Question 1 (10 marks)

This question is about astronomy, astrophysics and units.

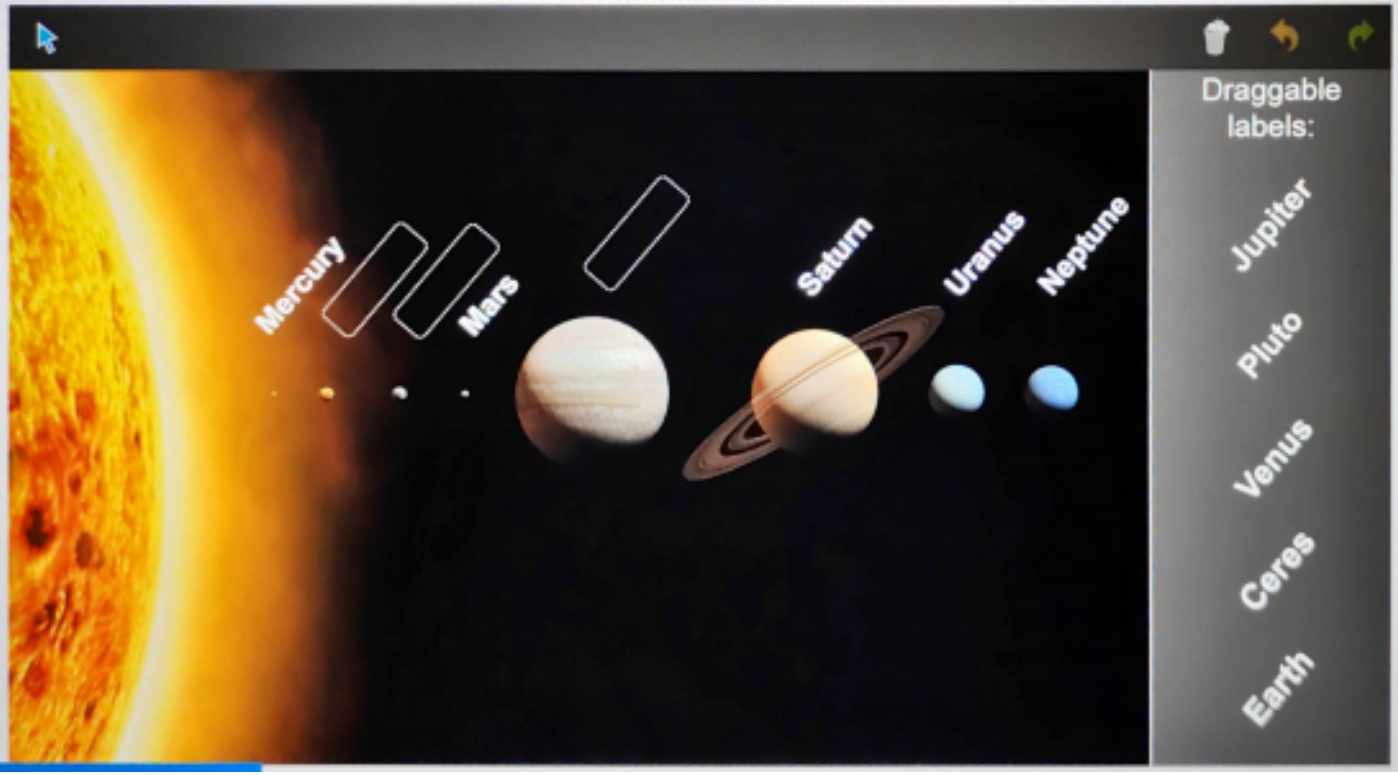
Question 1a (2 marks)

Drag and drop to **select** the correct location for the planet names on the diagram.

Diagram not to scale

Drag and drop to **select** the correct location for the planet names on the diagram.

Diagram not to scale



Question 1b (1 mark)

In addition to the Sun and planets, **state** one type of object **not** made by humans that forms part of the solar system.

B I | Styles

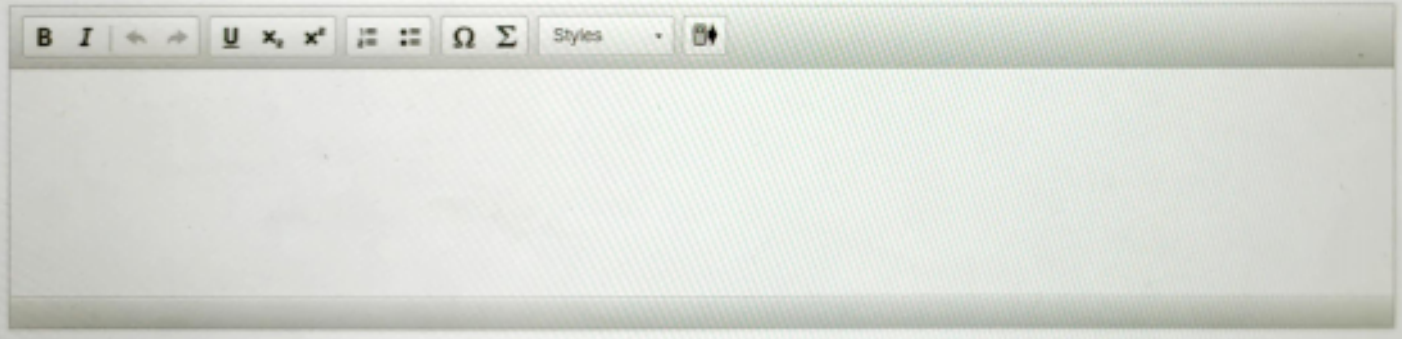
Question 1c (2 marks)

The Sun is a star. **Outline** two differences between a star and a planet.

B I | Styles

Question 1d (3 marks)

Stars and planets are found in huge collections called galaxies. Observations of distant galaxies show that they are moving away from our galaxy. The more distant the galaxy, the greater its speed. From these observations, scientists developed the Big Bang theory. **Describe** the Big Bang theory and how it is supported by these observations.



Question 1e (2 marks)

The closest star to the Earth is *Proxima Centauri* which is 4×10^{16} m away. Astronomers may state this distance as 1.3 parsecs. The parsec is a unit of distance which is not an SI unit.

Suggest an advantage and a disadvantage of using non-SI units in astrophysics.

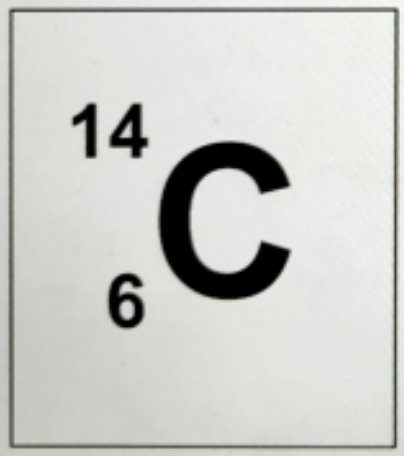
Advantage:

Disadvantage:

Question 2 (8 marks)

This question is about using carbon dating to identify the age of organic matter.

An atom of carbon-14 is represented as:



Question 2a (2 marks)

Determine the number of protons and the number of neutrons in a nucleus of carbon-14.

