Question 1 (9 marks)

In 1938, an experiment took place that led to important developments in the fields of science and technology. The first step in this experiment used neutrons to bombard a sample of uranium.

Some atoms of uranium-235 $\left({}^{235}_{92}\mathrm{U}\right)$ changed into atoms of uranium-236 $\left({}^{236}_{92}\mathrm{U}\right)$

Question 1a (3 marks)

Select words to complete the following statements:

Both of these forms of uranium have [Select] of 92.

Uranium-236 has one more [Select] than uranium-235.

These two different forms of uranium are known as [Select].

Question 1 (9 marks)

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Question 1a (3 marks)

Select words to complete the following statements:

Both of these forms of uranium have Select of 92.

Uranium-236 has one more Select

These two different forms of uranium t .

Select
an atomic number
a mass number
a half-life
an electron shell

Question 1 (9 marks)

In 1938, an experiment took place that led to important developments in the fields of science and technology. The first step in this experiment used neutrons to bombard a sample of uranium.

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Question 1a (3 marks)

Select words to complete the following statements:

Both of these forms of uranium have [Select] of 92.

Uranium-236 has one more [Select] than uranium-235.

These two different forms of [Select] re known as [Select].

Select
proton
neutron
electron
nucleus

Question 1 (9 marks)

In 1938, an experiment took place that led to important developments in the fields of science and technology. The first step in this experiment used neutrons to bombard a sample of uranium.

Some atoms of uranium-235 $\left({}^{235}_{92}\mathrm{U}\right)$ changed into atoms of uranium-236 $\left({}^{236}_{92}\mathrm{U}\right)$

Question 1a (3 marks)

Select words to complete the following statements:

Both of these forms of uranium have Select

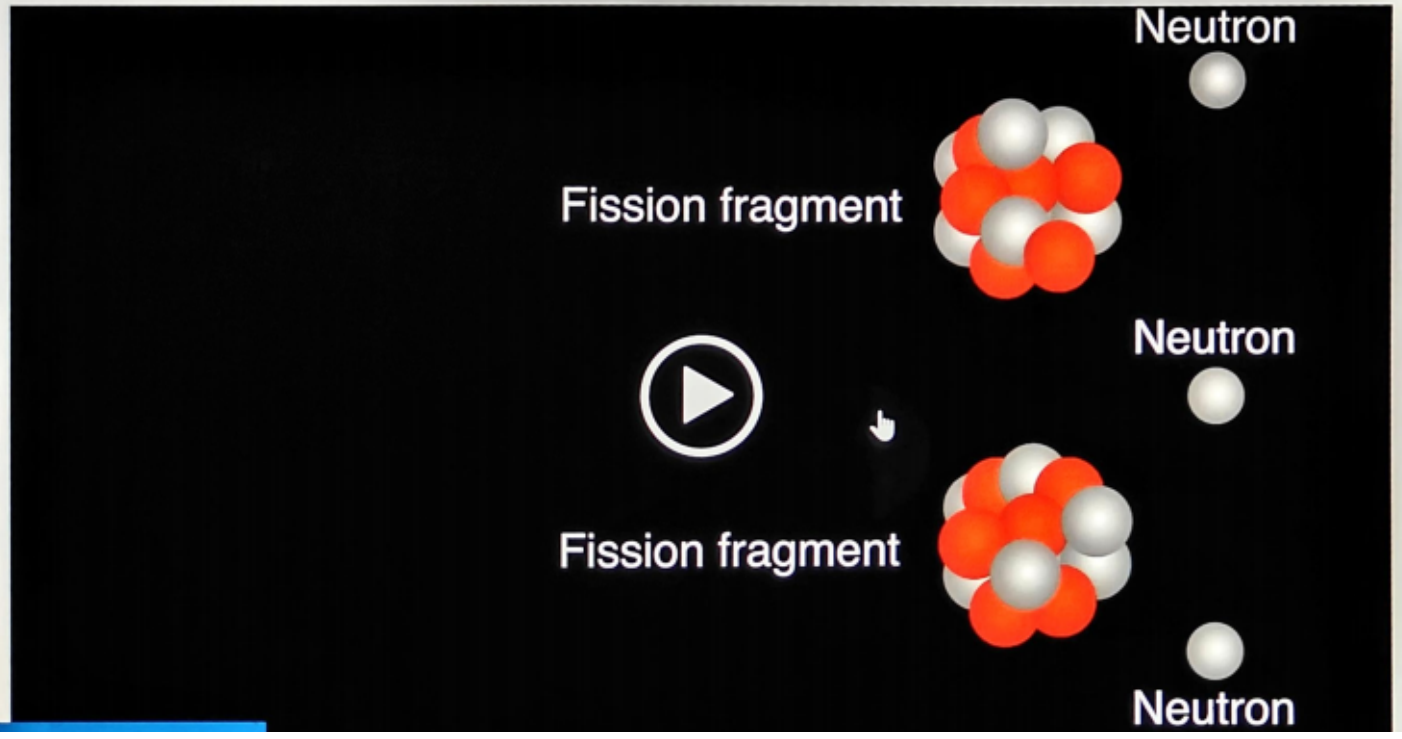
Uranium-236 has one more Select than uranium

These two different forms of uranium are known as Select.

Select
isotopes
electrons
compounds
molecules

Uranium-236 can split into smaller nuclei. This is an example of nuclear fission. The total number of protons and neutrons are unchanged during this reaction.

This media contains no audio



One such reaction is shown below but one of the chemical symbols is missing.

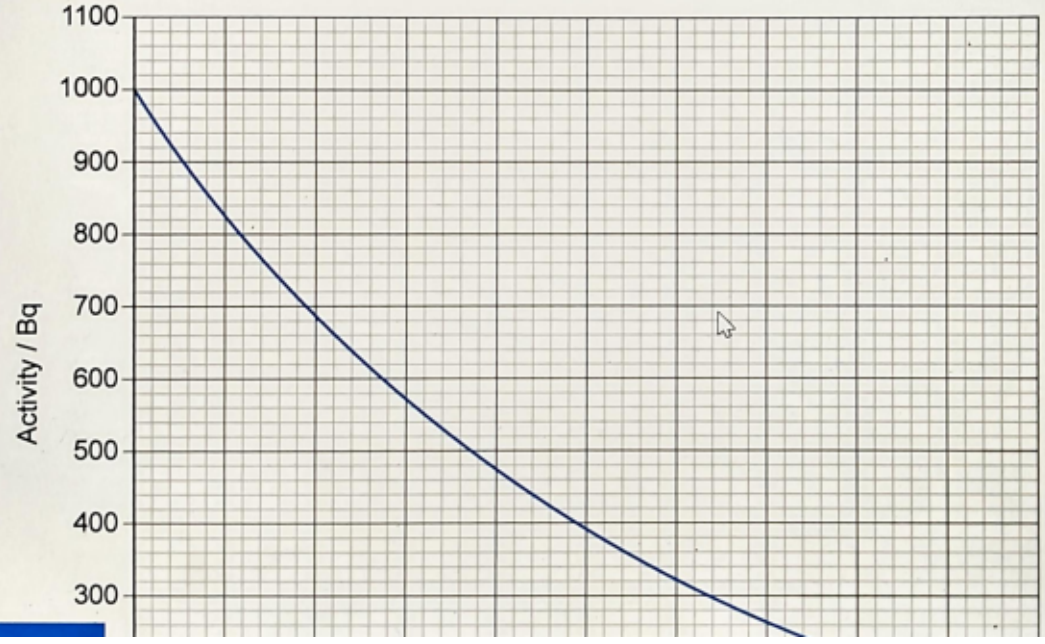
Determine the missing symbol and add it to the equation.

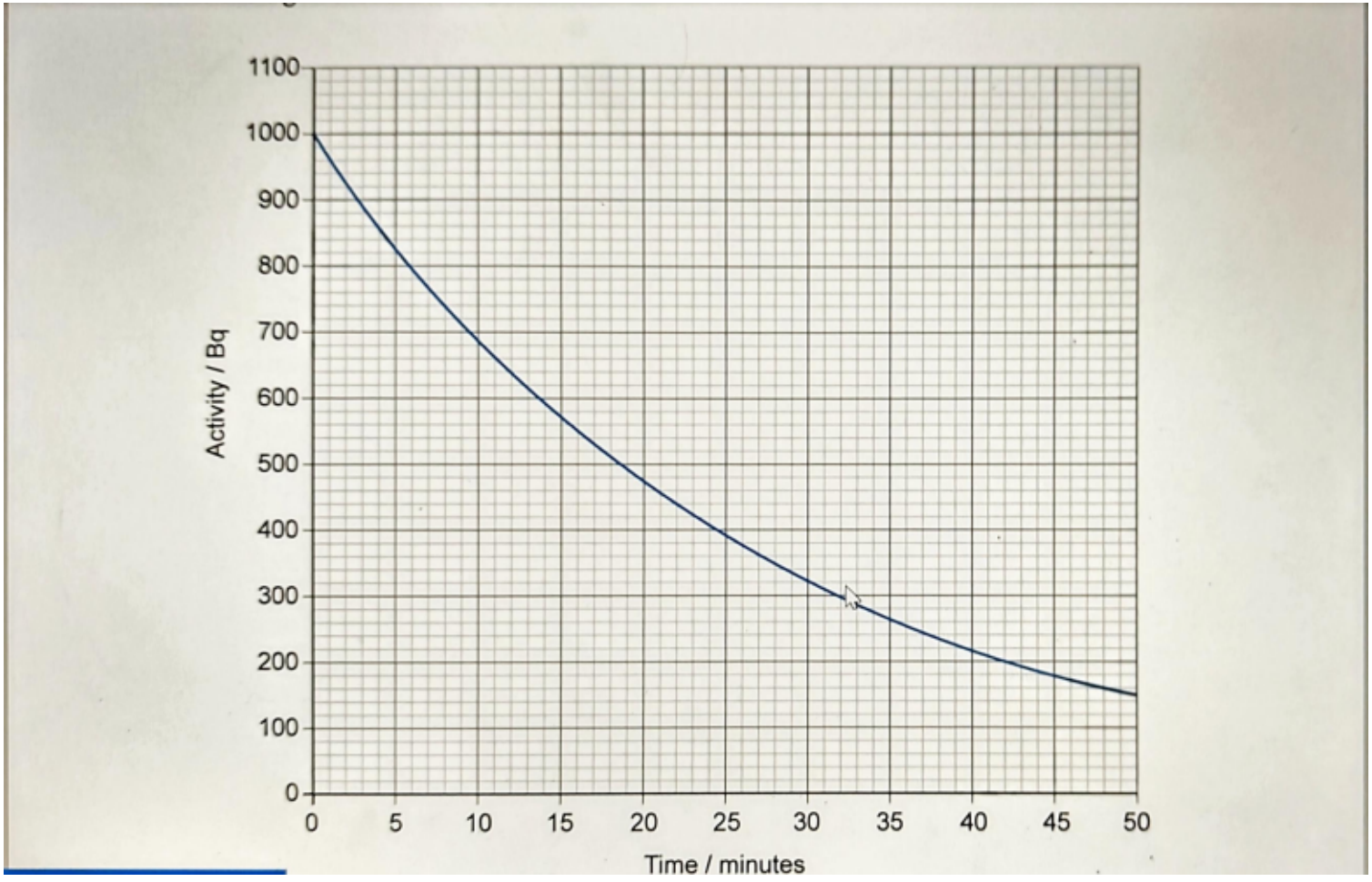
Draggable items: $^{60}_{33}As$ $^{92}_{33}As$ $^{92}_{36}Kr$ $^{95}_{36}Kr$

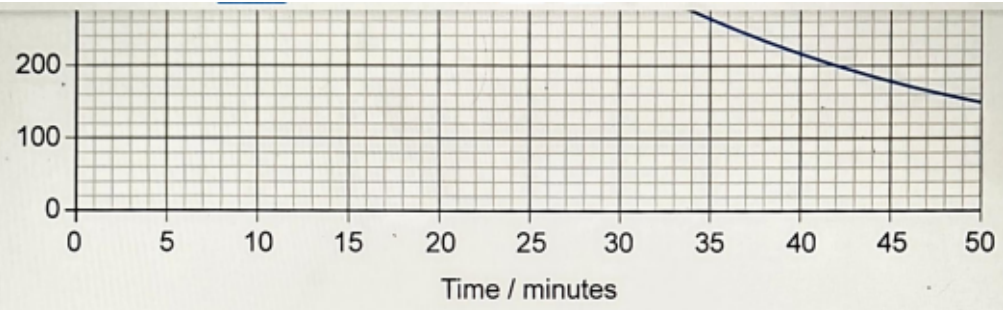
$$^{236}_{92}U \rightarrow {}^{141}_{56}Ba + \square + 3 \text{ neutrons}$$

Question 1c (2 marks)

The products of the fission reaction are radioactive. The graph below shows how the activity of barium-141 changes with time.




