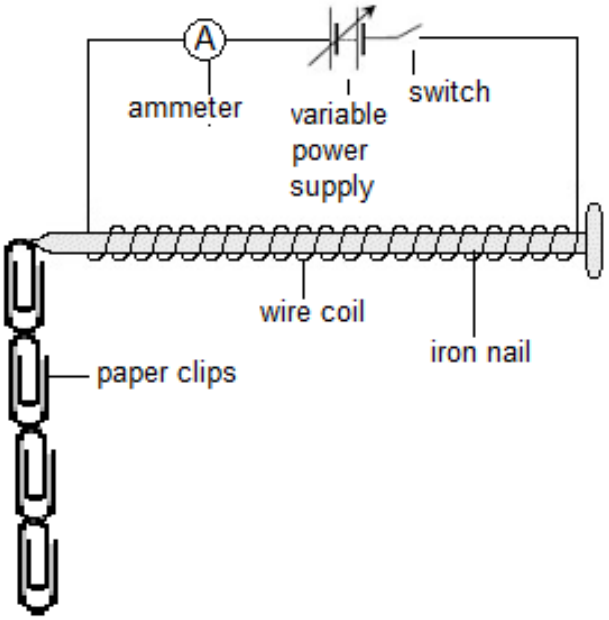
You are provided with the following:

- iron nail (15 cm)
- length of insulated wire (2 m)
- variable power supply (0 – 6 volts)
- ammeter
- a supply of paper clips
- connecting leads with plugs
- a switch
- crocodile clips
- stand, boss and clamp
- access to a top pan balance

You should read these instructions carefully before you start work.

1. Remove the insulation from the two ends of the insulated wire.
2. Wind about half of the wire into coils around the iron nail. Remember to leave enough wire at each end to connect to the rest of the circuit.
3. Attach crocodile clips to the ends of the coiled wire.
4. Support the nail with the coil of wire around it in the stand and clamp.
5. Use the leads with plugs to connect the rest of the circuit, as shown in the diagram.
6. Set the variable power supply to zero and close the switch in the circuit.
7. Switch on the power supply, and gradually increase the voltage until there is just enough current flowing to support one paper clip.
8. Record the value of the current.
9. Now increase the current until it will just support two paper clips. Make sure that the paper clips are supported end to end (as in the diagram) and not side by side.
10. Again record the current.
11. Repeat this for up to 6 paper clips, **BUT** take care that the coil of wire does not get too hot. If it does, switch off immediately.
12. Plot a graph of the number of paper clips supported against the current needed to support them.
13. You may wish to measure the mass of one of the paper clips using the balance, and instead plot a graph of mass supported against current.

The diagram shows how to set up the equipment.



(ii) Does the number of turns on the coil, for a fixed value of the current flowing, affect the strength of an electromagnet?

Learning outcomes
1 **2**

METHOD

You are provided with the following:

- iron nail (15 cm)
- length of insulated wire (enamel coated, 36 swg)
- variable power supply (0 – 6 volts)
- ammeter
- a supply of paper clips
- connecting leads with plugs
- a switch
- crocodile clips
- stand, boss and clamp
- access to a top pan balance

You should read these instructions carefully before you start work.

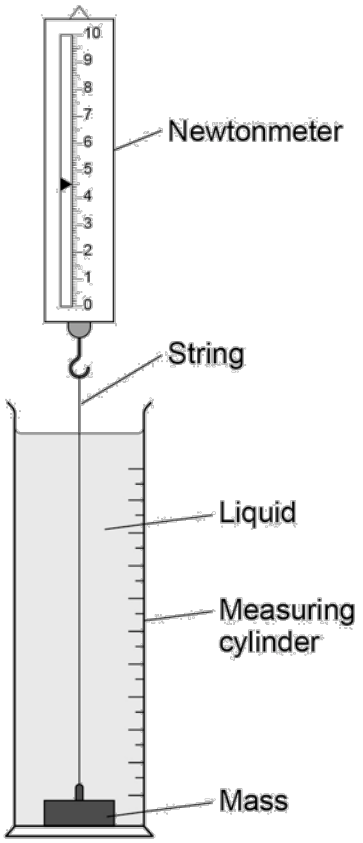
1. Wind 50 turns of the wire into coils around the iron nail. Remember to leave enough wire at each end to connect to the rest of the circuit.
2. Remove the insulation from the two ends of the insulated wire by scratching off the enamel coating.
3. Attach crocodile clips to the ends of the coiled wire.
4. Support the nail with the coil of wire around it in the stand and clamp.
5. Use the leads with plugs to connect the rest of the circuit, as shown in the diagram.
6. Set the variable power supply to zero and close the switch in the circuit.
7. Switch on the power supply, and gradually increase the voltage until there is just enough current flowing to support one paper clip.
8. Record the value of the current.
9. Now wind 100 turns of the wire on to the nail.
10. Adjust the power supply so that the current is the same as before.
11. Record how many paper clips the electromagnet can now support. Make sure that the paper clips are supported end to end (as in the diagram) and not side by side.
12. Repeat this for 150 and 200 turns, **BUT** take care that the coil of wire does not get too hot. If it does, switch off immediately.
13. Plot a graph of the number of paper clips supported against the number of turns on the coil.
14. You may wish to measure the mass of one of the paper clips using the balance, and instead plot a graph of mass supported against current.

