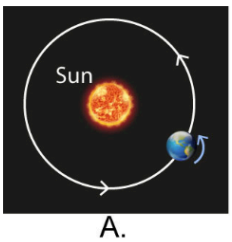
Question 1 (12 marks)

Question 1a (1 mark)

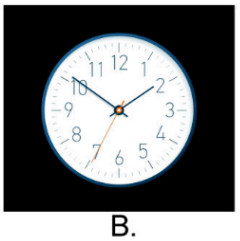
Regular, repeating movement can be described as periodic motion.

Select the image that does **not** show periodic movement.

Select

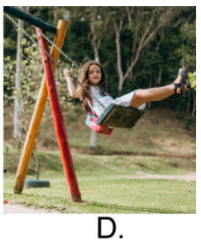


A.



B.

C.



D.

1b Video link: Q.1b.mp4

Select the option that describes the energy and speed of the pendulum at positions A, B and C.

	Kinetic energy	Potential energy	Speed
Position A	Select	Select	Select
Position B	Select	Select	Select
Position C	Select	Select	Select

Question 1c (3 marks)

A pendulum can be used to determine the acceleration due to gravity, g.

The period T of a pendulum is the time taken to complete one swing. T depends on the length of the pendulum, L and g. It is given by the relationship:

$$T^2 = 4\pi^2 \frac{L}{g}$$

The value of g varies with location on the Earth's surface. A pendulum used in a laboratory in Canada has a length of 72.5 cm. The time taken for 10 periods is measured to be 17.1 s.

Calculate the acceleration due to gravity in $m\,s^{-2}$ in this laboratory, giving your answer to three significant figures.

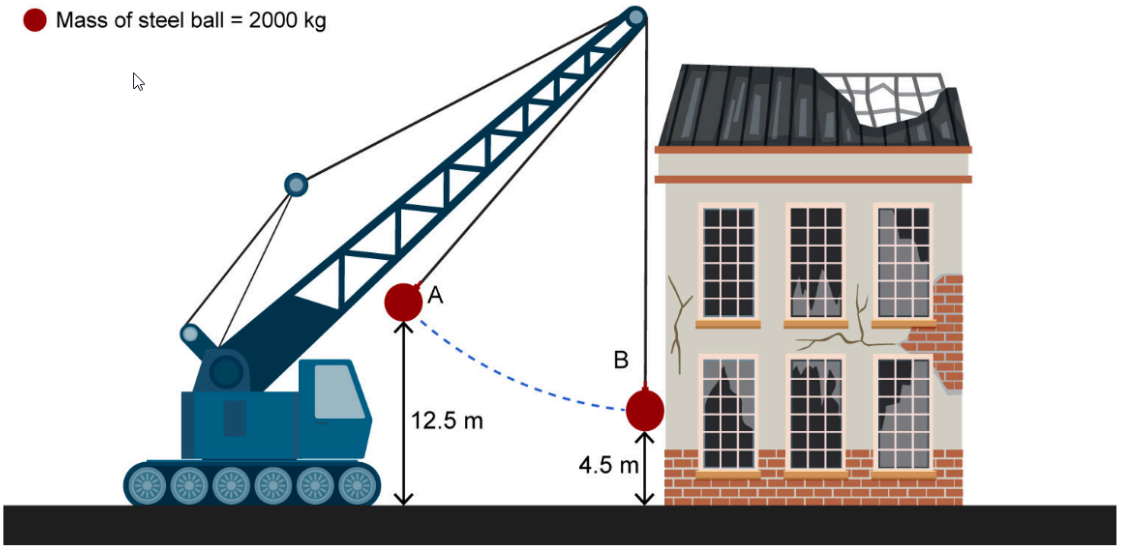
Question 1d (1 mark)

The expected value of acceleration due to gravity at this location is 9.82 m s^{-2}. **Suggest** why the experimental value in part (c) is different.

Question 1e (4 marks)

A wrecking ball is an example of a pendulum that can be used to demolish buildings. It is a very heavy steel ball hanging from a crane, which is released and swung to hit the structure.

Diagram not to scale



Initially, the ball is stationary. The crane operator releases the ball from a height of 12.5 m.

Calculate the kinetic energy of the ball when it hits the building at 4.5 m above the ground. You should assume that the acceleration due to gravity, g = 9.81 m s^{-2}. Give your result in kJ rounded to two significant figures.

Question 1f (1 mark)

Suggest why the real-world kinetic energy of the wrecking ball would be lower than the calculated value.

Question 2 (12 marks)

Smoke detectors are devices that sound an alarm when smoke enters them. The sound of the alarm warns people to take action in the event of a fire. Some smoke detectors use the properties of radiation to detect smoke.

Question 2a (2 marks)

Outline why smoke detectors are installed on the ceiling in a house instead of on the walls or floor.