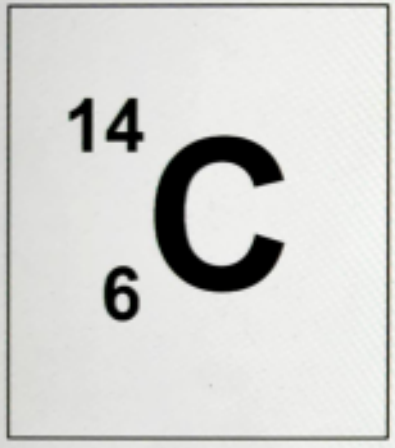
Number of protons:

B I U x_2 x^2 Ω Σ

Styles

Scroll down to continue

An atom of carbon-14 is represented as:



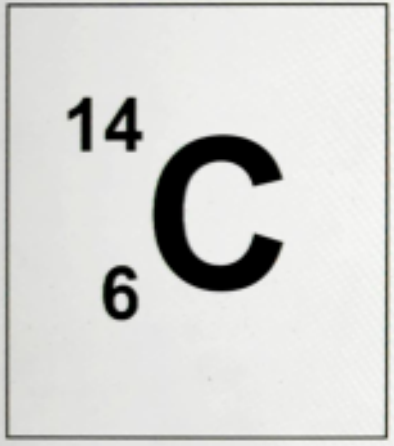
Question 2a (2 marks)

Determine the number of protons and the number of neutrons in a nucleus of carbon-14.

Number of protons:

Number of neutrons:

An atom of carbon-14 is represented as:



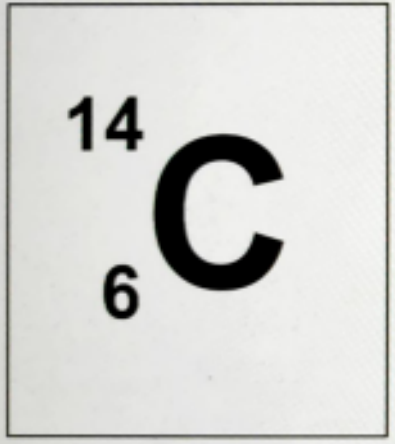
Number of neutrons:

Styles

Question 2b (2 marks)

Carbon-14 is an unstable isotope.
It decays to nitrogen-14. **Select** the type of
decay process and **state** one product of

An atom of carbon-14 is represented as:



Question 2b (2 marks)

Carbon-14 is an unstable isotope.
It decays to nitrogen-14. **Select** the type of decay process and **state** one product of this decay, apart from the nitrogen-14 nucleus that is formed.

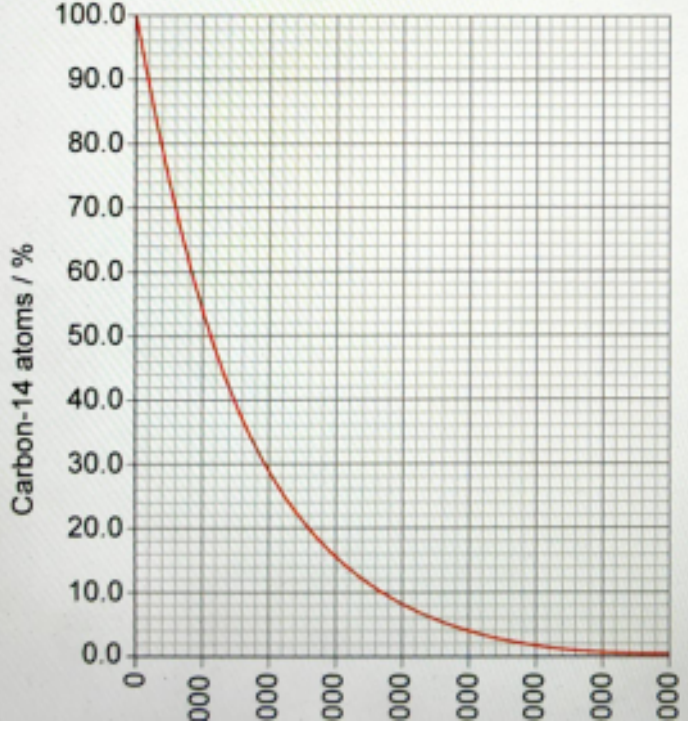
Select

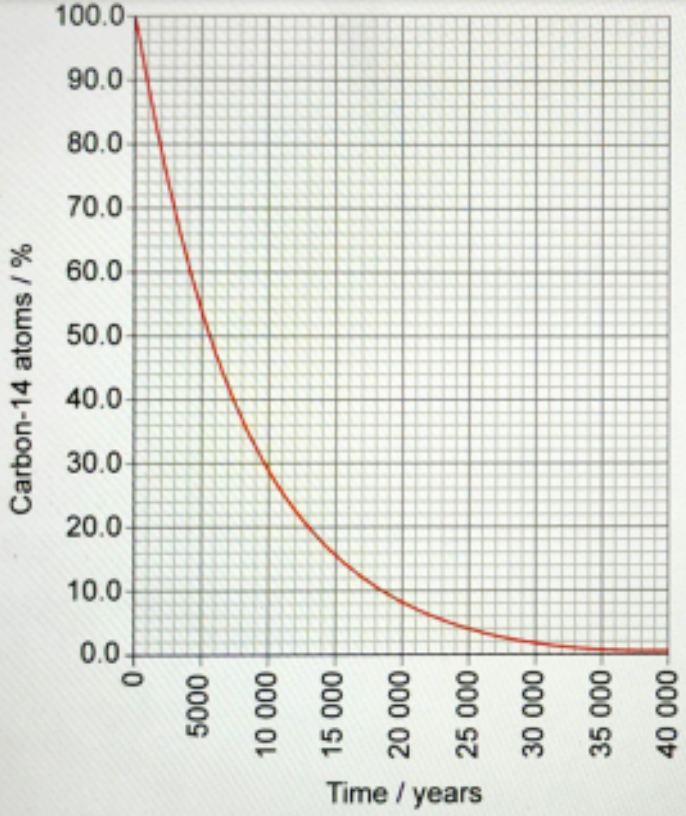
B I U Ω Σ

Styles

Question 2c (1 mark)

The graph below shows the percentage of carbon-14 atoms remaining as a sample decays over time.





Using the graph, **determine** the half-life of carbon-14.

Question 2d (1 mark)

Living things contain a large number of carbon atoms. The proportion of carbon-14 atoms compared to the total number of carbon atoms stays constant until they die. If an ancient sample of wood contains 20% of the carbon-14 possessed by living things, use the graph to **determine** the approximate age of the sample.