Activity / Bq
1100
1000
900
800
700
600
500
400
300
200
100
0
0
5
10
15
20
25
30
35
40
45
50
Time / minutes



Using the graph, **determine** the half-life of barium-141.

B I U x_2 x^2 Ω Σ Styles

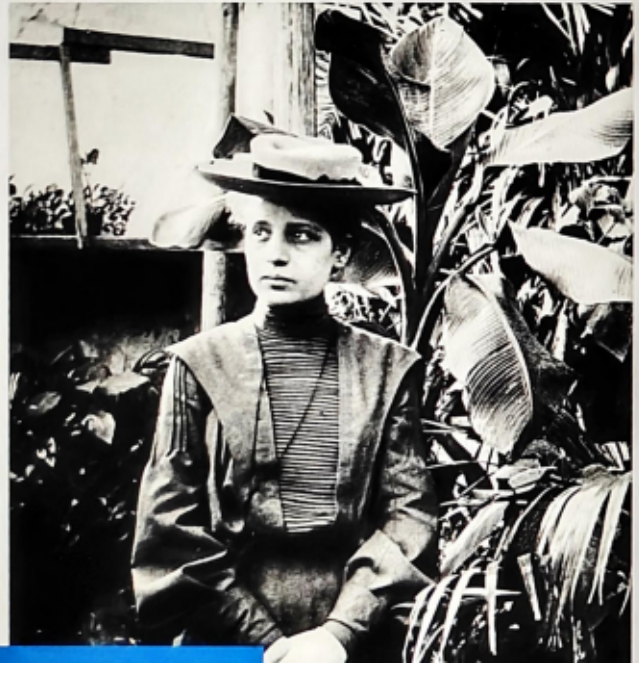
Question 1d (2 marks)

Fission reactions release energy. The energy requirement of an average person in an economically developed country is 1.26×10^{11} J per year. The fission of 1g of uranium releases 82 000 MJ of energy.

Calculate the number of grams of uranium that would be needed to provide all of the energy required by an individual in an economically developed country.

Question 1e (1 mark)

The amount of energy released in fission was calculated by the physicist Lise Meitner.



Meitner was also a part of the team that analysed the products of the fission reaction. During the discovery of fission, physicists and chemists worked together collaboratively.

Suggest the importance of collaboration in science.

B I U x_2 x^2 Ω Σ

Styles

Question 2 (9 marks)

Thermal energy is also known as heat energy. The addition or removal of heat energy can cause changes in temperature and in state.

Question 2a (2 marks)

Drag and drop the state changes to **identify** which require heat energy to be added and which require heat energy to be removed. The first has been completed for you.

Draggable items: Melting Freezing Condensing

Heat energy added	Heat energy removed
Boiling	

Question 2b (2 marks)

Compare and contrast the processes of evaporation and boiling.

B I | U x_2 x^2 | Ω Σ | Styles

Question 2c (2 marks)

The evaporation of liquid sweat from the surface of the skin helps to remove heat from the human body and keep it cool. A student decides to model this relationship in a laboratory investigation.

Click on the green arrow to see the animation.

A student performs an investigation in which temperature probes are placed into different liquids. One probe is placed in cooking oil, one is placed in pure water and another is placed in ethanol.

Click on the green arrow to see the animation.

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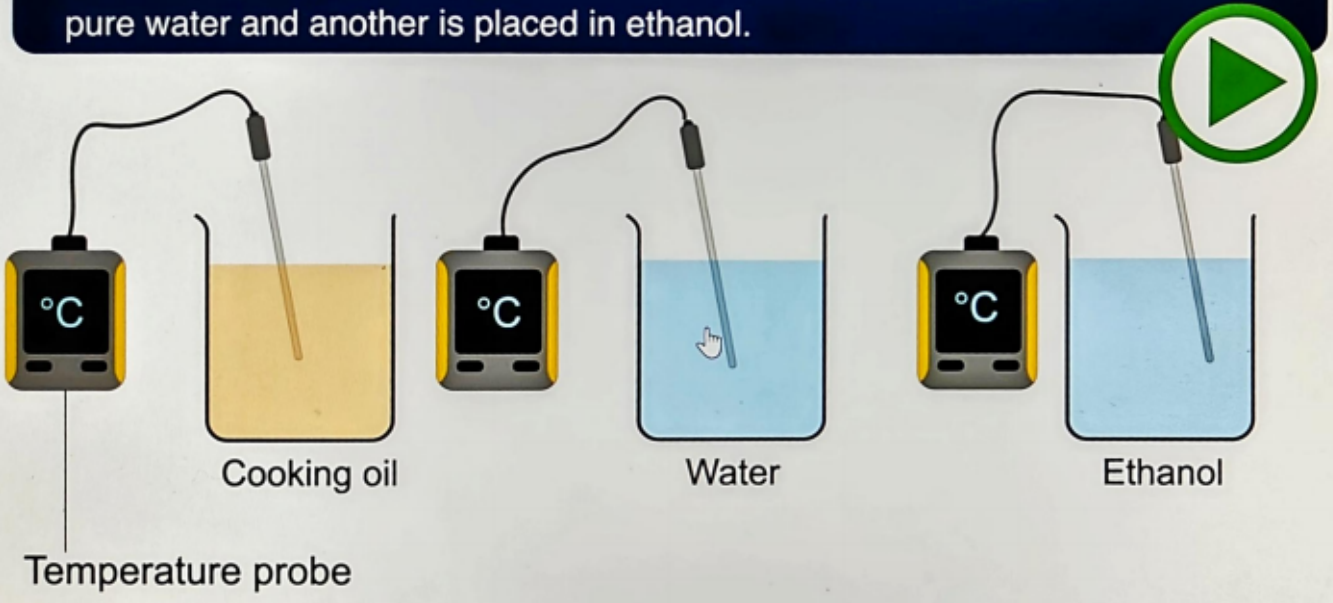
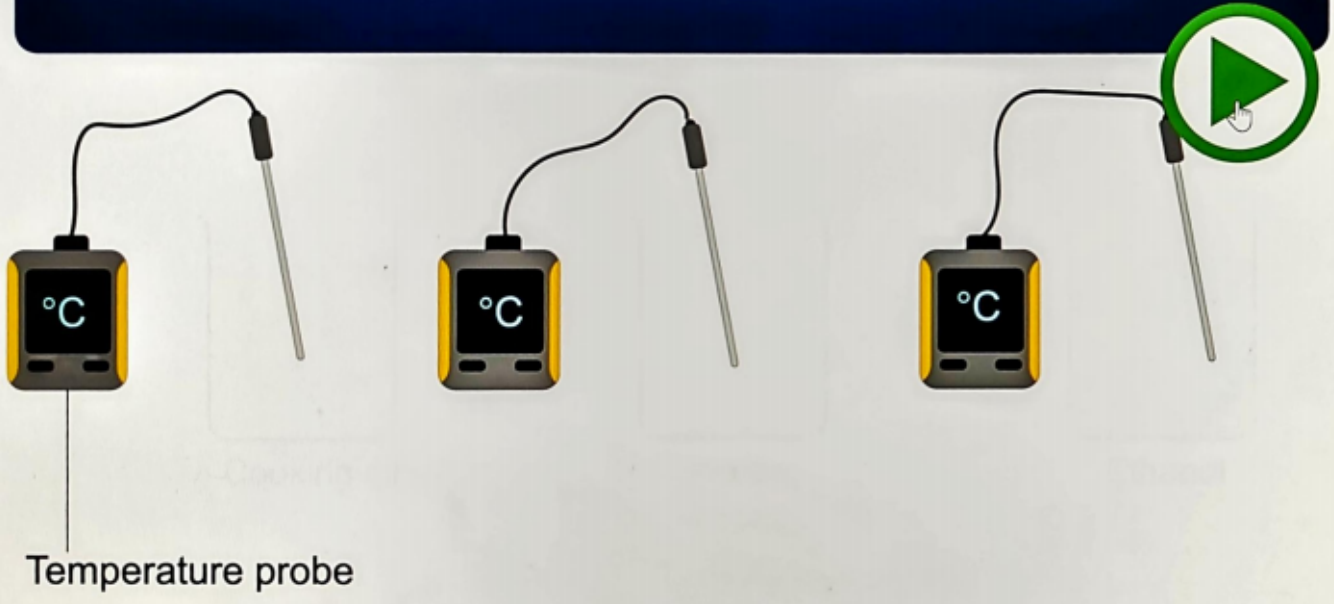


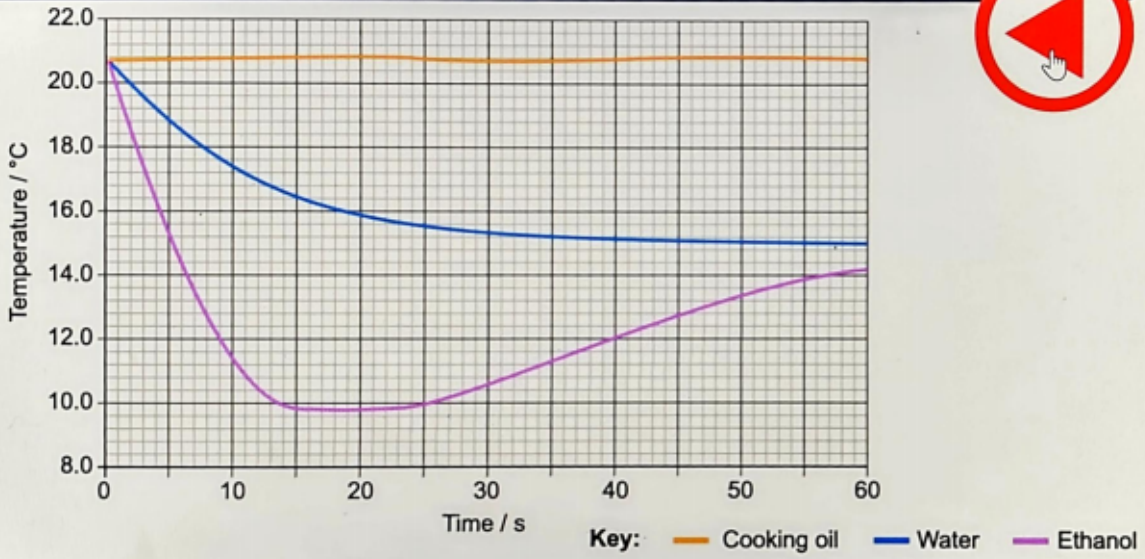
Click on the green arrow to see the animation.