Question 2b (2 marks)

Some smoke detectors use a small amount of a radioactive isotope, americium-241. Americium-241 emits alpha particles. **State** two properties of alpha particles.

Question 2c (1 mark)

Select the equation that represents the radioactive decay of americium-241 in a smoke detector:

A. $^{241}_{95}Am \rightarrow {}^{237}_{93}Np + {}^{4}_{2}\alpha$

B. $^{241}_{95}Am + {}^{4}_{2}\alpha \rightarrow {}^{237}_{93}Np$

C. $^{241}_{95}Am \rightarrow {}^{234}_{91}Pa + {}^{4}_{2}\alpha$

D. $^{241}_{95}Am \rightarrow {}^{237}_{93}Np + {}^{0}_{-1}\beta$

Question 2d (2 marks)

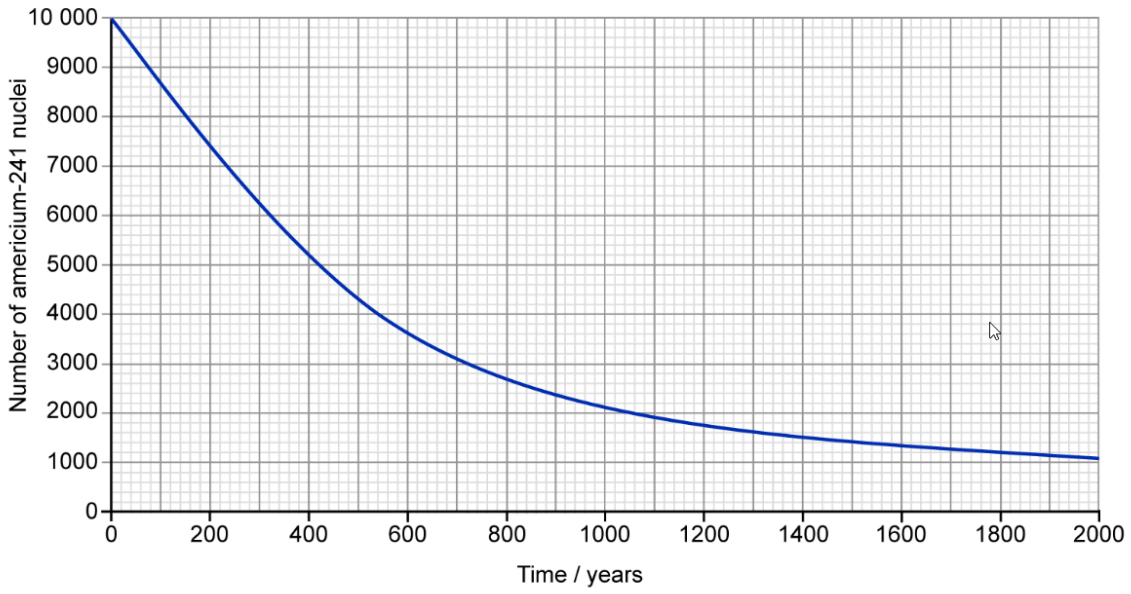
Americium-241 is an isotope of americium. **Select** which of the following is **not** an isotope of americium-241. Use scientific terminology to **justify** your answer.

$^{243}_{95}Am$	$^{240}_{93}Am$	$^{242}_{95}Am$	$^{223}_{95}Am$
A. ○	B. ○	C. ○	D. ○

Justification:

Question 2e (1 mark)

The graph below shows the radioactive decay of americium-241. Using the graph, **determine** the half-life of americium-241 in years.



2f Video link: Q.2f Video.mp4

Question 2f (1 mark)

Use your answer to part (e) to **calculate** the time taken for 625 nuclei to remain in this sample.

B I U x_2 x^2 Ω Σ Styles

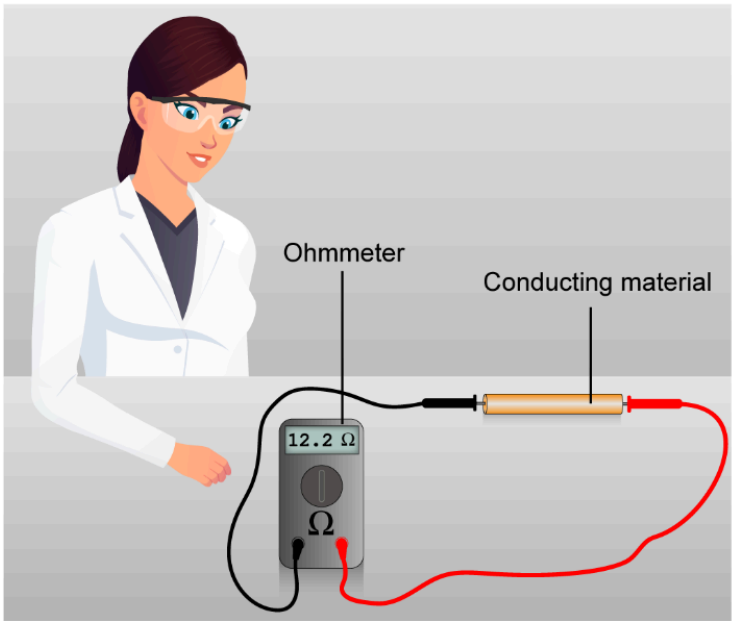
Question 2g (3 marks)