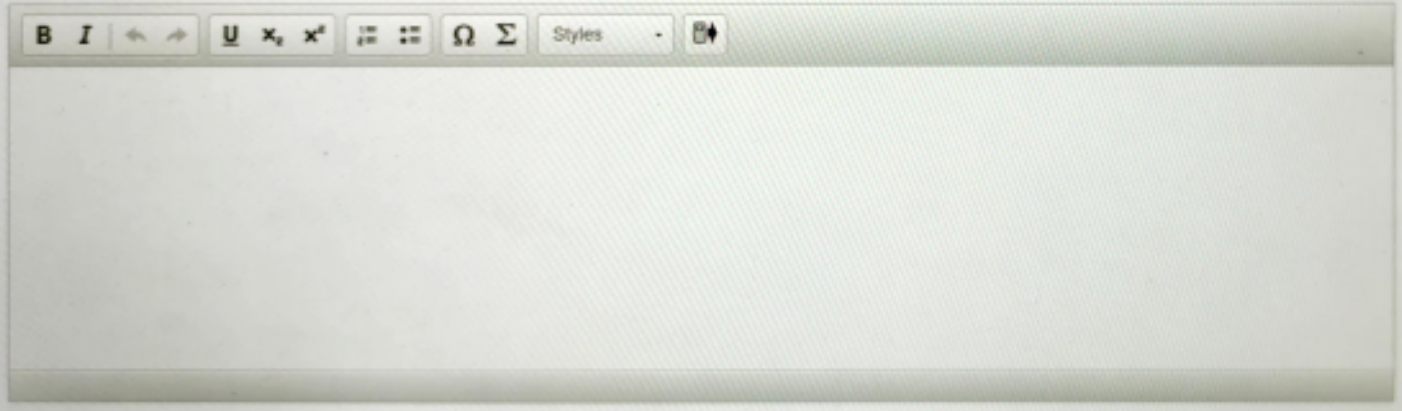
B I U x_2 x^2 Ω Σ Styles

Question 2e (2 marks)

A student makes the following claim:

> Carbon-14 dating has shown that dinosaur bones are over 65 million years old.

Use the graph in part (c) to **evaluate** this statement.



Question 3 (9 marks)

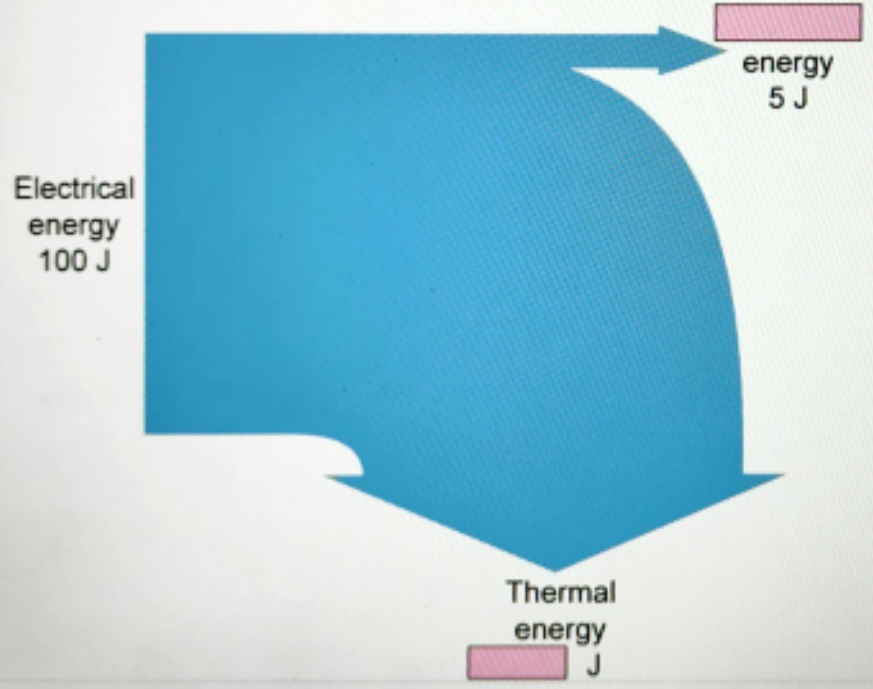
A student decides to compare the efficiency of modern lightbulbs using Light Emitting Diodes (LEDs) to older filament lightbulbs.

LED bulb

Filament bulb

Question 3a (2 marks)

Label the Sankey diagram for a filament light bulb by writing in the text boxes.

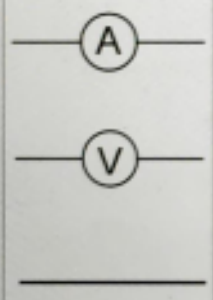


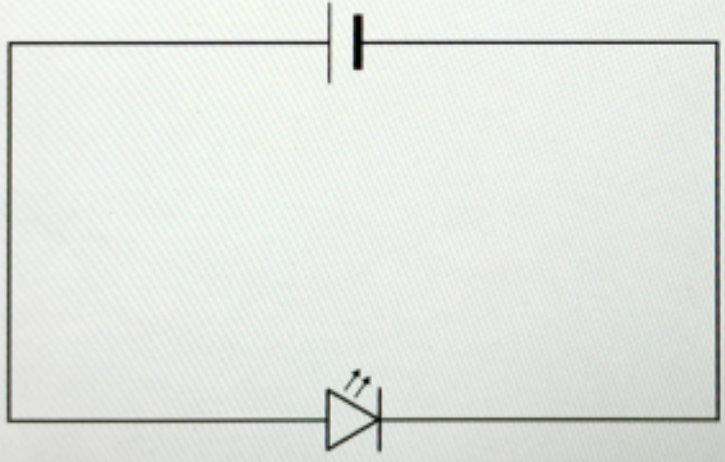
Question 3b (2 marks)

The student uses the circuit below to investigate an LED.

Design a circuit to measure current through the LED and the voltage across the LED.

Draggable items:





Question 3c (2 marks)

The student takes measurements using her circuit and finds that the current through the LED is 0.05 A when the voltage is 1 V. Use information on the formula sheet to **calculate** the power of the LED.

B I U x_2 x^2 Ω Σ Styles

Question 3d (3 marks)

The LED emits 0.02 W of light. Using information from part (a) and your answer to part (c), **compare** the efficiency of an LED with that of a filament bulb.