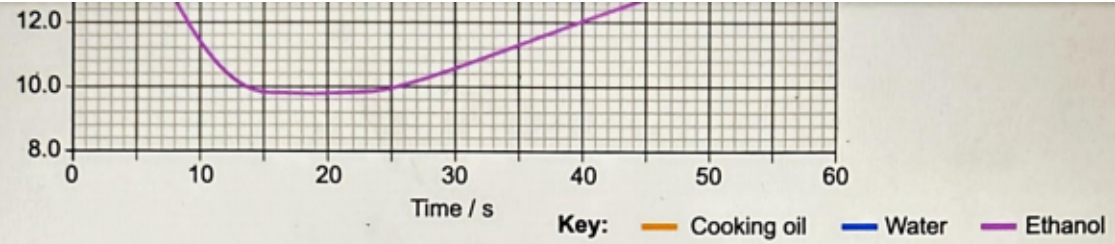
The probes are removed and temperature is measured with time.



Click on the green arrow to see the animation.

The aim of the experiment is to see if the kind of liquid used has an effect on the cooling effect caused by evaporation.

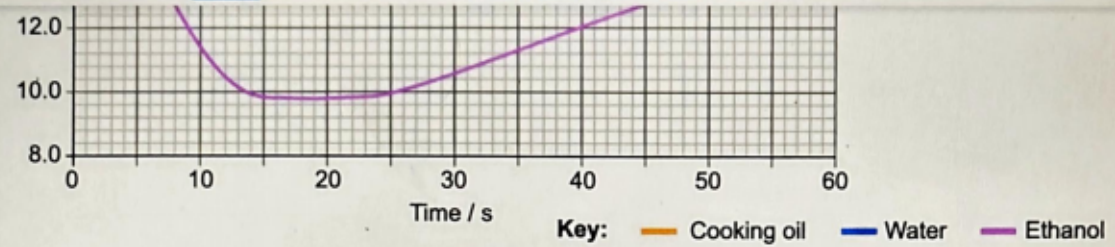




Using the graph, **select** the liquid that caused no cooling effect and the liquid that caused the greatest cooling effect.

No cooling effect: Select

Greatest cooling effect: Select



Using the graph, **select** the liquid that caused no cooling effect and the liquid that caused the greatest cooling effect.

No cooling effect: Select

Greatest cooling e

Select
cooking oil
water
ethanol

Question 2d (1 mark)

Use the graph in part (c) to **identify** the temperature of the laboratory.

B I | U x_2 x^2 | Ω Σ Styles

Question 2e (2 marks)

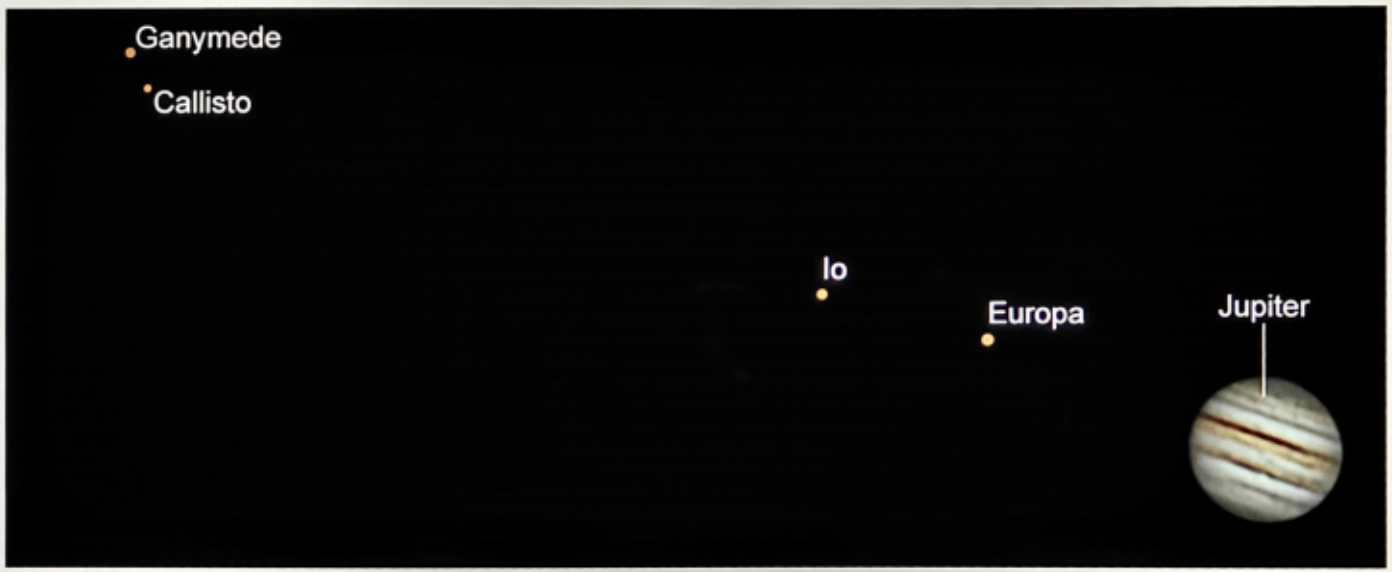
Student A says that ethanol requires the most energy to evaporate. Student B says that cooking oil requires the most energy to evaporate.

Using the graph in part (c), **justify** which student is correct.

B I | U x_2 x^2 | Ω Σ | Styles

Question 3 (7 marks)

In 1610, the astronomer Galileo Galilei used his telescope to observe the planet Jupiter. He noticed four small objects that appeared to be distant stars. However, he later realised that they were in fact moons.



Question 3a (2 marks)

State two differences between a moon and a star.

B I U x_2 x^2 Ω Σ Styles

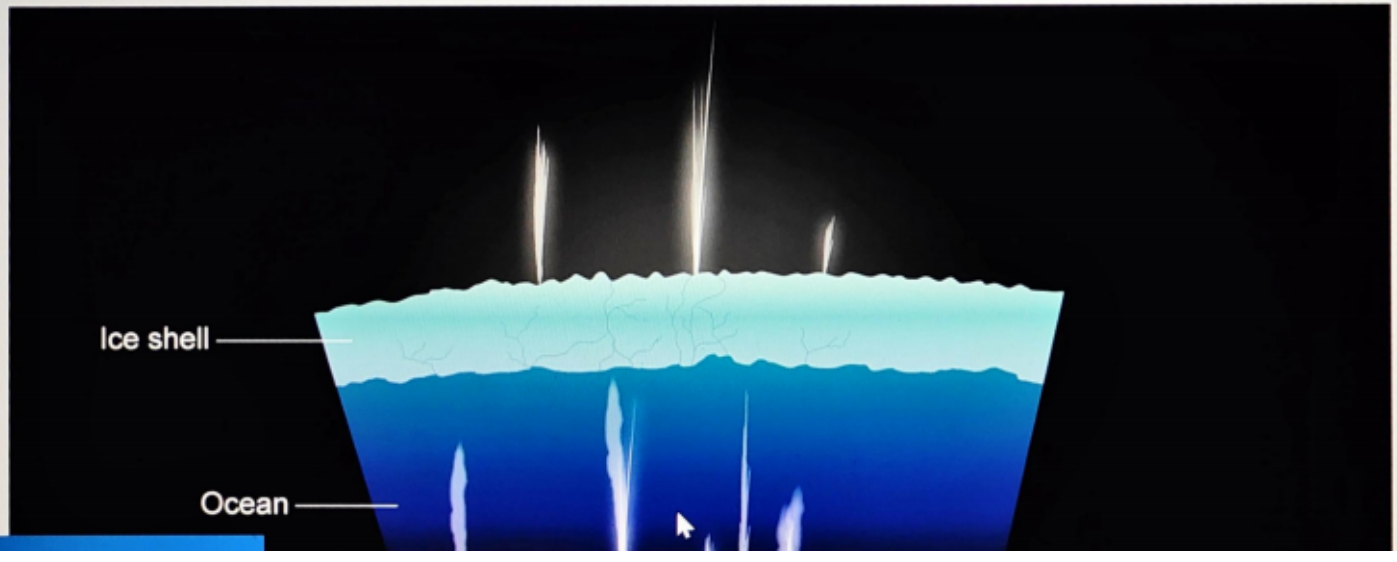
Question 3b (2 marks)

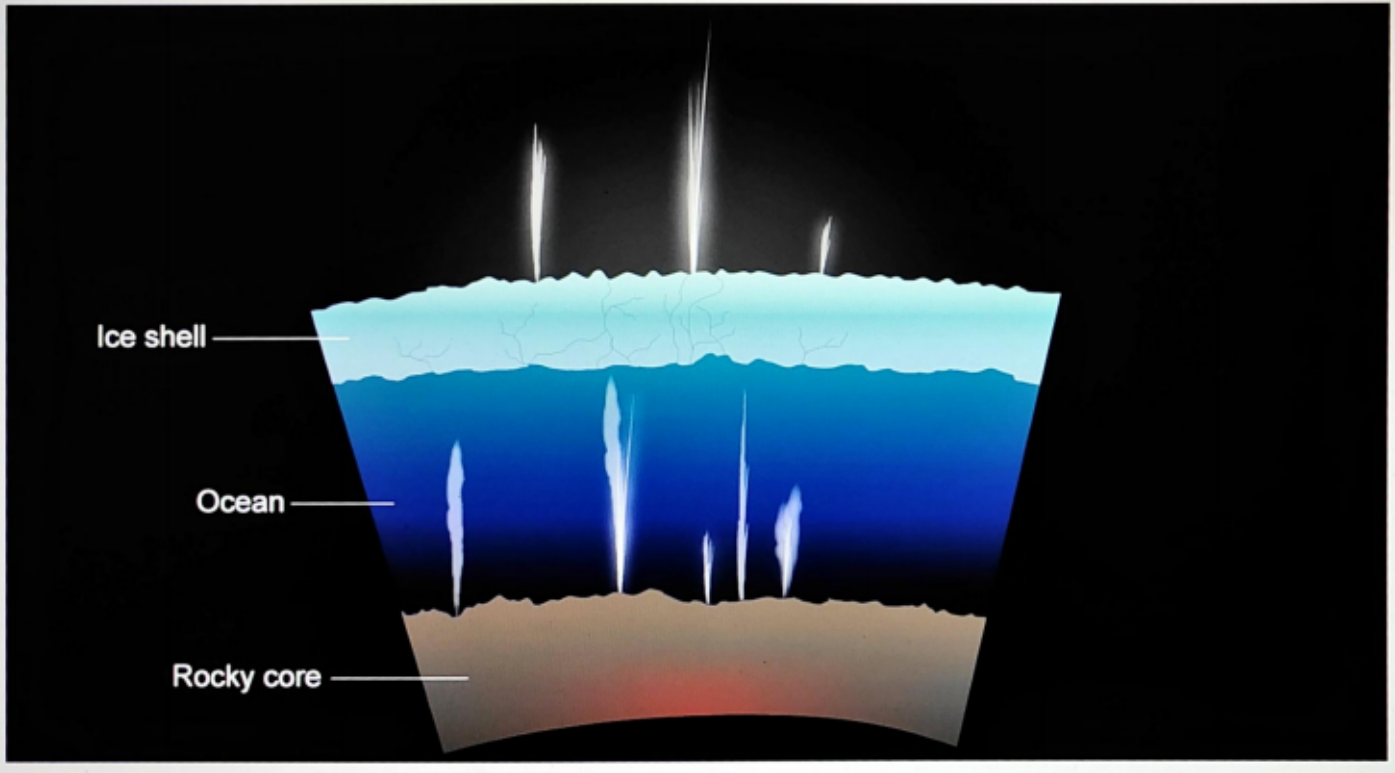
At the time it was widely believed that everything in the universe orbited Earth. This is known as the geocentric model of the universe. Galileo observed the four moons and their movement over time. This new evidence showed that the geocentric model was incorrect.