Explain why this kind of smoke detector would not function correctly with a radioactive isotope that emits beta or gamma radiation.

Question 3 (17 marks)

Question 3a (2 marks)

A resistor is an electrical component that limits the flow of current in a circuit and converts electrical energy to heat. Resistance can be measured using an ohmmeter.



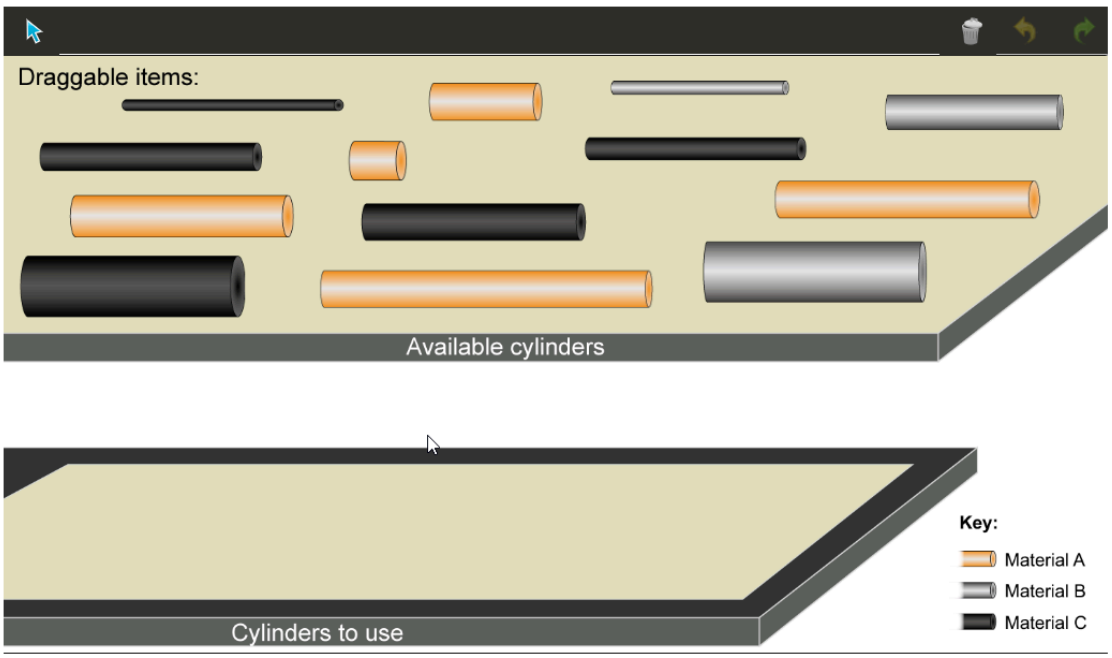
A student is interested in studying resistance. They decide to model resistors using cylinders of conducting material. Their research question is:

> What is the relationship between the diameter of a cylinder and its resistance?

Formulate a hypothesis to test this research question.

Question 3b (3 marks)

Select the cylinders the student should use to collect appropriate data by dragging the cylinders from the box onto the table.

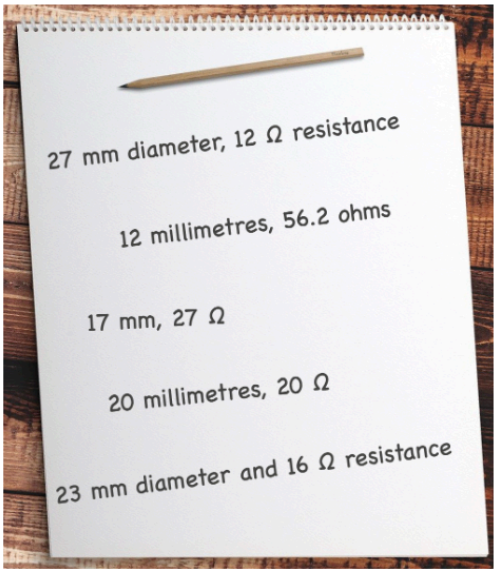


Question 3c (2 marks)

Justify your selection of cylinders in part (b).