B I U x_2 x^2 Ω Σ Styles

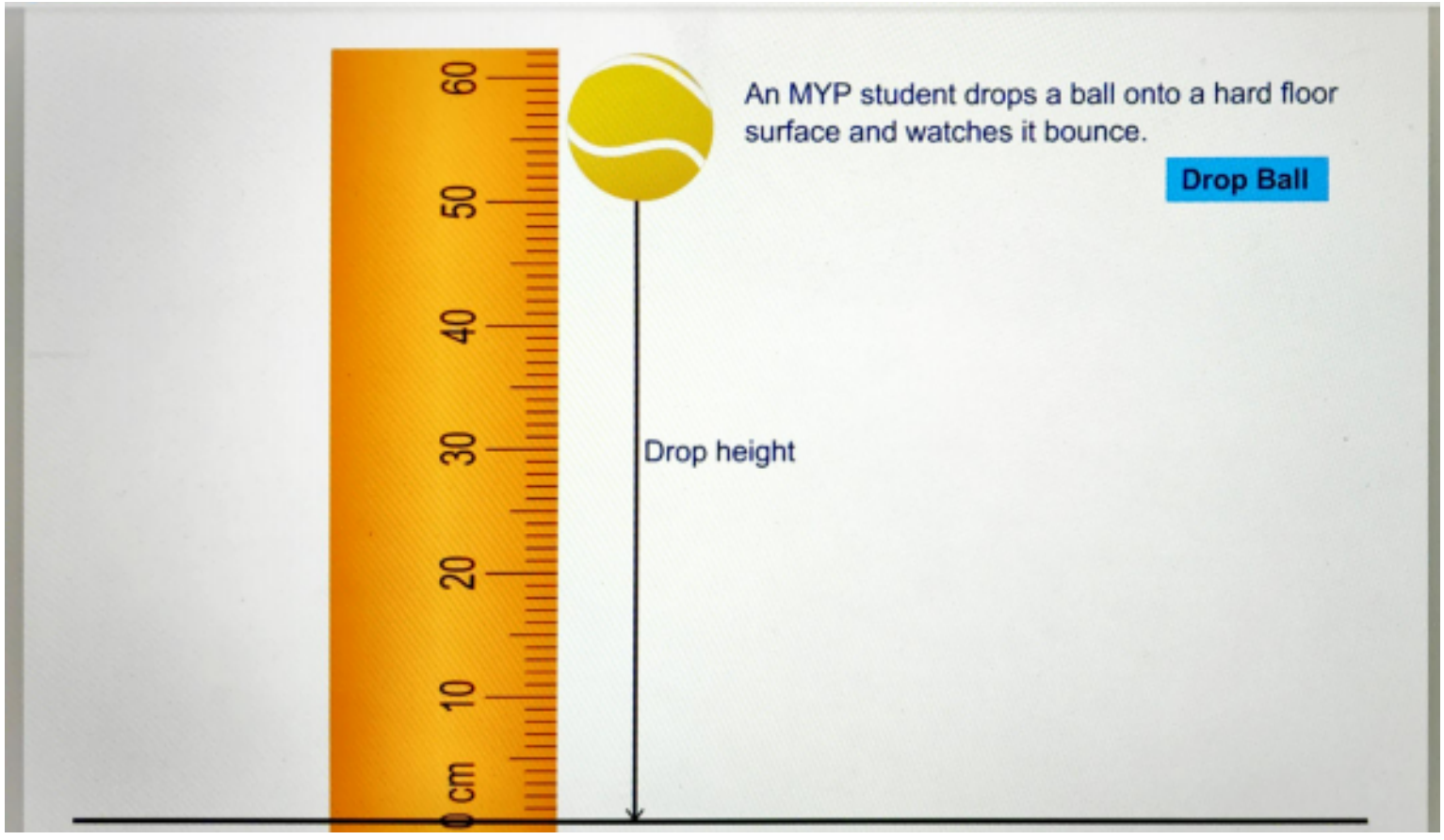
Question 4 (18 marks)

A student wants to study the motion of balls when they bounce. The student decides to find out how the height the ball is dropped from affects the height of the first bounce by carrying out an investigation. The animation below gives some information about the student's investigation.

An MYP student drops a ball onto a hard floor surface and watches it bounce.

Drop Ball

Drop height


60
50
40
30
20
10
0 cm
An MYP student drops a ball onto a hard floor surface and watches it bounce.
Drop Ball
Drop height

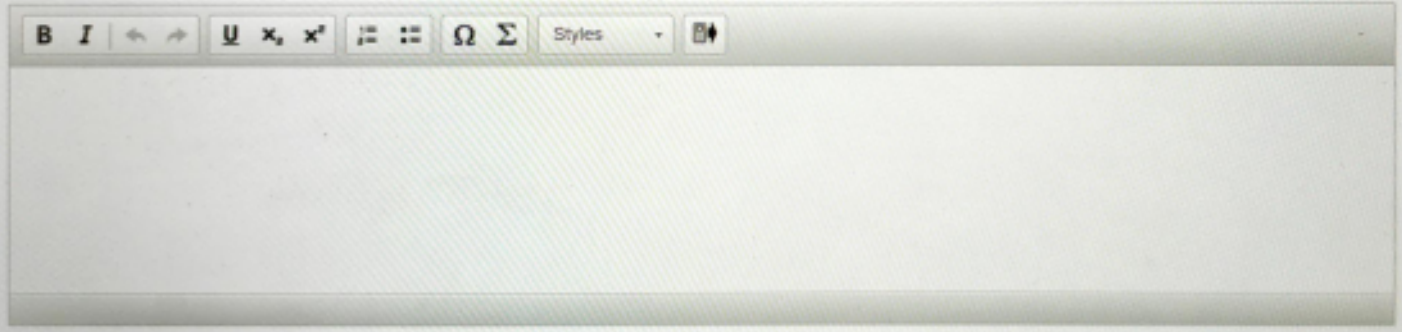
She notices that the height of the first bounce is not the same as the drop height.

She considers the different factors that could affect the height the ball bounces to.

Reset

Question 4a (1 mark)

State a research question that would be addressed by this investigation.



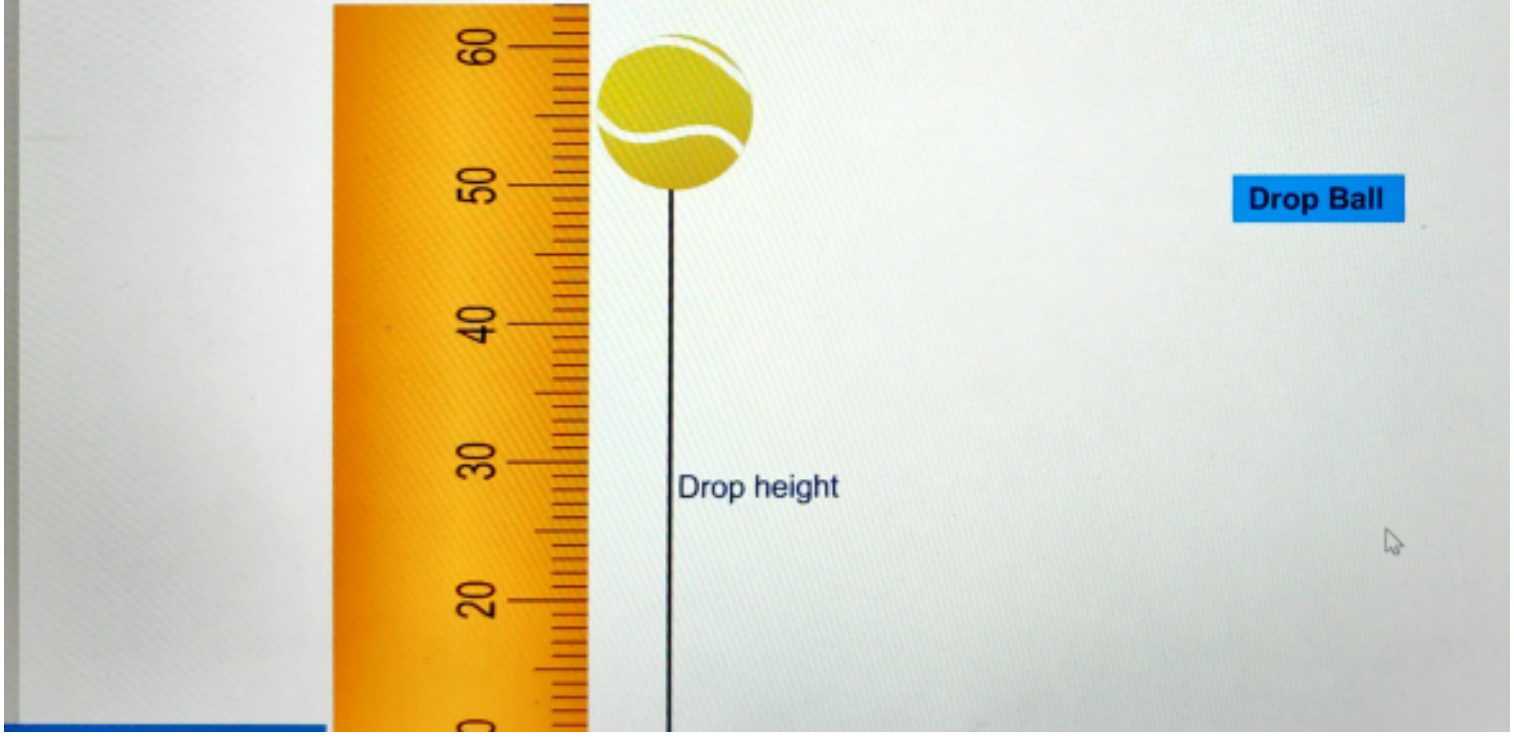
Question 4b (3 marks)

Classify the variables for this investigation by completing the table below.