PHYSICS PRACTICAL QUESTIONS

1 A student investigated the force needed to raise a mass through different liquids at a constant speed.

She set up the apparatus shown in **Figure 1**

Figure 1



1.1 In the investigation there are several variables.

Draw **one** line from each variable to the correct description for this investigation.

[3 marks]

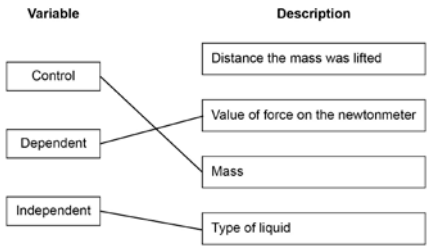
Variable	Description
Control	Distance the mass was lifted
Dependent	Value of force on the newtonmeter
Independent	Mass
	Type of liquid

1.2 What was the resolution of the newtonmeter?

[1 mark]

Tick one box.

- 0.1 N ☐
- 0.5 N ☐
- 1 N ☐
- 10 N ☐

Question	Answers	Extra information	Mark
01.1		allow **one** mark for each correct line if more than one line is drawn from any variable then all of those lines are wrong	1 1 1
01.2	0.1 N	if more than **one** box ticked apply list principle	1

2 A student investigated the strength of different fridge magnets by putting small sheets of paper between each magnet and the fridge door.

The student measured the maximum number of sheets of paper that each magnet was able to hold in place.

2.1 Why was it important that each small sheet of paper had the same thickness?

[1 mark]

2.2 Before starting the investigation the student wrote the following hypothesis:

'The bigger the area of a fridge magnet the stronger the magnet will be.'

The student's results are given in **Table 1**.

Table 1

Fridge magnet	**Area of magnet in mm^2**	**Number of sheets of paper held**
A	40	20
B	110	16
C	250	6
D	340	8
E	1350	4

Give one reason why the results from the investigation do not support the student's hypothesis.

[1 mark]

Question	Answers	Extra information	Mark
02.1	so the results for each magnet can be compared **or** so there is only one independent variable	fair test is insufficient allow different thickness of paper would affect number of sheets each magnet could hold accept it is a control variable	1
02.2	because the magnet with the biggest area was not the strongest	accept any correct reason that confirms the hypothesis is wrong eg smallest magnet holds more sheets than the largest	1

3 A teacher demonstrated an experiment to measure the count rate of a radioactive source.

Figure 2 shows how the teacher set up the apparatus.

Figure 2

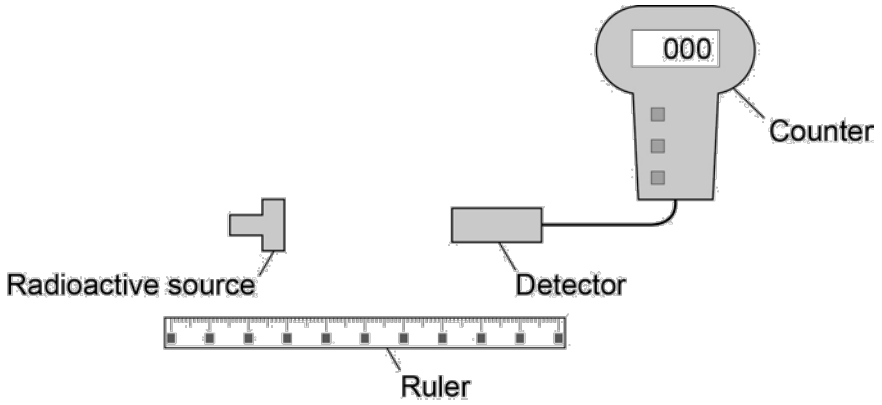


Table 2 shows the results.