Question 3d (4 marks)

Having carried out one trial for each cylinder, the student records their data as shown below.



Organize and **present** the data in a table.

Create New Table

Reset

Question 3e (2 marks)

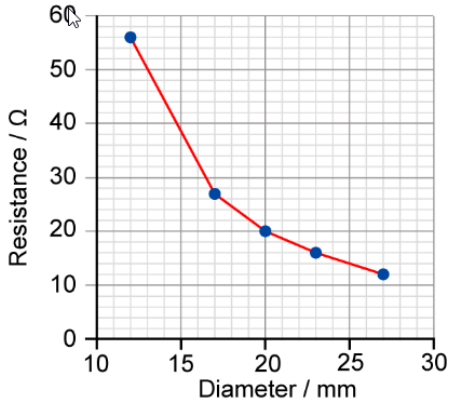
The student's lab partner wants to carry out more trials. **Suggest** how this would improve the investigation.

Question 3f (1 mark)

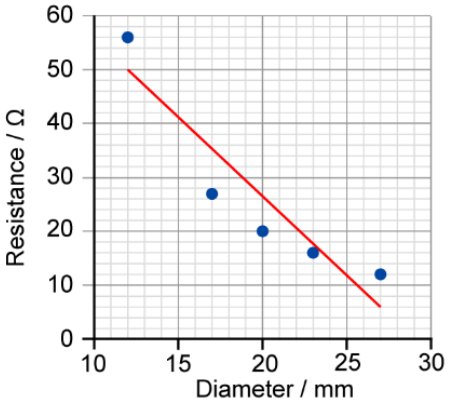
The student draws four graphs using the data from part (d). **Select** the most appropriate trend line to show the relationship between diameter and resistance.

Select

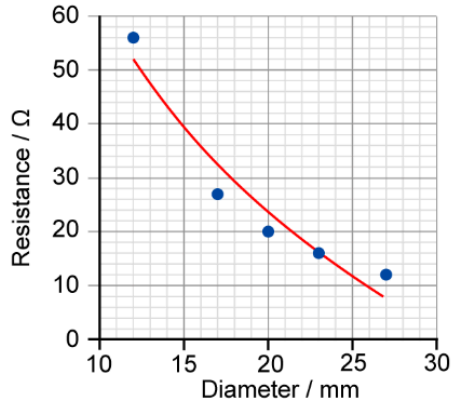
A.



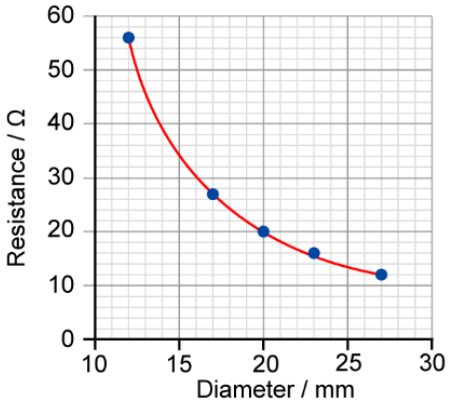
B.



C.



D.



Question 3g (3 marks)

The student wishes to extend the investigation using the same materials and equipment available in parts (a) and (b). The dependent variable will be resistance.

State an appropriate research question, independent variable and one control variable for this extension.

Question 4 (14 marks)

The resistance of a light-dependent resistor (LDR) depends on the intensity of light shining on its upper, light-sensitive surface. A student predicts:

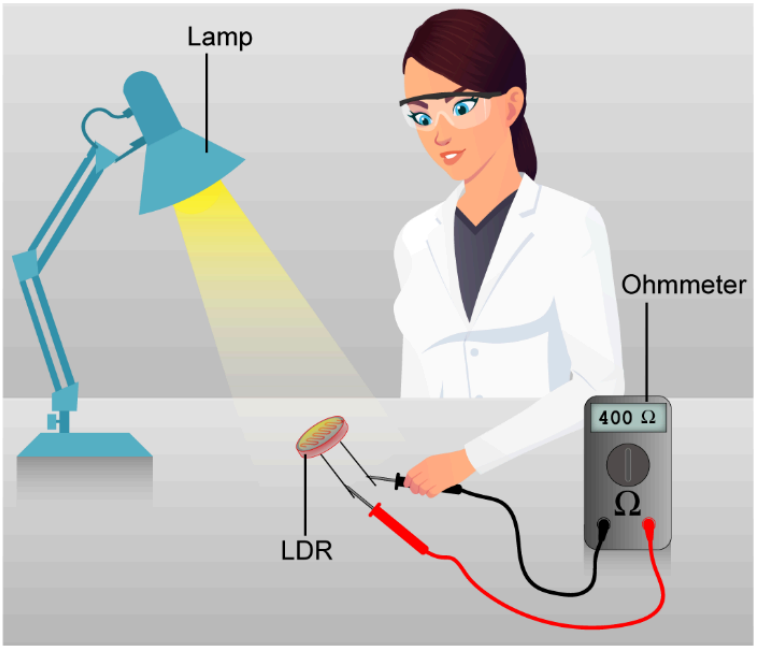
> If the distance between a light source and an LDR increases, then the resistance of the LDR will also increase.