	Independent variable	Dependent variable	Control variable
Height of the first bounce	☐	☐	☐
The kind of ball used	☐	☐	☐
Surface that the ball bounces from	☐	☐	☐
Drop height	☐	☐	☐
Temperature of the ball	☐	☐	☐

Question 4c (2 marks)

The simulation below shows how data was collected by the student's experiment.



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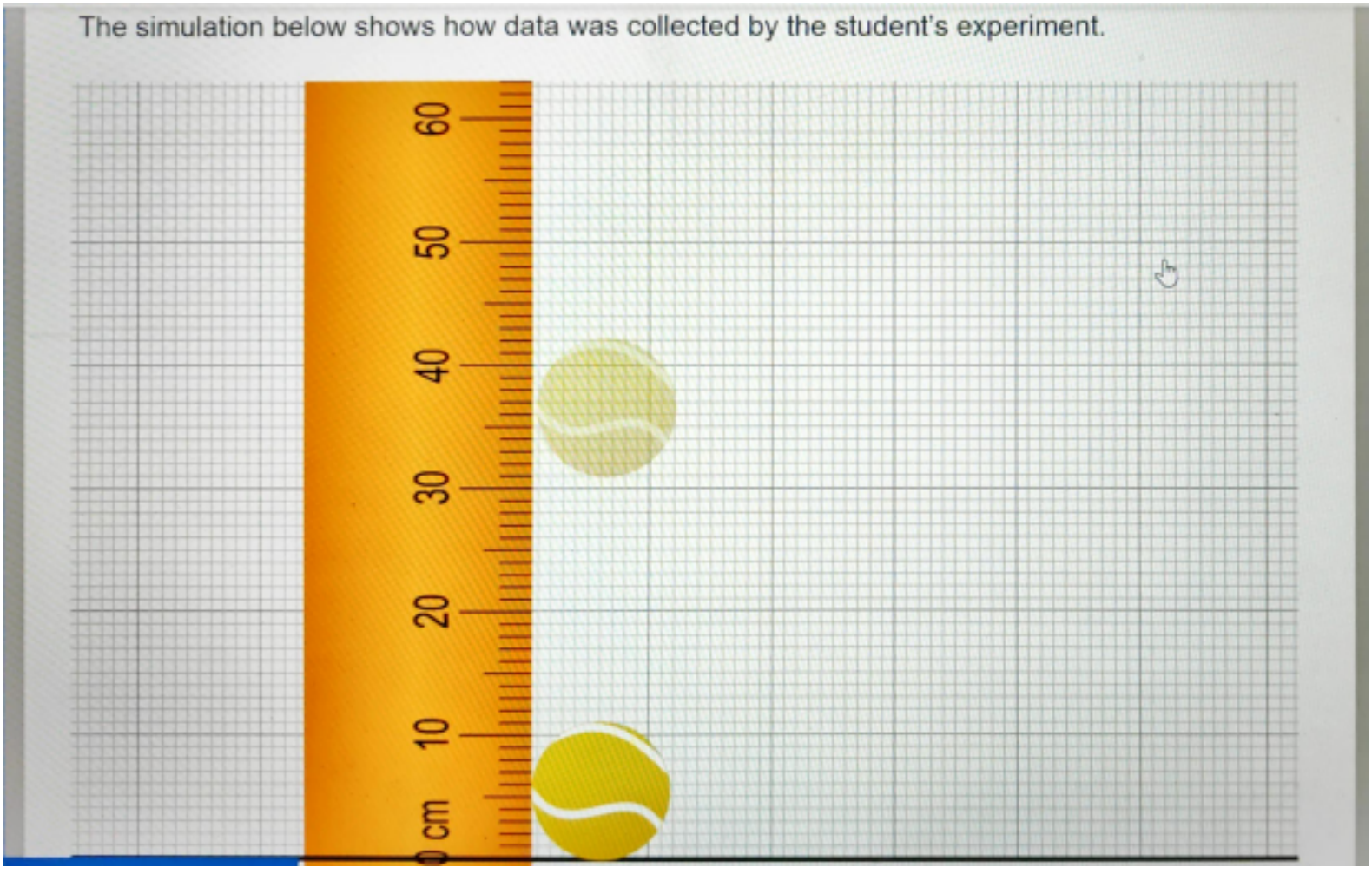
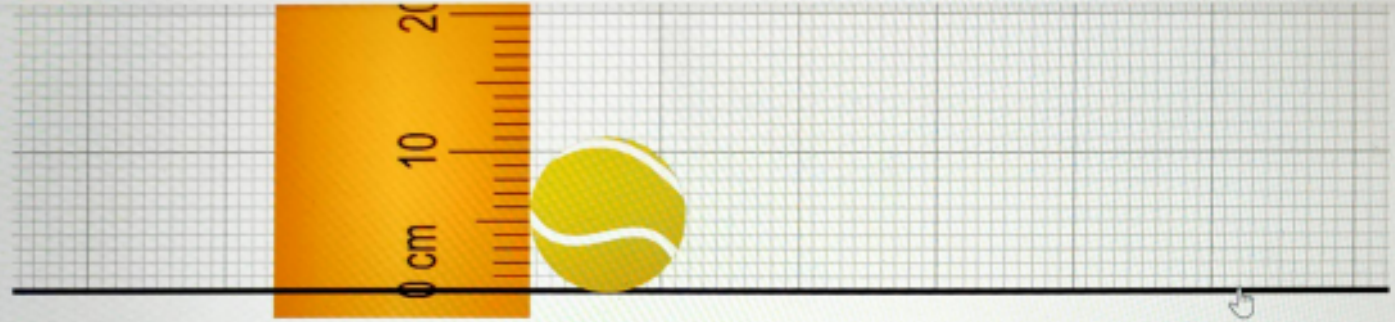




Reset

State the height of the bounce.