Suggest how Galileo's observations helped to disprove the geocentric model.

Question 3c (1 mark)

It has been known for a long time that the surface of the moon Europa is covered with ice because of how it reflects light. There is additional evidence that beneath the ice there could be liquid water and possibly an ocean.

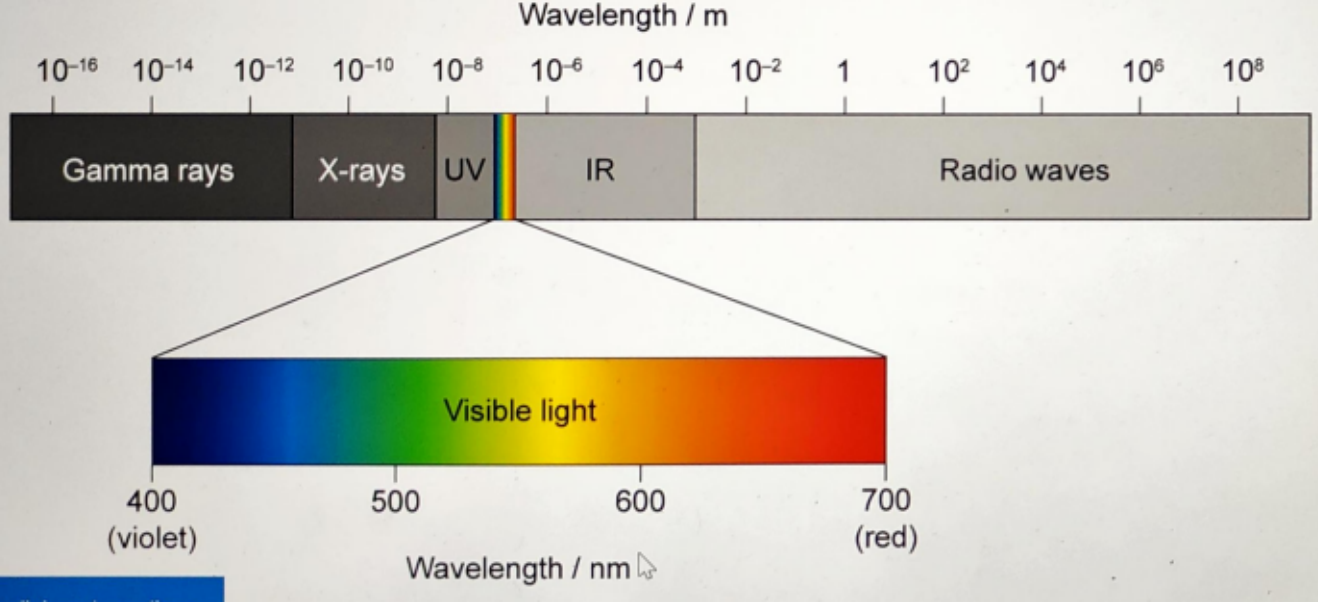


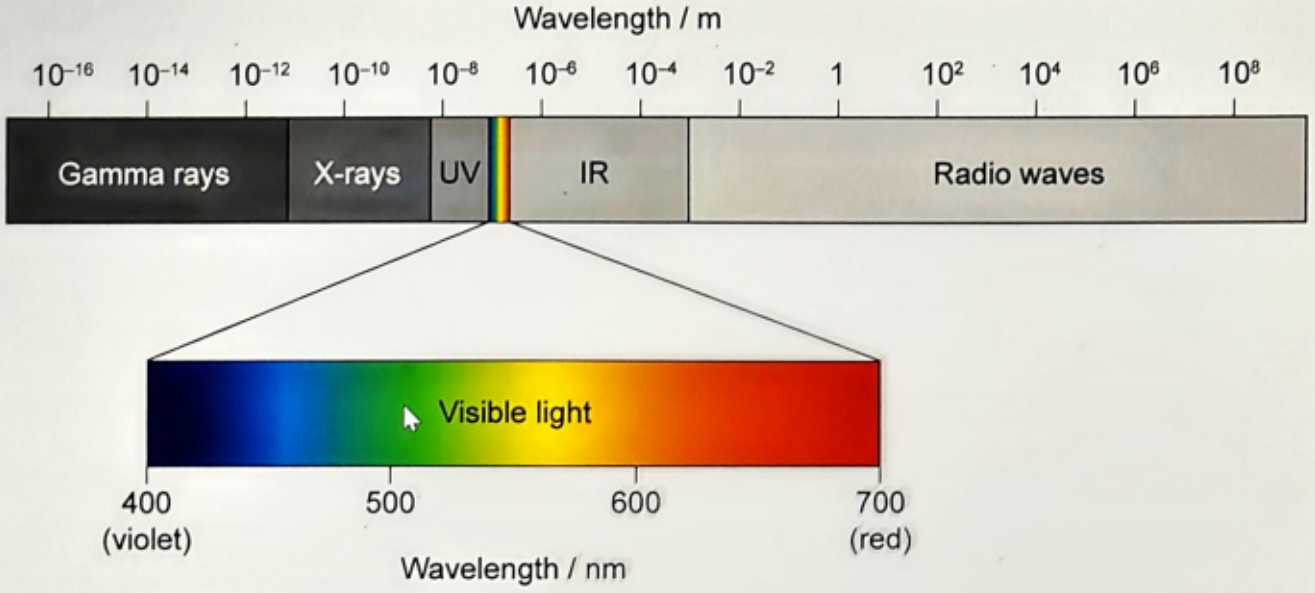


Suggest why the presence of liquid water on the moon Europa would be of particular interest to scientists.

Question 3d (2 marks)

The moon Europa is of particular interest to scientists. In 2019, water vapour was detected for the first time above Europa's surface. The technique used to detect it involved the analysis of infrared waves. Infrared waves are part of the electromagnetic spectrum shown below.





State two properties that are shared by **all** waves in the electromagnetic spectrum.

B I U x_2 x^2 Ω Σ Styles

Question 4 (10 marks)

All modern technologies rely on changing energy from one form into another. The efficiency of any energy conversion is found using the formula below:

$$\text{efficiency} = \frac{\text{useful energy out}}{\text{total energy in}} \times 100$$

No device is 100% efficient in converting energy — vehicles, electronic devices, even power plants waste some energy. Improving the efficiency of energy conversion is an important goal for scientists and engineers who want to reduce the environmental impact of new technologies.

A student decides to test the efficiency of a simple electric motor lifting a mass with a pulley.

Diagram not to scale

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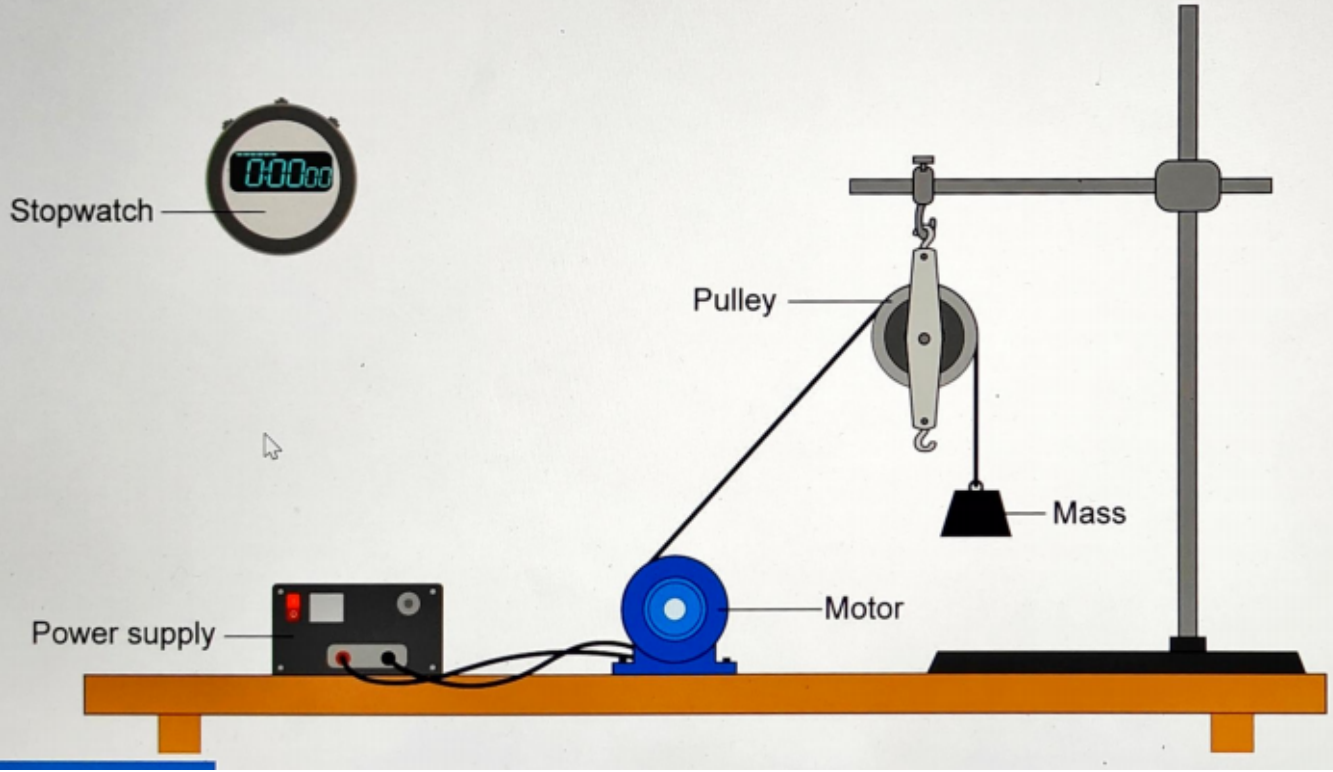
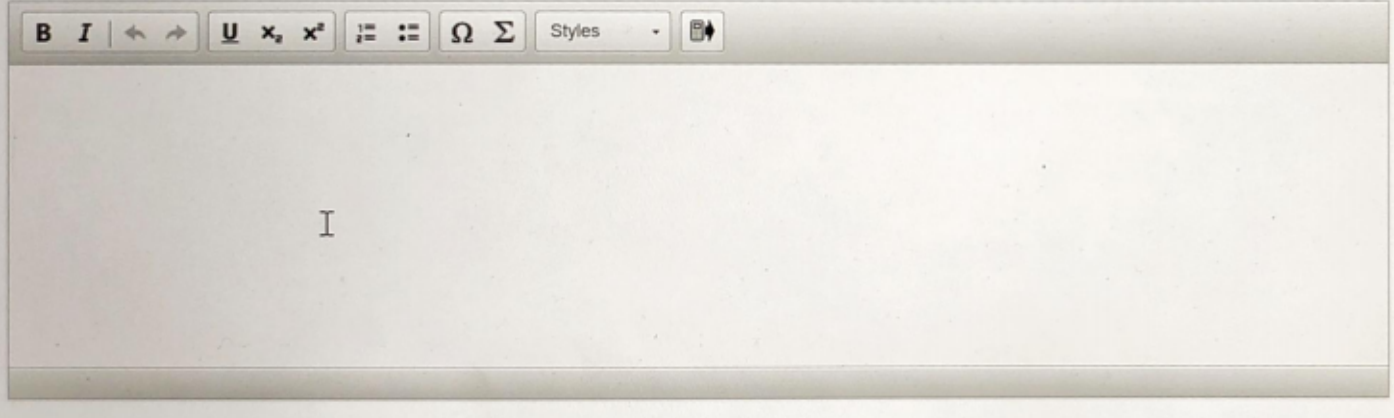
Diagram not to scale



Question 4a (1 mark)

For an electric motor, the useful energy output is the work done in lifting the mass. The student suspects that when the motor does more work, its efficiency will change.