Question 4a (1 mark)

State a research question for the student's investigation.

Question 4b (13 marks)

The student uses a lamp as a light source and an ohmmeter to measure the resistance.

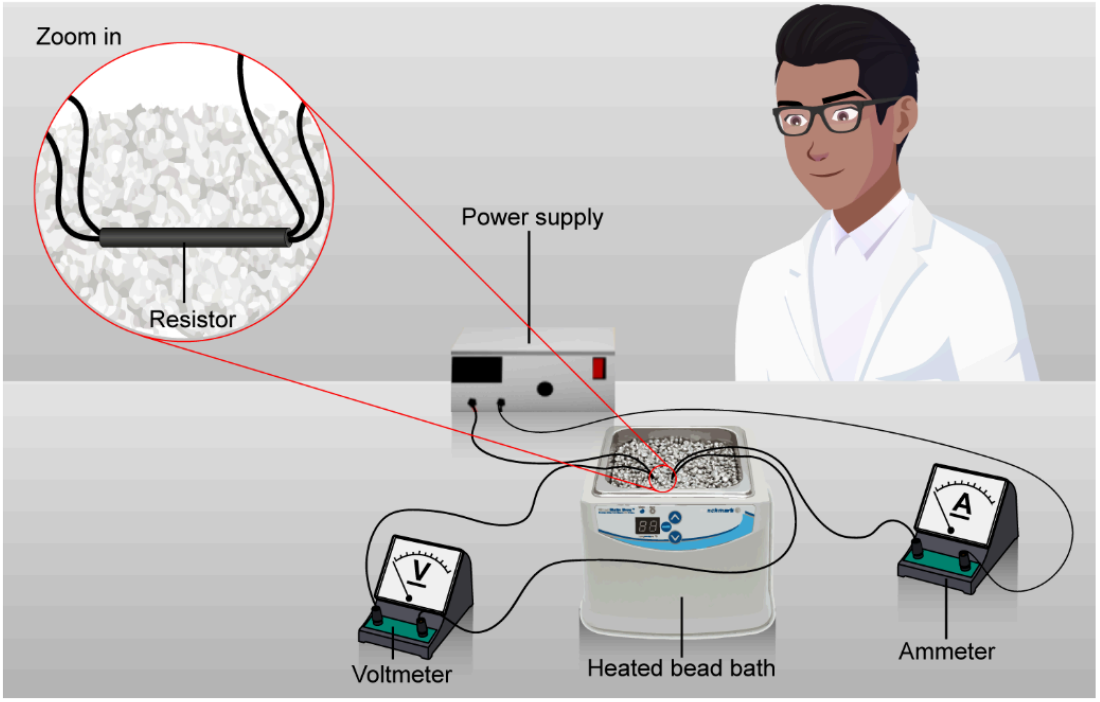


Design an investigation the student could use to test their prediction. In your answer, you should include:

- the independent variable and dependent variable
- two control variables and a justification of why they should be controlled
- a list of equipment
- a detailed method for how you will collect data
- an explanation of how you will collect sufficient data.

Question 5 (19 marks)

Another student decides to investigate the effect of varying the temperature of a resistor on its resistance. Instead of using an ohmmeter, this student measures current in order to calculate resistance. The supply voltage is kept constant throughout the investigation. The temperature of each resistor is modified by immersing it in a temperature-controlled bead bath.

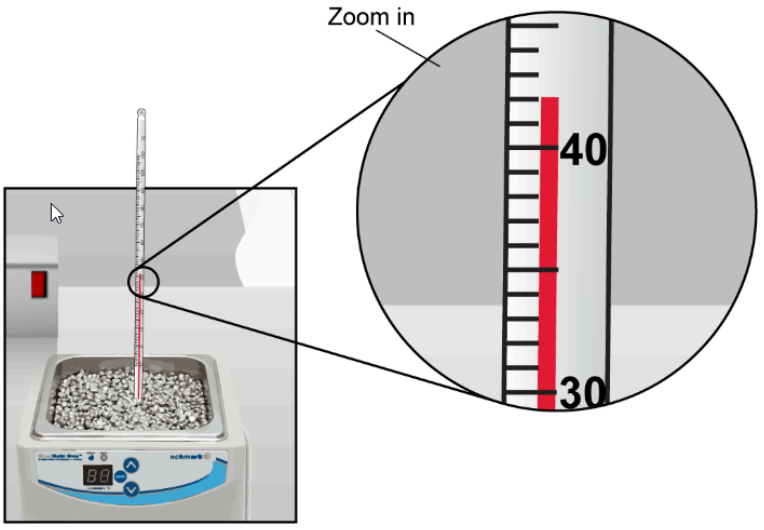


The student's research question is:

How does the temperature of a resistor affect the current in a circuit?