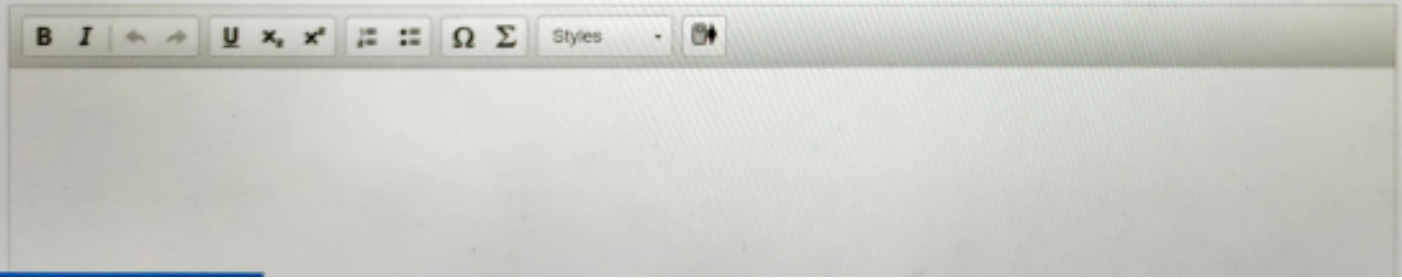
B I U x_2 x^2 Ω Σ Styles

Question 4d (3 marks)

The student starts to write an explanation for what they think happens to a ball when it bounces but the work is unfinished:

> The reason that the height of the first bounce of a ball is different to the drop height is because of the energy transformations that occur…

Use the concept of energy transformations to **explain** why the height of the first bounce is not the same as the drop height.



Question 4e (2 marks)

The student collects data that is presented in the table below:

Calculate the missing average height and add it to the table.

Drop height / m	Height of first bounce / m			
	Trial 1	Trial 2	Trial 3	Average
0.40	0.25	0.27	0.25	
0.80	0.43	0.42	0.45	0.43
1.20	0.66	0.64	0.65	0.65
1.60	0.80	0.80	0.81	0.80
2.00	0.93	0.92	0.95	0.93

Question 4f (2 marks)

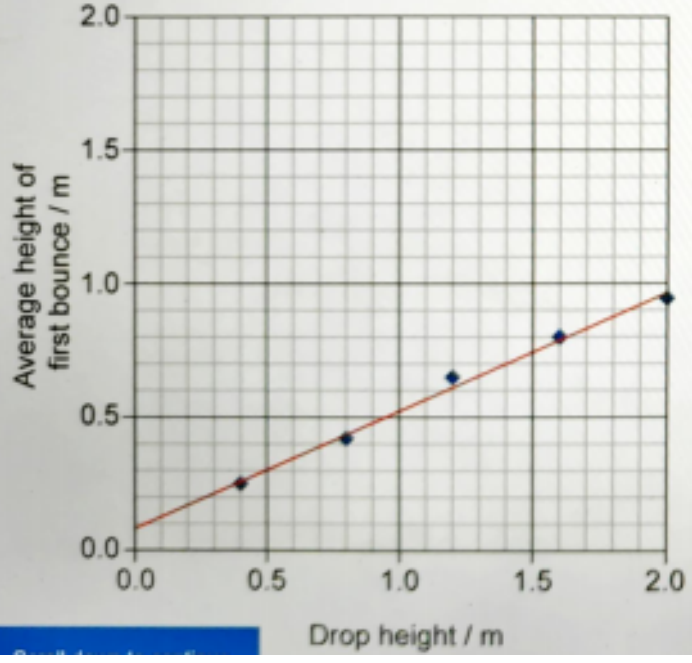
Outline why multiple trials were performed in this investigation and why this would lead to more reliable results.

B I U x_2 x^2 Ω Σ Styles

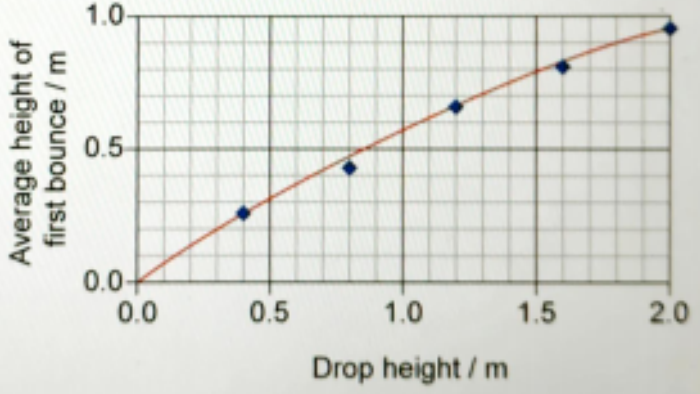
Question 4g (2 marks)

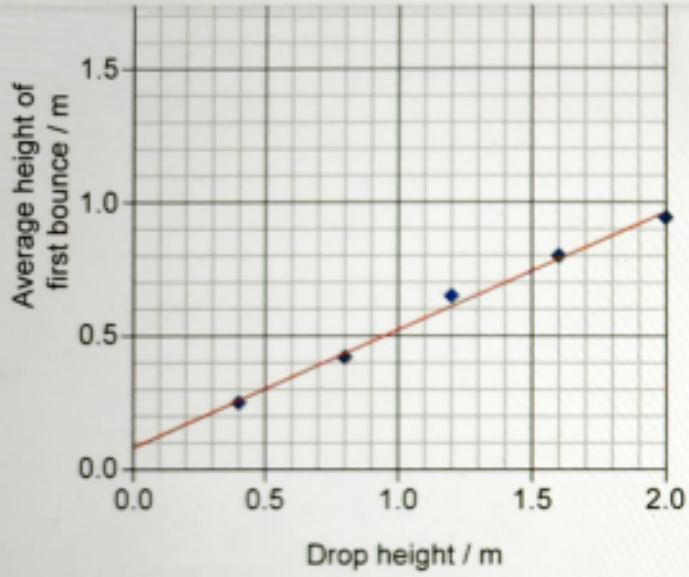
Two graphs of the student's results are shown below. The data plotted on each graph are the same but the scaling and trendline chosen for each graph is different.

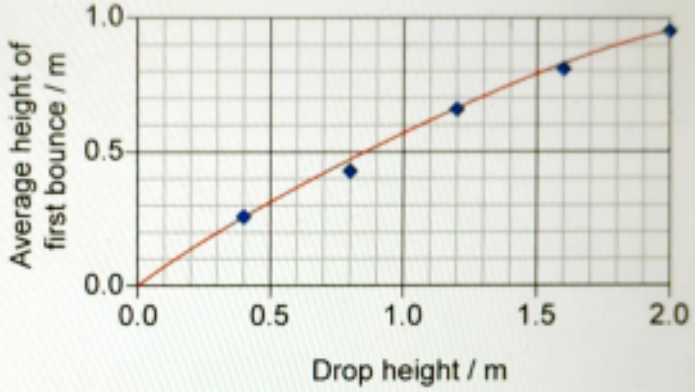
Graph A



Graph B







Identify which graph shows more clearly the relationship between the variables. **Justify** your answer.

Select

Select
Graph A
Graph B

n:

B I U Styles

Drop height / m

Identify which graph shows more clearly the relationship between the variables. **Justify** your answer.

Select

Justification:

B I U x_2 x^2 Ω Σ Styles

Question 4h (3 marks)

Before collecting data, the student made the following prediction:

> As the drop height increases, the height of the first bounce will also increase.
> There will be a proportional relationship between the variables.

Use the graphs in part (g) to **evaluate** the student's prediction.

B I U x_2 x^2 Ω Σ Styles

Question 5 (14 marks)

Another student in the same class is doing a similar investigation. They do some research and read about a quantity called the coefficient of restitution.

The video has information about the coefficient of restitution.