State one form of wasted energy in an electric motor.

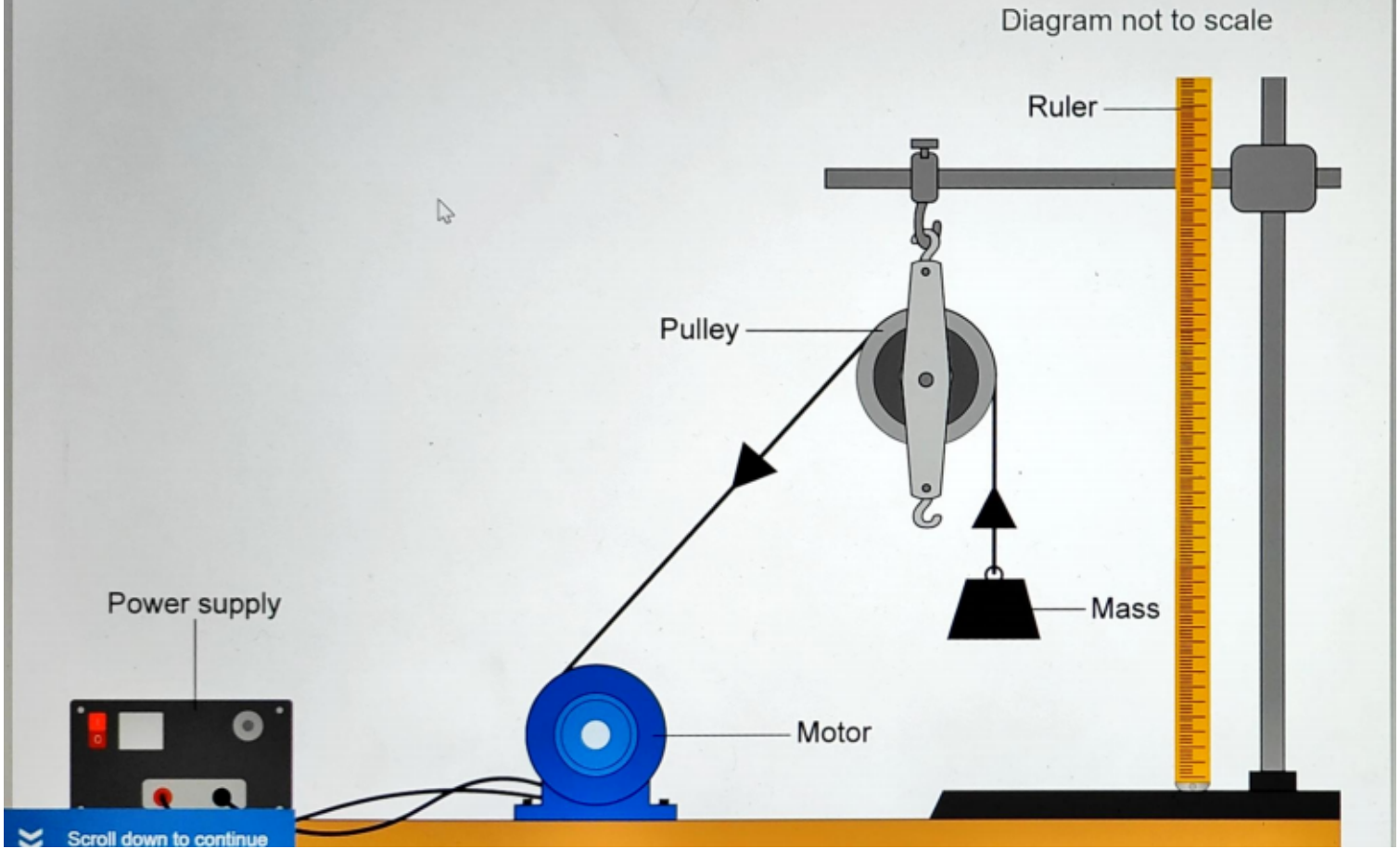


Question 4b (2 marks)

State a research question the student could use to guide their investigation.

B I | U x_2 x^2 | Ω Σ | Styles

The student plans to use the motor to lift a mass.



Scroll down to continue

The useful energy output is equal to the mass's change of gravitational potential energy as shown by the formula:

$$\Delta E_p = m\,g\,\Delta h$$

The student plans to use height lifted as the independent variable in their experiment.

Outline how the student could vary the independent variable and how this data could be used to determine the useful energy output of the motor.

Question 4d (3 marks)

To measure efficiency, the student must also determine the total energy used by the motor while lifting the mass.

$$\text{efficiency} = \frac{\text{useful energy out}}{\text{total energy in}} \times 100$$

In order to calculate the total energy used by the motor, the student must determine the power output of the motor. To do this, they measure the current flowing through the motor and the voltage across it.

Draw a circuit to measure the power output of a motor. The diagram below has been started for you.

Draggable:

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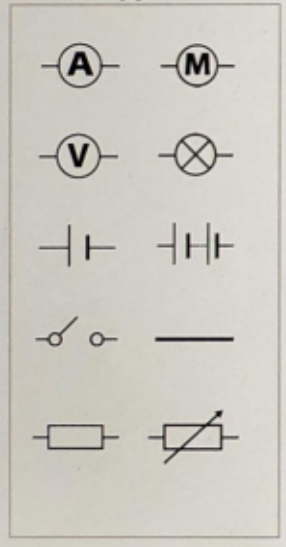
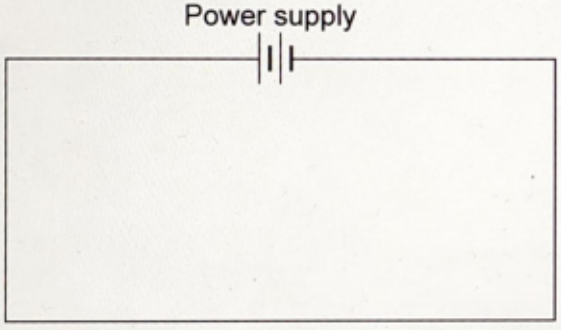
Draggable:





Scroll down to continue

Question 4e (2 marks)

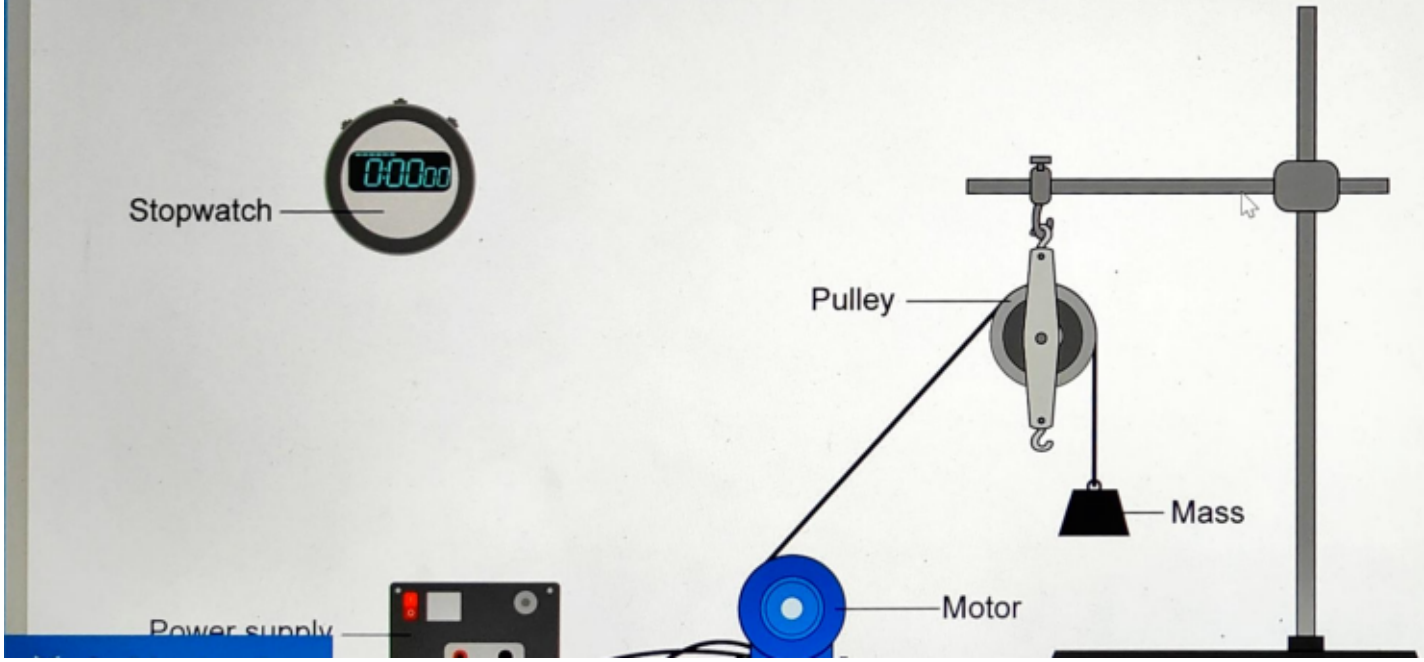
Measuring the power output of the motor alone is not sufficient to determine the total energy used by the motor.

Outline what other quantity the student must measure and **state** how this would be used to calculate the total energy used.

Question 5 (14 marks)

A second student decides to investigate how changing the voltage supplied to the motor affects the time taken to lift a mass. They will use this to calculate the efficiency of the motor.