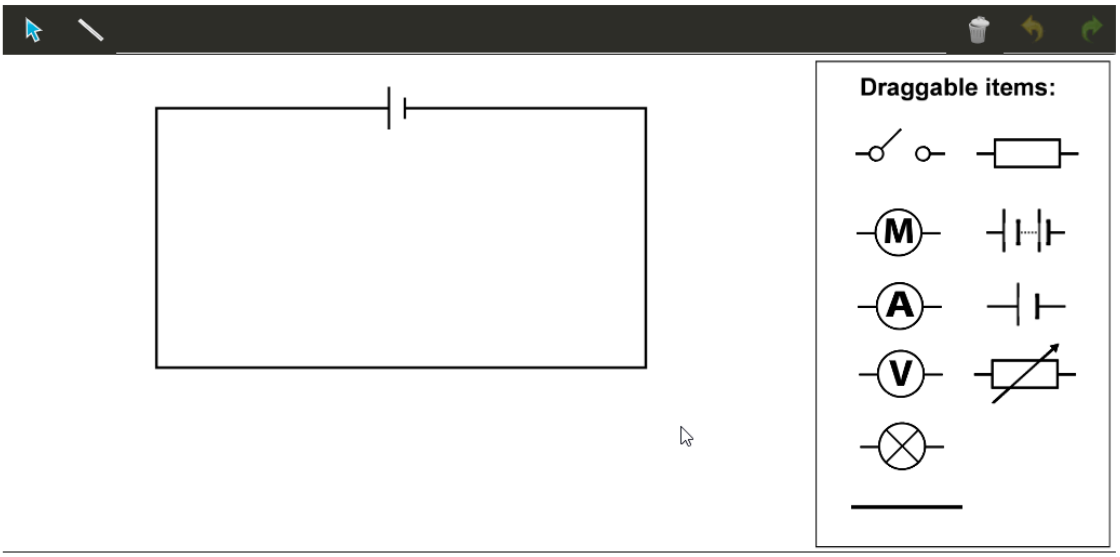
Question 5a (1 mark)

Measure the temperature of the bead bath.



Question 5b (3 marks)

Draw a diagram of the circuit used by the student. You do not need to include a bead bath in your diagram.



Question 5c (3 marks)

Identify the variables in this investigation.

Variable	Independent	Dependent	Control
Temperature of the resistor	☐	☐	☐
Length of the resistor	☐	☐	☐
Current in the circuit	☐	☐	☐
Diameter of the resistor	☐	☐	☐
Voltage across the resistor	☐	☐	☐

Reset

Question 5d (1 mark)

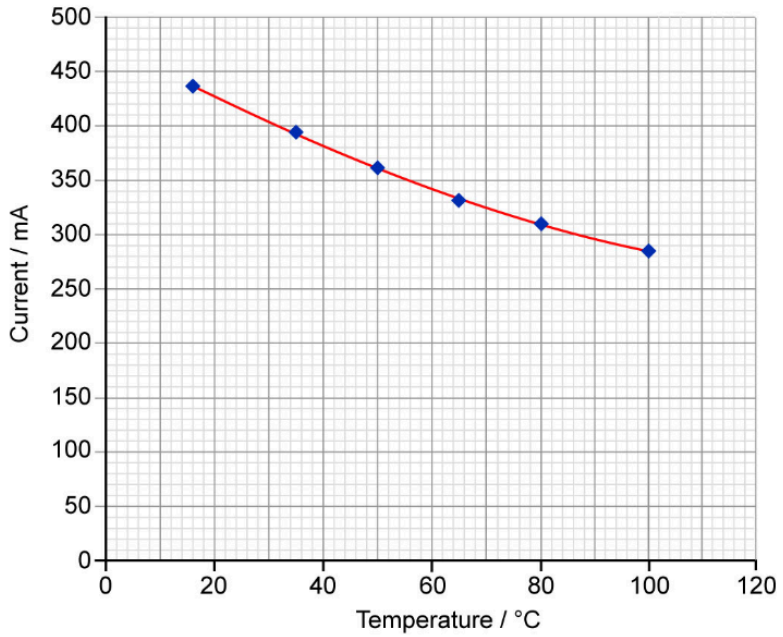
Identify a safety issue that the student should have considered when planning this investigation.

Question 5e (3 marks)

The student predicts:

> As the temperature of the resistor increases, the current through the resistor will decrease. I predict that there will be an inversely proportional relationship between the variables.