Video | Script

When two objects collide their velocities change. Energy transformations also take place.

The velocities of each object involved in a collision can be used to calculate a value known as the coefficient of restitution, *e*.

When a ball bounces there is a collision between the ball and the ground.

For bouncing a ball, *e* can be calculated using speed instead of velocity. *e* is calculated by dividing the speed of the ball after the collision by the speed of the ball before the collision.

The quantity, *e*, has no units.

When $e = 1$, this means that the ball has the same speed after the collision as it had before the

Video Script

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The quantity, e, has no units.

When $e = 1$, this means that the ball has the same speed after the collision as it had before the collision.

This relationship can be written using heights instead of speeds.

Question 5a (1 mark)

The student decides to calculate the coefficient of restitution (e) as part of their data processing.

For a bouncing ball investigation, e can be calculated using the relationship:

$$e = \sqrt{\frac{\text{height of first bounce}}{\text{drop height}}} = \sqrt{\frac{h_2}{h_1}}$$

Suggest why this student would find it easier to measure height than measure the speed of the ball in order to calculate e.

B I U x_2 x^2 Ω Σ Styles

Question 5b (1 mark)

State what would be observed if $e = 0$ for the ball.

B I U x_a x^a Ω Σ Styles

Question 5c (6 marks)

The student's table of processed data is shown below.

Drop height (h_1)	Average height of first bounce (h_2) / m	Coefficient of restitution (e)
50.0 cm	0.34	0.82
2.50m	1.44	0.76
1.50m	0.94	0.79
2.00m	1.21	
1.00m	0.65	0.806

There are many errors in the way this student has presented their data.

Present the data in the correct format.

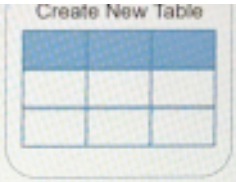
Calculate the *e* value for a drop height of 2.00 m and add your value to the table.

B I U x_2 x^2 Ω Σ

Styles

Create New Table

There are many errors in the way this student has presented their data.



Reset

Question 5d (3 marks)

Before collecting this data, the student wrote the following hypothesis:

> The coefficient of restitution, *e*, will not be affected by the drop height. The value of *e* will be constant as it depends on the material the ball is made from and not on the drop height.

Use the table of processed data in part (c) to **evaluate** the student's hypothesis.

Question 5e (3 marks)

A collision with an *e* value of 1 is known as a perfectly elastic collision. This means that all of the kinetic energy of the system is conserved and none is converted to other forms.

A student in the class made the following statement:

> A collision with an *e* value of 0.5 means that 50 % of the kinetic energy of the ball is converted to other forms of energy.

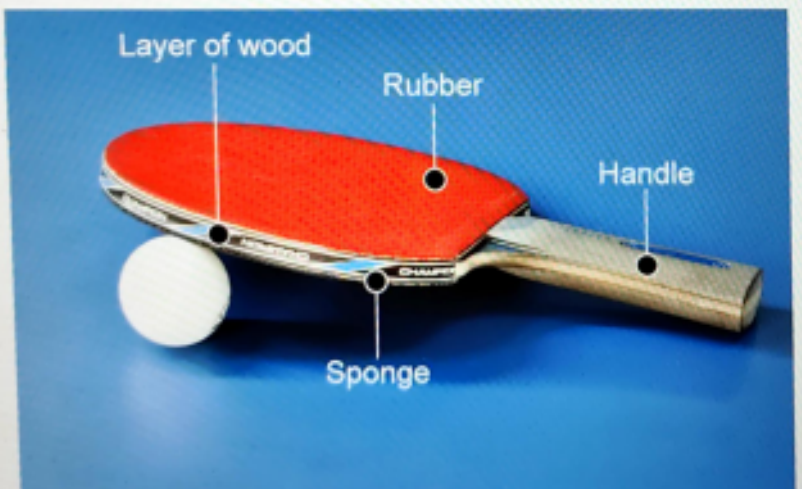
Use the equation for kinetic energy from the formula sheet and the equation below to **evaluate** the statement made by the student.

$$e = \frac{speed\ after\ collision}{speed\ before\ collision} = \frac{v_2}{v_1}$$

B I U x_2 x^2 Ω Σ Styles

Question 6 (18 marks)

The game of table tennis or ping pong involves hitting a plastic ball with a wooden racket. The racket is usually made from wood covered with a layer of sponge and rubber on top. The thickness of the sponge layer depends on the choice of the player. Some players prefer a thick layer of sponge and other players prefer a thin layer. The thickness can vary from no sponge to a thickness of around 2.5 mm.



Scroll down to continue

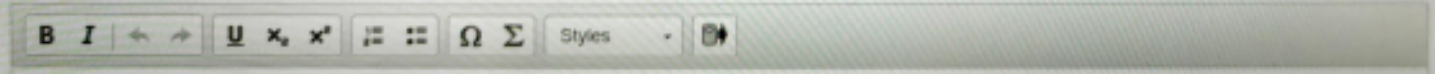
Question 6a (14 marks)

A student is interested in how the bounce of a table tennis ball is affected by the thickness of the sponge layer on the racket. They decide to put a table tennis racket on the floor, drop table tennis balls onto the racket and measure the height of the first bounce.

Use the student's idea to **design** an investigation to find out how the thickness of the sponge layer on a table tennis racket affects the height of the first bounce.

In your plan you should include:

- the independent and dependent variables together with the justification of **one** control variable
- a hypothesis for your investigation including a scientific explanation
- a list of equipment you will use
- how you will collect sufficient data
- a method detailing the procedure you will follow.



Question 6b (4 marks)

In question 4 you considered the effect of drop height on bouncing balls and in part (a) of this question you considered the effect of the sponge layer on a table tennis racket.

Suggest an investigation into another factor that could affect the height of bounce of a ball. In your answer you should include a research question and independent and control variables. The dependent variable is the height of first bounce, this has been completed for you.

Research question:

Independent variable:

Dependent variable:

Height of the first bounce

Control variable 1:

Control variable 2:

Question 7 (10 marks)

Houses in cold climates are usually heated to provide a comfortable living environment. Passively heated houses are designed to lower the energy required for heating. In passively heated houses, the amount of heat lost to the surroundings is greatly reduced compared to houses which are actively heated. Passively heated houses are built to standards that guarantee their quality and performance. The video below gives some more information about passively heated houses.

Video | Script

In many parts of the world with cold climates, people need to heat their houses to maintain a comfortable living environment. This can result in them spending large amounts of money or using significant resources. An alternative is to spend money on adapting the design of their house to be more energy efficient.

Passively heated houses are designed to lower the energy required for heating. In passively heated houses, the amount of heat lost to the surroundings is greatly reduced compared to houses which are actively heated.