Diagram not to scale



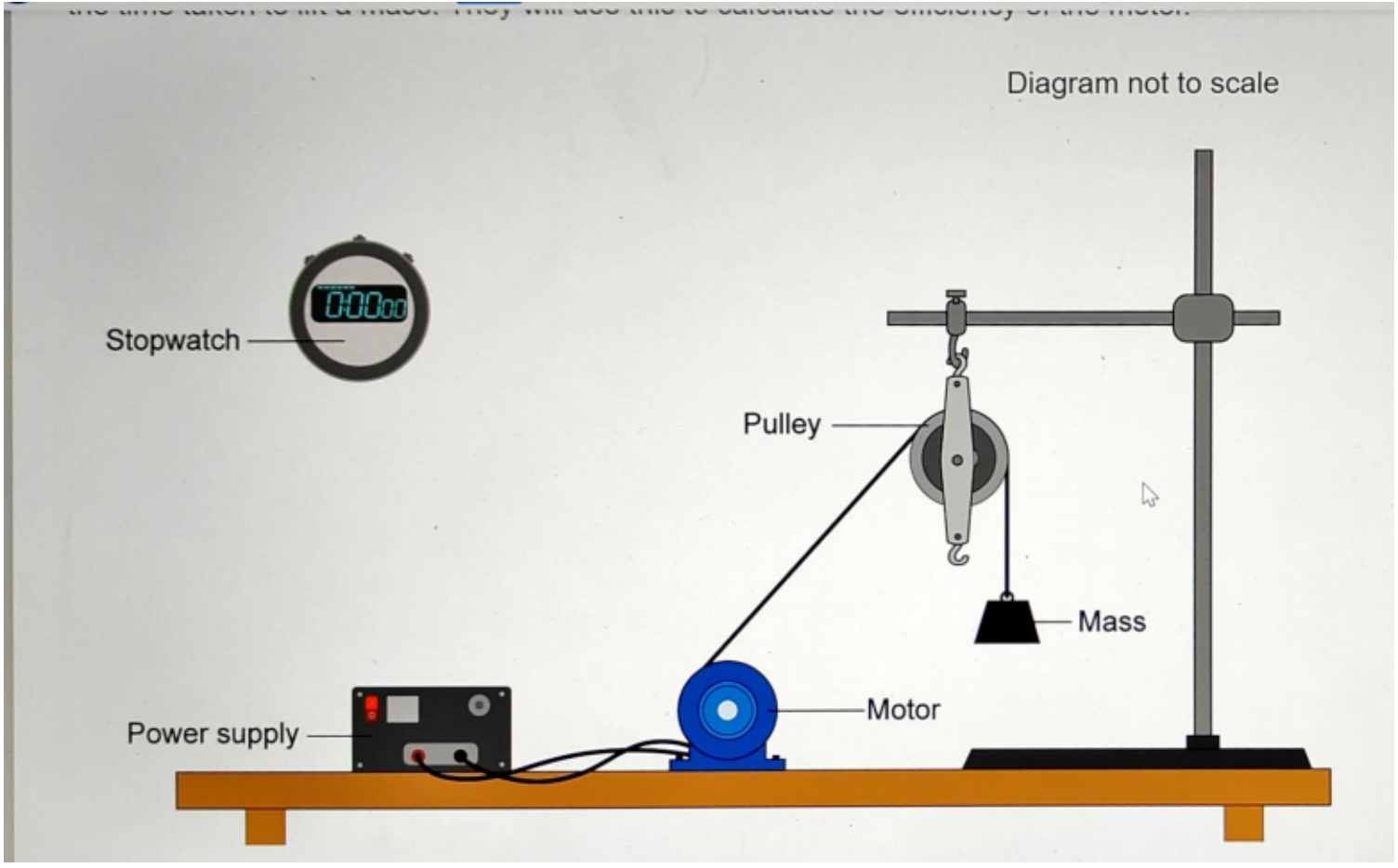
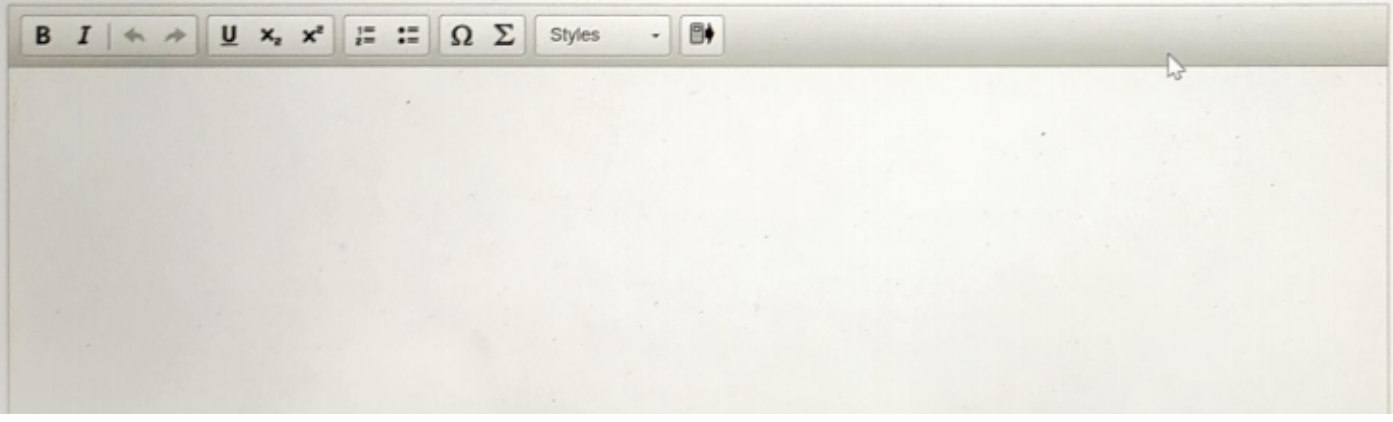


Diagram not to scale
Stopwatch
Pulley
Mass
Motor
Power supply

Design an investigation that the student could use to collect data. In your answer you should include:

- the independent and dependent variables
- two control variables with justification
- a detailed method for the collection of data
- an explanation of how you will collect sufficient data
- a statement of how data will be processed to calculate efficiency.

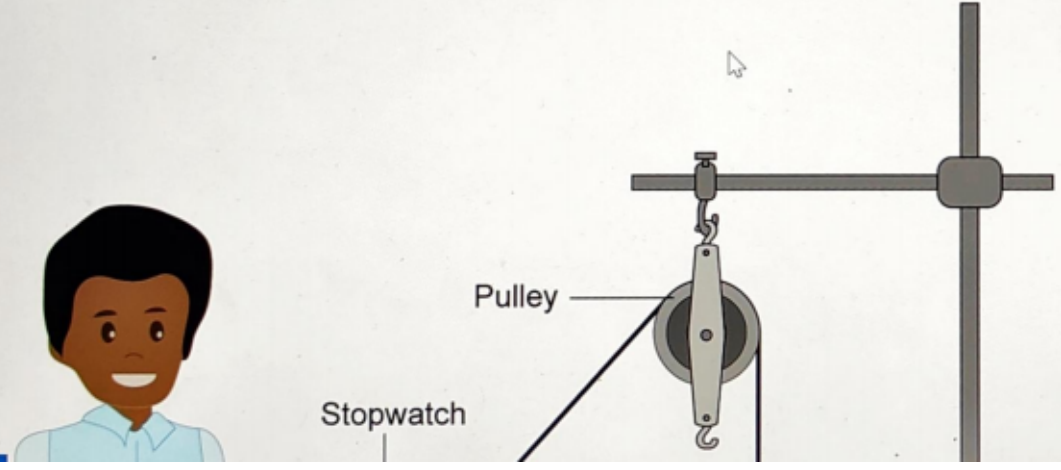


Question 6 (10 marks)

Another student has decided to change the mass lifted to see if this affects the motor's efficiency.

In each trial of their experiment, they use the motor to lift different masses from the surface of a table to a height of 95.0 cm.

Diagram not to scale



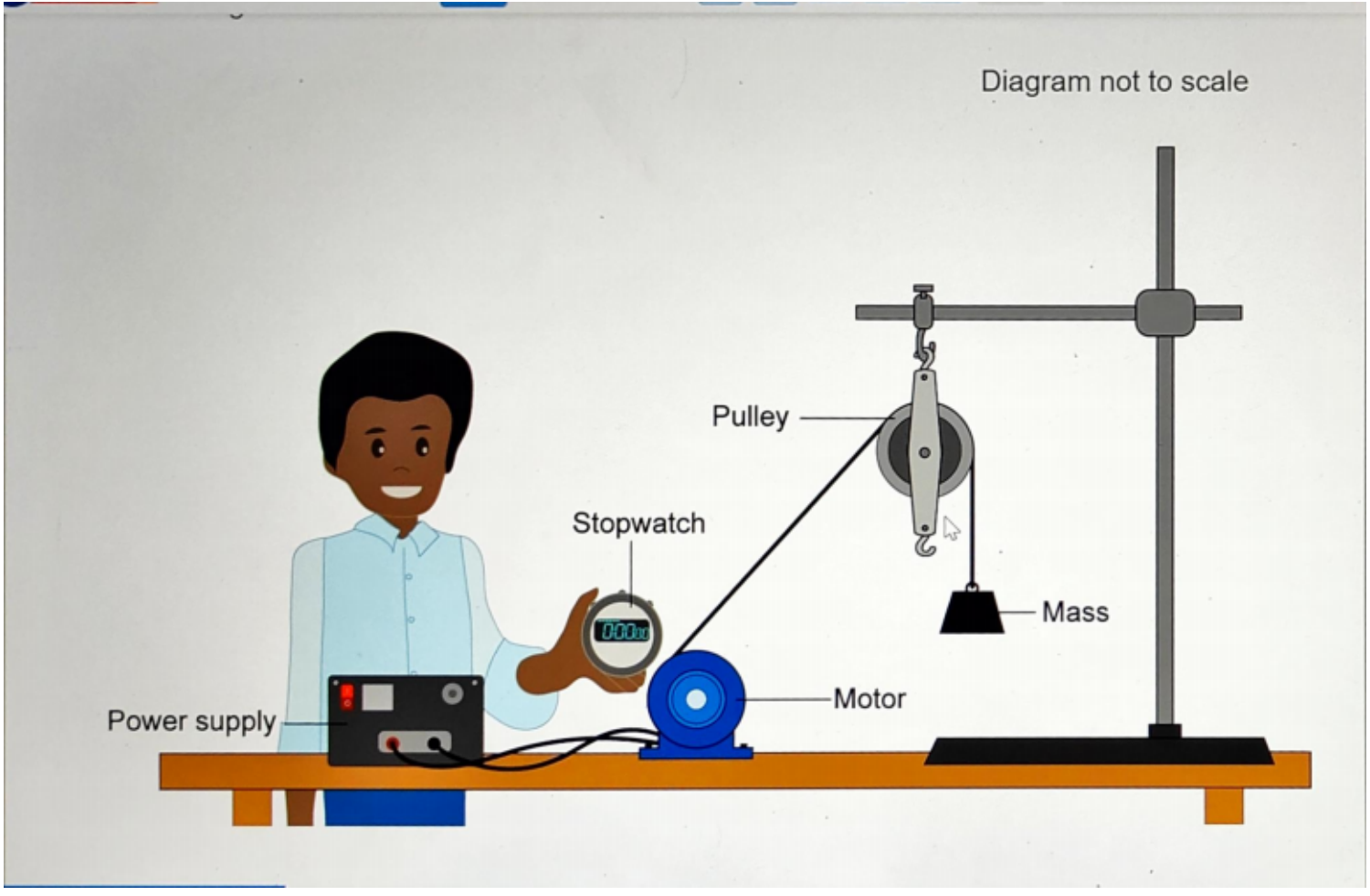


Diagram not to scale
Pulley
Stopwatch
Mass
Motor
Power supply

Question 6a (2 marks)

Calculate the change of gravitational potential energy of a 0.050 kg mass as it is lifted above the table. You assume that the value of $g = 9.81\,N\,kg^{-1}$.