Table 2

Distance in metres	Count rate in counts per minute
0.5	108
1.0	38
1.5	23
2.0	18

3.1 Suggest how the student could modify the experiment to determine the radiation type present in the source.

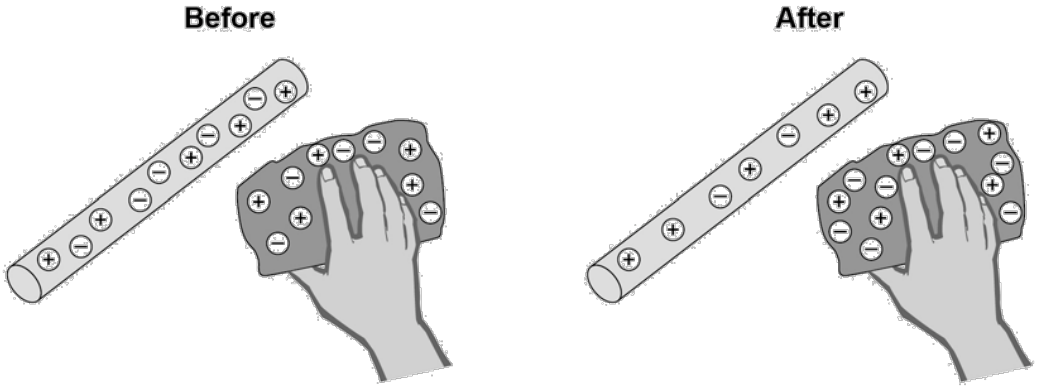
[4 marks]

Question	Answers	Extra information	Mark
03.1	put different substances in between the source and the detector		1
	if the count decreases substantially when a sheet of paper is used, the radiation contains alpha radiation		1
	if the count decreases substantially when a sheet of paper is used, the radiation contains beta radiation		1
	if the count only decreases substantially when a sheet of lead is used, the radiation contains gamma radiation		1

4 A student rubs an acetate rod with a cloth.

Figure 3 shows the charges on the acetate rod and cloth before and after rubbing.

Figure 3



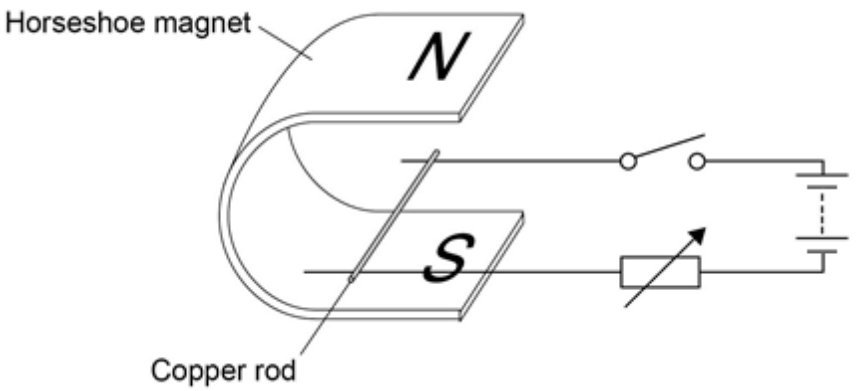
4.1 Explain how rubbing an acetate rod with a cloth causes the rod and cloth to become charged.

[4 marks]

Question	Answers	Extra information	Mark
04.1	**Level 2:** A detailed and coherent explanation is provided. The student makes logical links between clearly identified, relevant points.	3–4	4
	Level 1: Simple statements are made, but not precisely. The logic is unclear.	1–2	
	No relevant content	0	
	Indicative content • friction (between cloth and rod) causes • electrons (to) move • from the acetate rod **or** to the cloth • (net) charge on cloth is now negative • (net) charge on rod is now positive		

5 A teacher used the equipment shown in **Figure 4.**

Figure 4



5.1 When the power supply was turned on, the copper rod moved.

Name the effect demonstrated**.**

[1 mark]

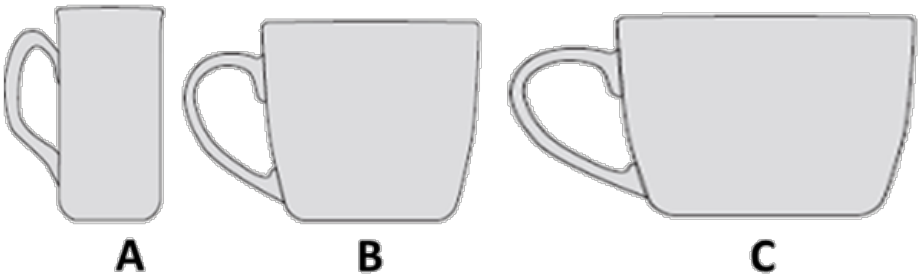
5.2 Describe how Fleming's left-hand rule can be used to determine the direction in which the rod will move when the switch is closed.