The graph of their results is shown below:



Use data from the graph and a calculation to **explain** whether the student's prediction is supported.

Question 5f (2 marks)

Having measured the current and voltage, additional processing is required to find the relationship between temperature and resistance. The voltage was kept constant at 30 V.

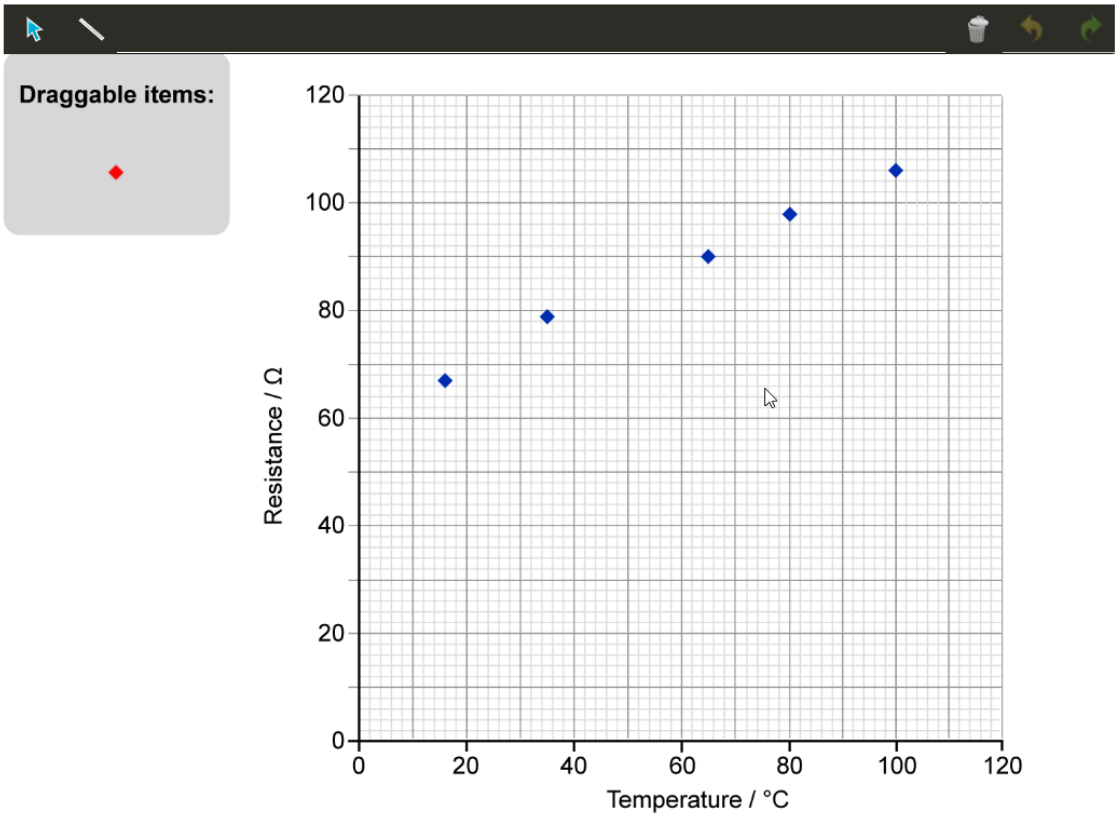
Using the graph in part (e) and information from the formula sheet, **calculate** the missing value and add it to the table of processed data below.

Temperature / ° C	Current / mA	Resistance / Ω
18	461	65
35	378	79
50	359	
65	341	88
80	297	101
100	284	106

Question 5g (2 marks)

The graph below shows the processed data from part (f).

Plot the data point you determined in part (f) and **draw** a line of best fit on the graph.



Question 5h (1 mark)

Using the graph in part (g), **predict** the value of resistance at 0°C.

Question 5i (2 marks)

Calculate the gradient of the line of best fit drawn in part (g). You should include your working and the unit in your answer.

Question 5j (1 mark)

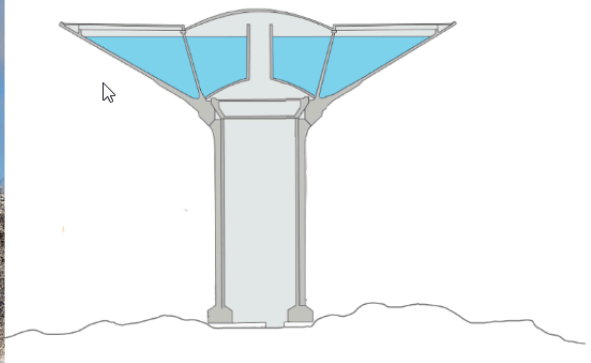
The student calculated that the resistance would be 500 Ω when the temperature was 1000°C.
Comment on the validity of the result from this calculation.