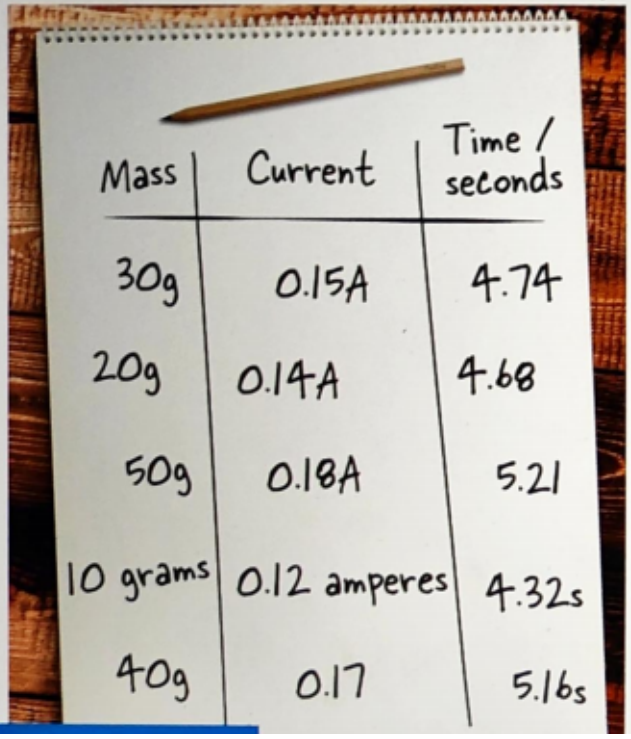
B I | U x_2 x^2 | Ω Σ | Styles

Question 6b (2 marks)

The student used the same supply voltage in every trial of their experiment. **Outline** how this helped to ensure the validity of the data.

B I U x_2 x^2 Ω Σ Styles

The student recorded their raw data in their notebook, as seen below.



Mass	Current	Time / seconds
30g	0.15A	4.74
20g	0.14A	4.68
50g	0.18A	5.21
10 grams	0.12 amperes	4.32s
40g	0.17	5.16s

Organize the student's raw data into a table.

Create New Table

Reset

Question 6d (3 marks)

The student then constructs a processed data table. For each trial, they calculate the power output of the motor and the efficiency of the motor. The voltage supplied to the motor was 2 V in each trial.

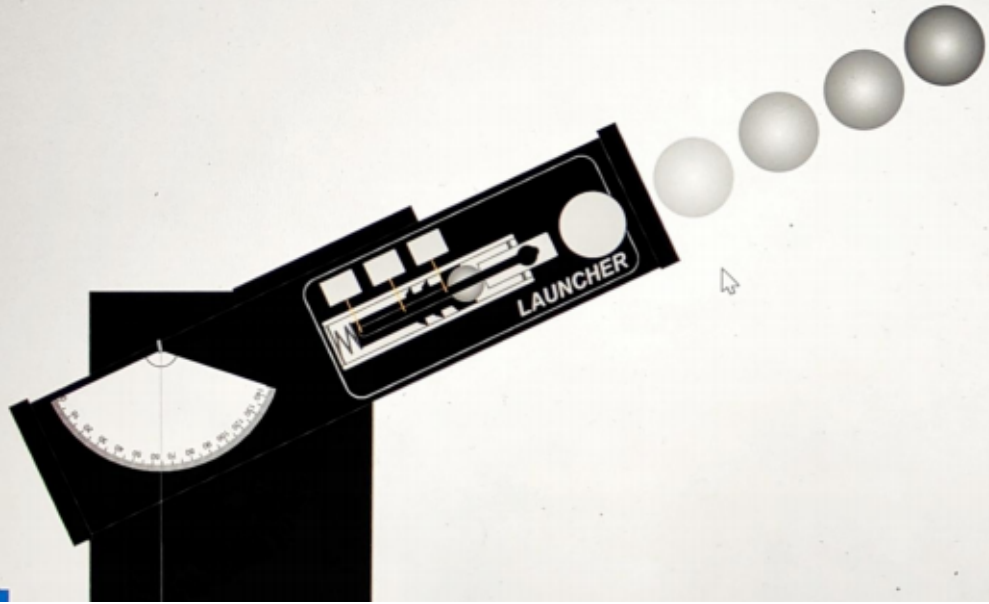
Using data from part (c), **calculate** the total energy output of the motor. Use this value and your answer from part (a) to **calculate** the efficiency of the motor for the trial when the mass was 50 g.

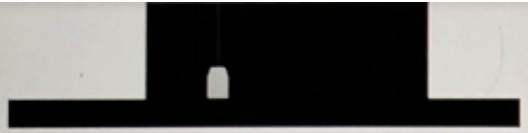
Total energy output:

Efficiency:

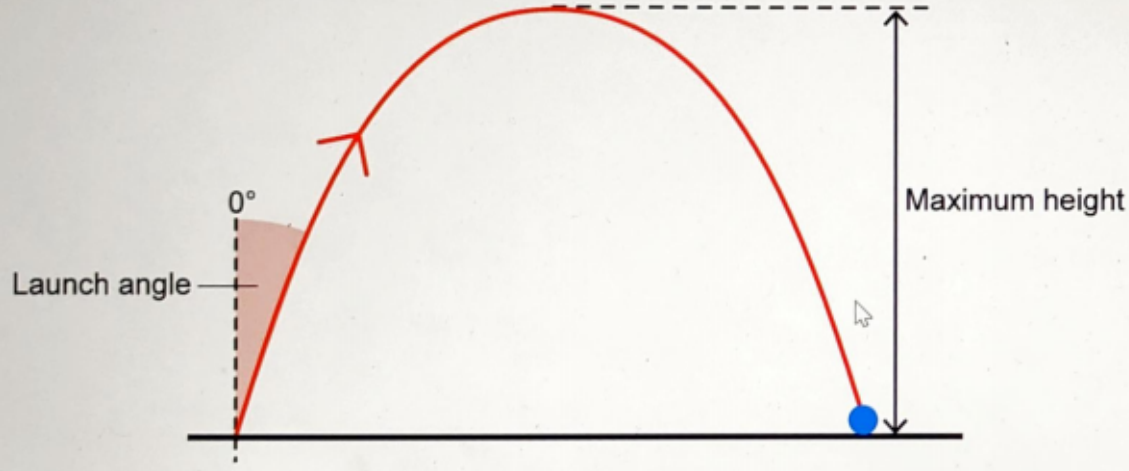
Question 7 (17 marks)

An MYP student is interested in the motion of a ball when it is launched into the air. The student uses a simple device to launch a ball using a compressed spring. Then they measured the maximum height that the ball reached.





They performed one trial for different launch angles, starting from a launch directed vertically upwards which was labelled as zero degrees.



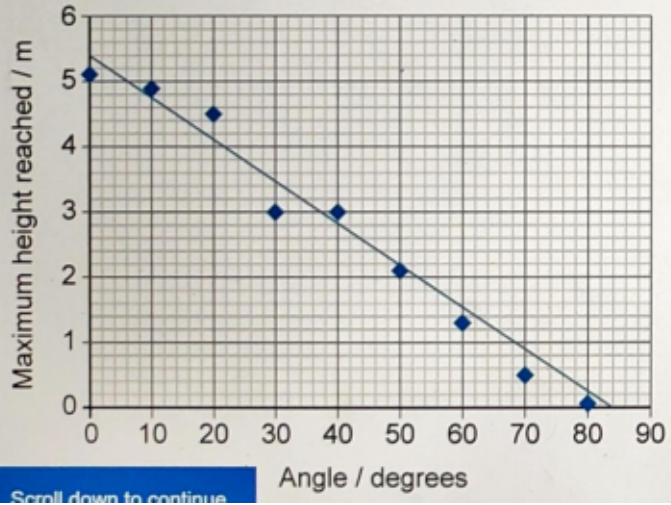
Question 7a (2 marks)

The student plotted this data on a graph and found a line of best fit. This helped the student to identify an outlier in their data when the launch angle was 30 degrees.

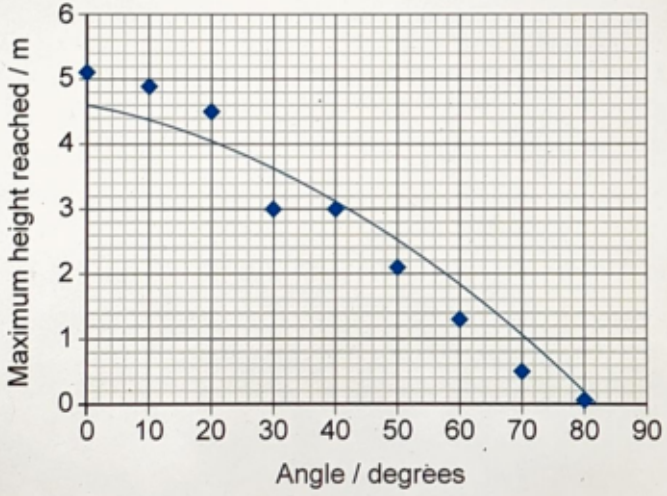
Select the graph that best represents the student's data and **justify** your choice.

Select

Graph A

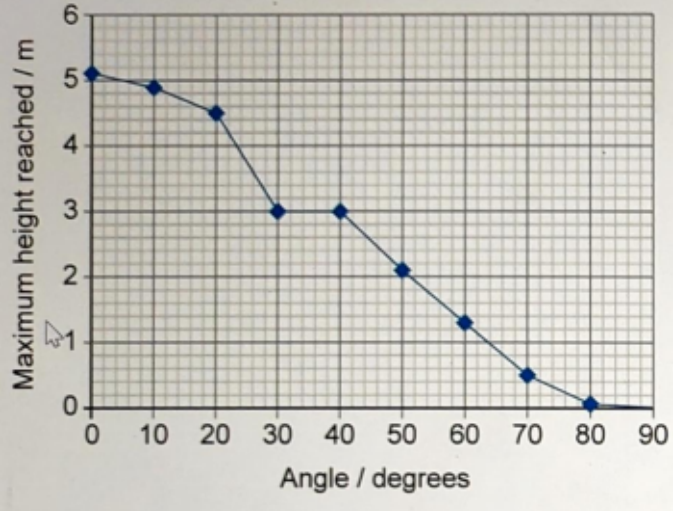


Graph B

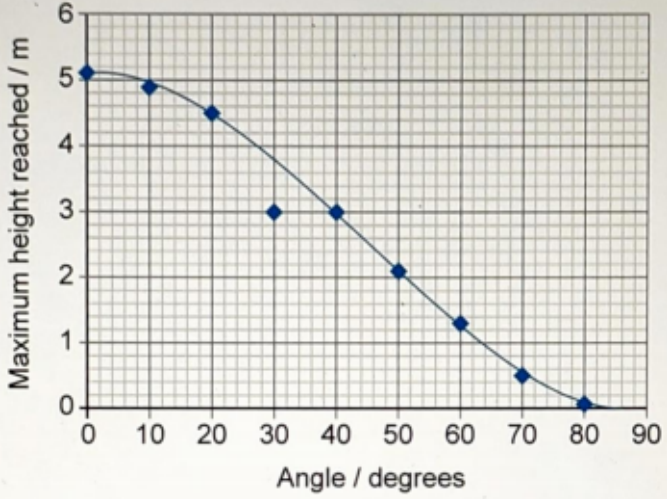


Scroll down to continue

Graph C



Graph D



Justification:

B I U x_2 x^2 Ω Σ Styles

Question 7b (2 marks)

Use the student's results in part (a) to **identify**:

The height reached when the angle was 0 degrees.