[4 marks]

Question	Answers	Extra information	Mark
05.1	the motor effect		1
05.2	thumb, index finger and third finger are held mutually at right angles		1
	index finger shows the direction of the magnetic field from North to South, third finger shows the direction of the current from positive to negative terminal		1
	the thumb then shows the direction of the force acting on the copper rod		1
	so the copper rod will move from down to up		1

6 The diagram shows three cups.

A student would like to investigate the rate of heat energy loss when each cup is filled with hot water.



6.1 Write a method to perform this investigation.

Include

- An equipment list
- What is the independent variable
- What is the dependent variable
- What variables you need to control
- What you will need to measure
- Safety issues

[6 marks]

6.2 Complete the **headings** in the table of results to collect this data.

[2 marks]

6.3 The table of results above does not allow any room to take repeat readings.

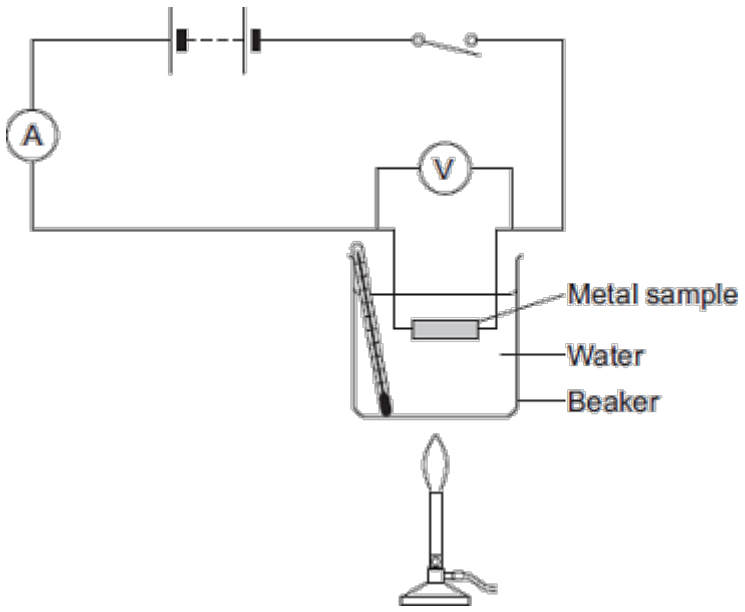
Suggest two reasons why it is always a good idea to repeat your experiment.

[2 marks]

Question	Answers	Extra information	Mark
06.1	Equipment to carry out the experiment. Measuring cylinder or way to measure the same amount of water Stop watch Thermometer Cups		1
	Independent variable – Cup		1
	Dependent variable – <u>Temperature change</u>		1
	<u>Any 2</u> The time the cups are left to cool Volume of water Starting temperature Temperature of the room All the cup need to be made of the same material All the cup need to be the same colour		1
	<u>All 3</u> Volume of water Initial temperature and final temperature Time the cups cool.		1
	Hot water may scald / burn		1
06.2	Table with heading of Time and Temperature change		1
	Units of time (s) or (min) Units of temperature (^{O}C) or (K)		1
06.3	Spot anomalous results		1
	Take a mean of results to make the experiment more accurate.		1

7. When some metals are heated the resistance of the metal changes.

The equipment for investigating how the resistance of a metal changes when it is heated is shown in the diagram.



7.1 Describe an investigation a student could do to find how the resistance of a metal sample varies with temperature. The student uses the equipment shown.

Include in your answer:

- how the student should use the equipment
- the measurements the student should make
- how the student should use these measurements to determine the resistance
- how to make sure the results are valid.