Question 6 (13 marks)

Different communities around the world do not have equal access to clean water and this is a challenge for fair development.

A water tower is an elevated structure found in many economically developed countries. It holds a water tank high above the ground. This allows the water to be distributed to the local area through a network of pipes.

The images below show a water tower in Finland with a capacity of 12 600 m^3 and a height of 52 m.



Question 6a (3 marks)

Calculate the work done in filling this water tower with water from ground level. You should assume that the value of g = 9.81 N kg^{-1} and the density of water = 1000 kg m^{-3}. Give your answer in standard form to two significant figures.

Question 6b (1 mark)

In many countries, water must be collected from sources that are sometimes located far away from the home. It is estimated that around a quarter of the global population have to collect water.

In a lot of these countries, women and girls bear the responsibility for water collection, spending a worldwide total of around 200 million hours every day collecting water.

Suggest why the need to collect water is a barrier to development for the people that live in these regions.

Question 6c (9 marks)

The United Nation's (UN) Sustainable Development Goal for clean water and sanitation calls for fair and universal access to safe and affordable drinking water by 2030. However, this is a significant global challenge, as shown in the video below.

Video | Script

It is estimated that one in four, or around two billion people worldwide, do not have access to water that is safe to drink. 1.4 million people die annually and 74 million people will have their lives shortened due to diseases caused by drinking unclean water, and the related problems of poor sanitation and hygiene.

The UN Sustainable Development Goal for clean water and sanitation aims to provide everyone in the world with a source of clean water within a 30-minute round trip. Currently, the UN estimates that around a third of sub-Saharan Africa's population rely on water sources that do not meet this standard.

Most of the water sources used are accessed by hand pumps. These raise clean water up from under the ground. However, up to 50 % of these hand pumps are broken at any given time. A recent study found that charging a small amount of money to use the pump can help train people to maintain the pumps so that they can remain in use for decades.

6c Video Link: Q,6c Video.mp4

You are tasked with giving advice to a charity collecting money to improve access to clean water. The charity wants to provide a hand pump to a local village community in rural sub-Saharan Africa. The charity wants to make sure that the hand pump will remain usable for a long time.

Discuss and **evaluate** providing a hand pump to a local village community. In your answer, you should include:

- the benefits to health that are associated with access to clean, drinkable water
- the ethical advantages or disadvantages of asking the villagers to pay a small fee to access the clean water
- a concluding appraisal giving your opinion about how the charity should ensure a long-term solution to water access for the village.

Question 7 (13 marks)

Water must be treated before it is safe to be consumed by humans.

Video | Script

In more economically developed countries, water treatment facilities are used to make sure that water is safe for human consumption. However, less economically developed countries do not have access to such facilities and different ways of making the water safe to drink are required.

One method that is used in less economically developed countries, where no centralized water treatment facilities are available, is solar disinfection, or SODIS. SODIS involves placing untreated water into a transparent container and exposing it to sunlight for several hours before drinking. The container is often a reused plastic water bottle. It is the combined effect of the UV waves and high temperatures that kills the harmful microbes that are present in the untreated water.

To be effective, the SODIS technique requires 6 hours of exposure to sunlight on a clear day in countries close to the equator. This increases to 48 hours on cloudy days. It also requires the availability of plastic bottles in which to hold the water.

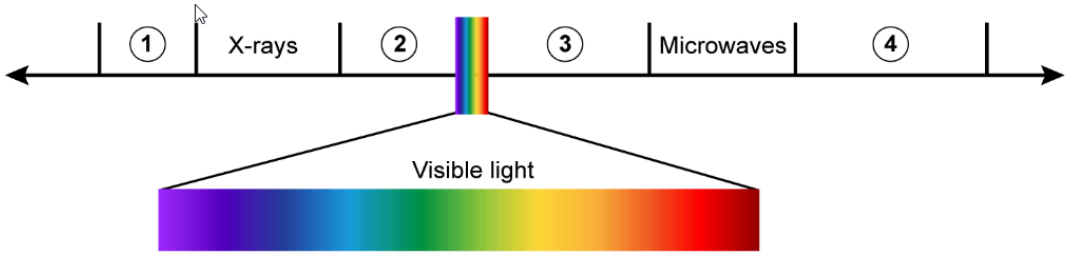
SODIS is recommended by the World Health Organization as a method for household water treatment, especially in locations where fuel is expensive.

7a Video Link: Q.7a.mp4

Question 7a (1 mark)

Select the region where ultraviolet (UV) waves are found in the electromagnetic spectrum shown below.

Select



Question 7b (1 mark)

State the property of ultraviolet waves that is useful for killing harmful microbes in water.

7c Video Link: Q.7c.mp4