The angle when the height reached was 0 metres.

Question 7c (3 marks)

The student had made the following prediction for this investigation:

> *If the angle from the vertical position increases,*
> *then the maximum height reached will decrease in inverse proportion.*

Use the student's results in part (a) to **discuss** the validity of the prediction.

B I U x_2 x^2 Ω Σ Styles

Question 7d (1 mark)

During the experiment, the student measured angle and height. The launching device was set at a specific angle for each trial before the ball was released. The height of the ball was measured by comparing the position of the ball during its flight to a metre ruler that was fixed to the wall. **Select** the most likely source of error in the student's data. **Justify** your answer.

Select

Justification:

B I U x_2 x^2 Ω Σ Styles

Question 7d (1 mark)

During the experiment, the student measured angle and height. The launching device was set at a specific angle for each trial before the ball was released. The height of the ball was measured by comparing the position of the ball during its flight to a metre ruler that was fixed to the wall. **Select** the most likely source of error in the student's data. **Justify** your answer.

Select

Select
height
angle

ion:

B I | U x_2 x^2 | Ω Σ Styles

Question 7e (1 mark)

Suggest one change the student could make to their method to reduce the chance of outliers in the data.

Question 7f (3 marks)

The student conducts additional research to understand their results. They learn that the motion of the ball can be influenced by the force of air resistance.

Select how the height reached by the ball would be affected by the force of air resistance. Use scientific reasoning to **justify** your answer.

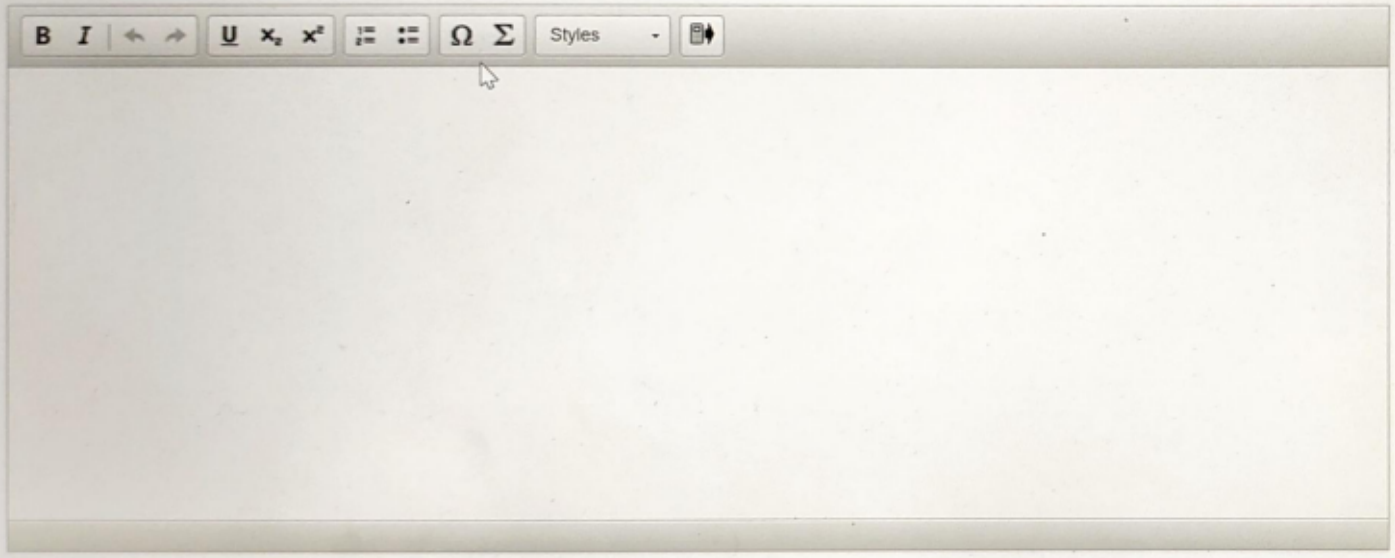
The height reached would be Select due to air resistance.

- Select
- decreased
- increased
- unchanged

Justification:

Question 7g (2 marks)

During this investigation, the student launched a small metal ball as the object. **Suggest** how the shape, size and material of the object would help to reduce the effect of force of air resistance on the results. You should refer to particle theory in your answer.



Question 7h (3 marks)

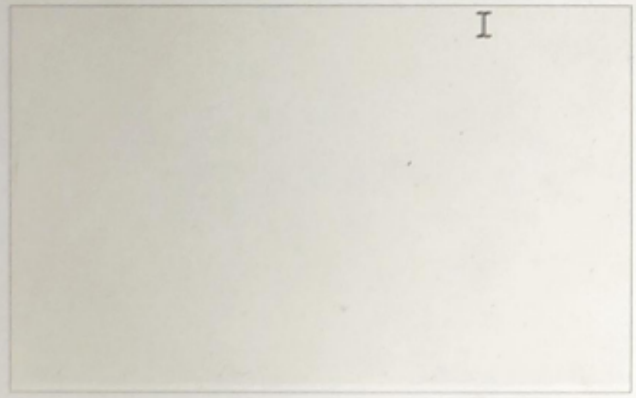
The student is interested in extending their investigation so that they can find out more about the motion of a projectile. **Suggest** another dependent variable that the student could measure together with two control variables. The independent variable is the launch angle.

Independent variable:

Launch angle

Dependent variable:

Control variable 1:



Control variable 2:

Question 8 (24 marks)

Ultrasound waves can be defined as sound waves with a frequency greater than 20 kHz, which is beyond the range of human hearing. A major use of ultrasound waves is in medical imaging systems.

A kidney stone is a hard mass formed in the kidneys that can stop them functioning correctly.

Scroll down to continue

Question 8a (3 marks)

If the speed of ultrasound waves in the human body is 1600 ms^{-1}, and the reflection is detected 1×10^{-4} s after transmission, **calculate** the distance in cm between the kidney stones and the detector.

Question 8b (16 marks)

Ultrasound waves were first used for medical imaging in the 1950s. Before this, x-rays were used as a medical imaging technique. The table below shows some information about these two medical imaging systems.

Ultrasound scans

Ultrasound image of unborn baby inside pregnant woman.

X-ray images

Ultrasound image of unborn baby inside pregnant woman.

X-ray image of woman pregnant with twins.

Uses sound waves to create live images of the organs, muscles and other structures. Heart rates and blood flows can also be viewed and measured.	Uses high-energy electromagnetic waves to create images of bones. Organs, muscles and other structures are imaged with limited detail.
Ultrasound waves can check for blood flow, heart problems, possible problems in the abdomen and kidneys, and investigate some cancerous and non-cancerous growths.	X-rays can check for broken bones and to monitor the healing and treatment of bone problems. They are also used to check the condition of the lungs and check for the presence of some cancerous and non cancerous growths.
The ultrasound scan itself is believed to be harmless.	The absorption of x-rays leads to an increase in risk of developing cancers later in life. The risk is particularly high in younger children. However,

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The ultrasound scan itself is believed to be harmless.	The absorption of x-rays leads to an increase in risk of developing cancers later in life. The risk is particularly high in younger children. However, shielding is used to protect parts of the body not being imaged, and the risk for each x-ray is very small.
Images can be hard to interpret and there is the possibility of a misdiagnosis.	X-ray images are clear and straightforward to interpret.
$500 cost per scan	$150 cost per image
$40 000 cost per machine	$30 000 cost per machine

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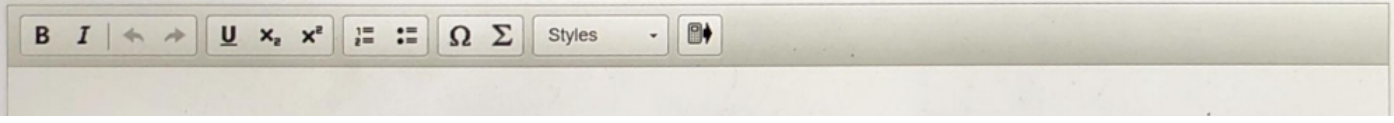
In 2016, the World Health Organization estimated that two-thirds of the global population do not have access to medical imaging facilities. A government of a country with limited access to medical imaging is considering providing free imaging technology for pregnant women.

Discuss and **evaluate** the use of x-rays compared to ultrasound waves in pregnant women. In your answer, you should include:

- an explanation of how the waves create images in each technique
- a discussion of the impacts on human health for each technique
- a discussion of the positive and negative economic implications for the government
- a comment about ethical implications
- a concluding appraisal giving your opinion.



Question 8c (5 marks)

Since the 1960s medical imaging has become much more widespread. Medical imaging has given information about the development of unborn babies, their growth, the functioning of their organs and identification of their sex. Data from the United Nations (UN) has shown a change in the sex ratio at birth since the 1970s. The sex ratio at birth is the number of boys born for every 100 girls born. The expected biological sex ratio is 105 males per 100 females. There is the concern that identification of sex from medical imaging might be selectively used to terminate pregnancies, changing the sex ratio.

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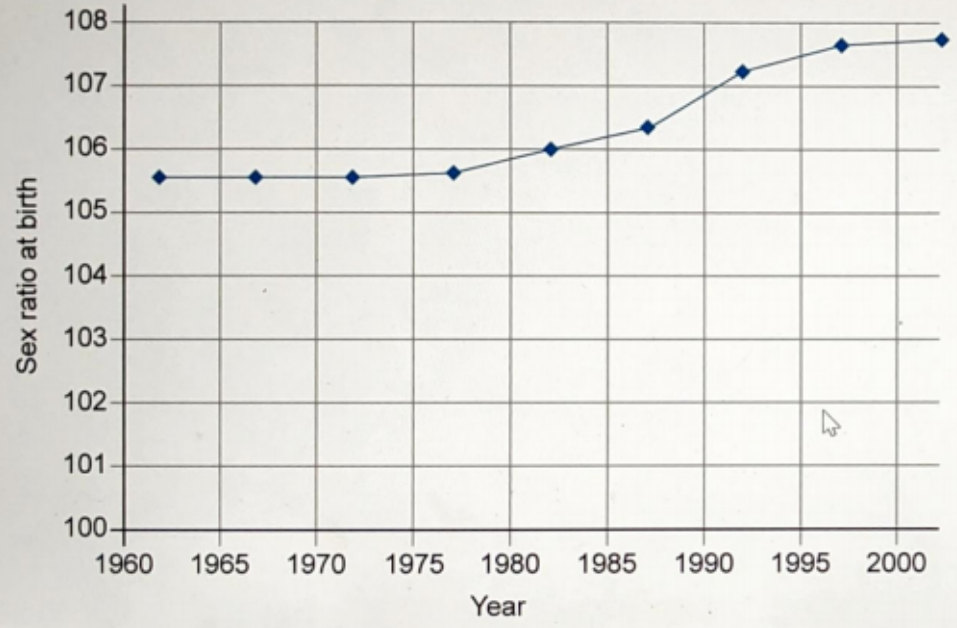

Discuss why there would be a concern to the government of a country which has a large change to the sex ratio at birth and **suggest** an ethical action the government could take to prevent further imbalance in sex ratio at birth.