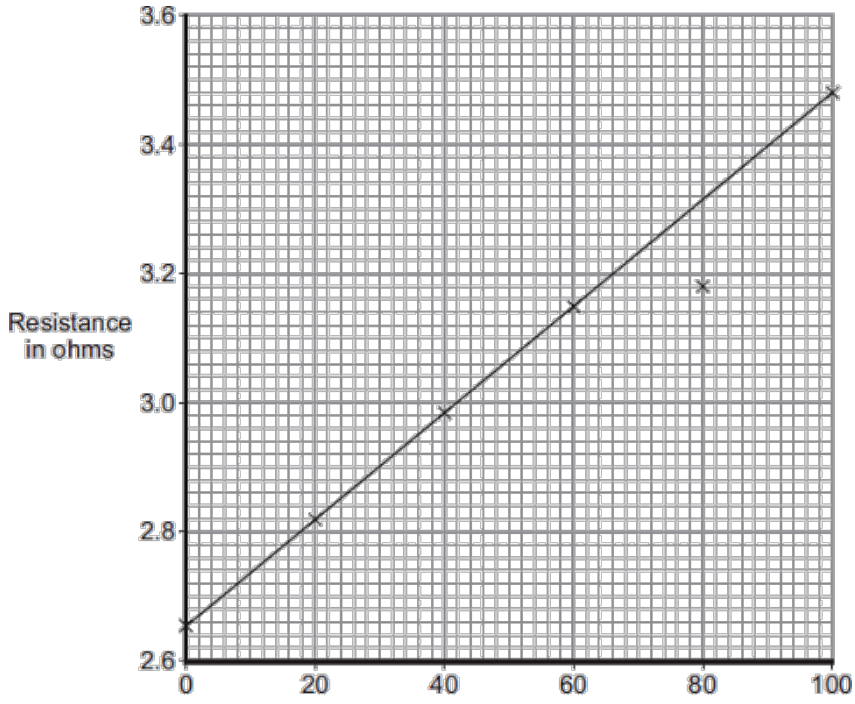
[6 marks]

7.2 The table shows some data for samples of four metals P, Q, R and S.

The metal samples all had the same cross-sectional area and were the same length.

Metal sample	Resistance at 0°C in ohms	Resistance at 100°C in ohms
P	4.05	5.67
Q	2.65	3.48
R	6.0	9.17
S	1.70	2.23

A graph of the results for one of the metal samples is shown



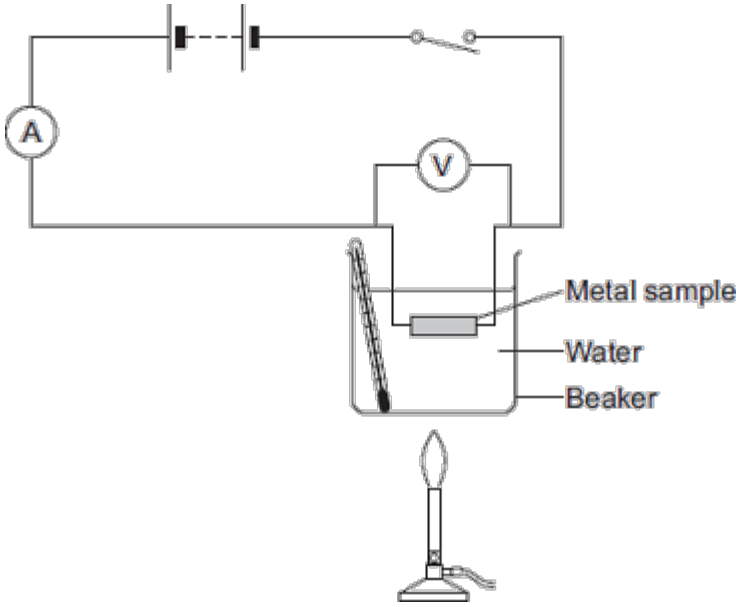
Which metal sample, **P**, **Q**, **R** or **S**, has the data shown in the graph?

[1 mark]

7.3 One of the results is anomalous. Suggest a reason for the anomalous result.

[1 mark]

7.4 The same equipment used in the investigation could be used as a thermometer known as a 'resistance thermometer.'



Suggest **two** disadvantages of using this equipment as a thermometer compared to a liquid-in-glass thermometer.

[2 marks]

1.

2.

Question	Answers	Extra information	Mark
07.1	**Level 3:** There is a detailed description of the method which would lead to valid results. To gain full marks an answer including graph, or another appropriate representation of results, must be given.		5–6
	Level 2: There is a description of the method which is almost complete with a few minor omissions and would lead to some results.		3–4
	Level 1: There is a basic description of the method. This is incomplete and would not lead to any useful results.		1–2
	No relevant content		0
	Indicative content • read V and I • read temperature • apply heat • read V and I at least one other temperature • determine R from V / I • range of temperatures above 50 °C • use thermometer to read temperature at regular intervals of temperature • remove source of heat and stir before taking readings • details of attaining 0 °C or 100 °C • last reading taken while boiling • graph of R against T • at least 3 different temperatures		
07.2	Q		1
07.3	any **one** from: • measurement of V too small • measurement of I too big • incorrect calculation of R • thermometer misread	*allow misread meter* *ignore any references to an error that is systematic*	1
07.4	any **two** from: • not portable • needs an electrical supply • cannot be read directly	*allow requires a lot of equipment* *accept it is more difficult to read compared to liquid-in-glass*	2

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You can contact the English subject team directly at:

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