Video Script

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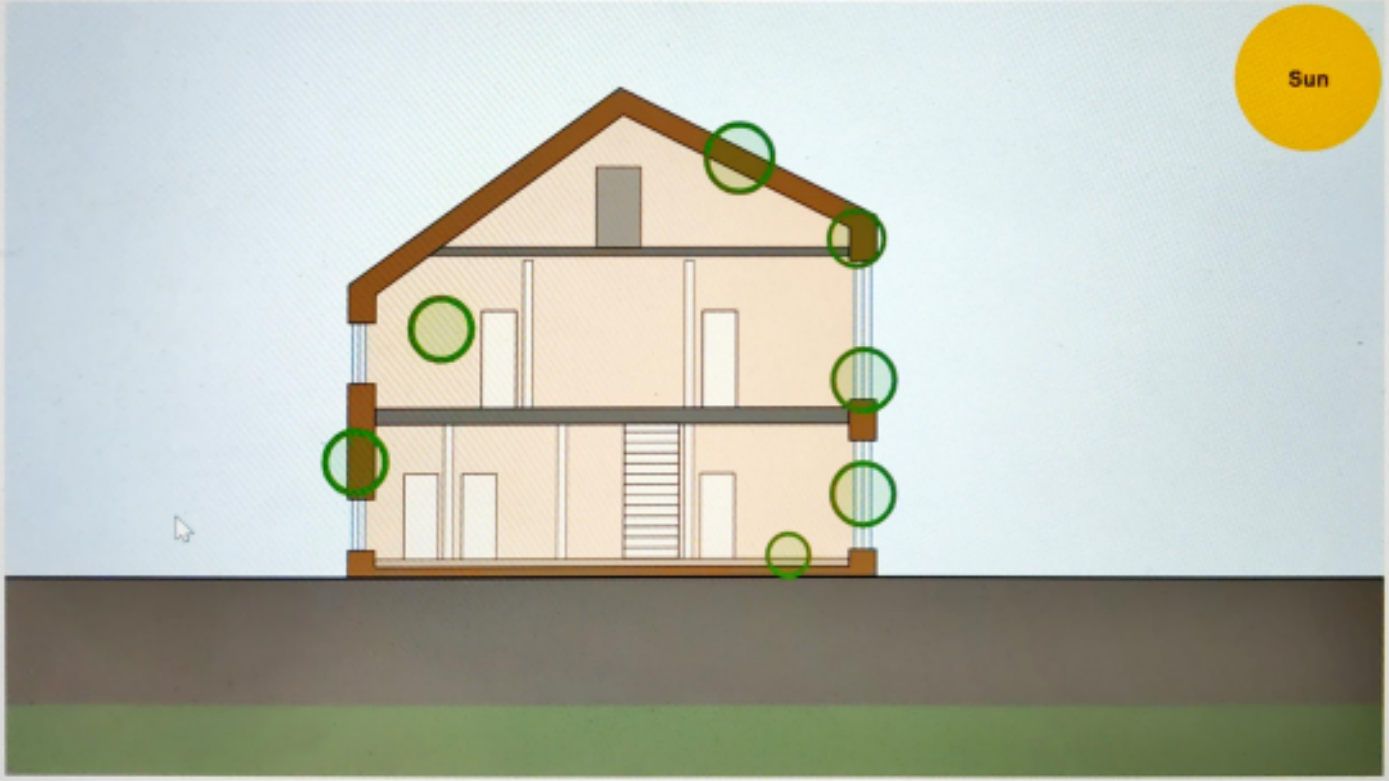
Passively heated houses are designed to lower the energy required for heating. In passively heated houses, the amount of heat lost to the surroundings is greatly reduced compared to houses which are actively heated.

Windows in a passively heated house are positioned to allow sunlight to enter for as much of the day as possible. The direction of the windows will depend on the country in which the house is located.

The walls, floor, windows, roof and doors are all designed to minimize the flow of heat out of the house. Thermal bridges are created when solid components directly connect the inside and outside of a house. In a passively heated house, the walls will be insulated as much as possible and include some gaps to avoid creating thermal bridges.

A mechanical air ventilation system circulates air from rooms where heat is produced, for example the kitchen, and distributes it so that the entire house is maintained at a consistent, comfortable temperature.

This media is interactive



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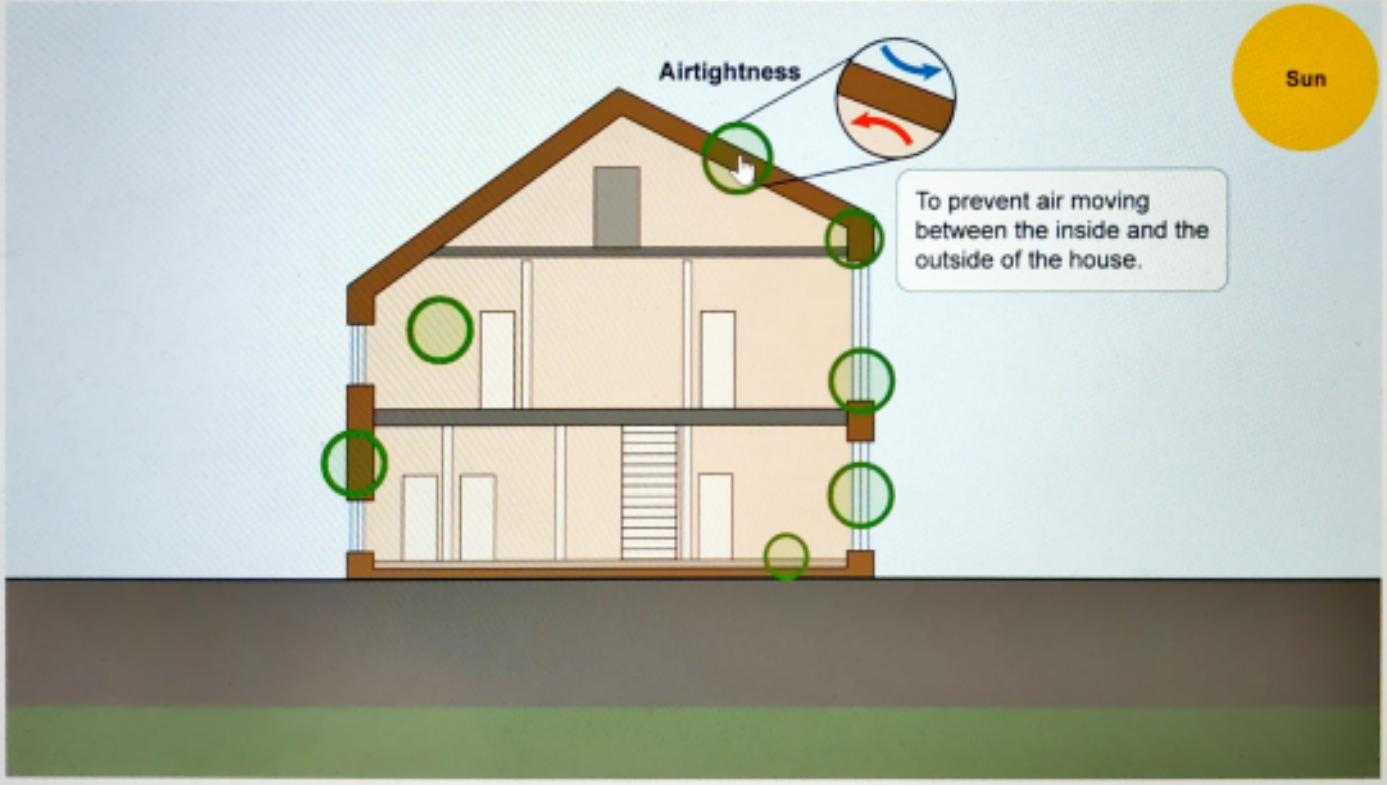

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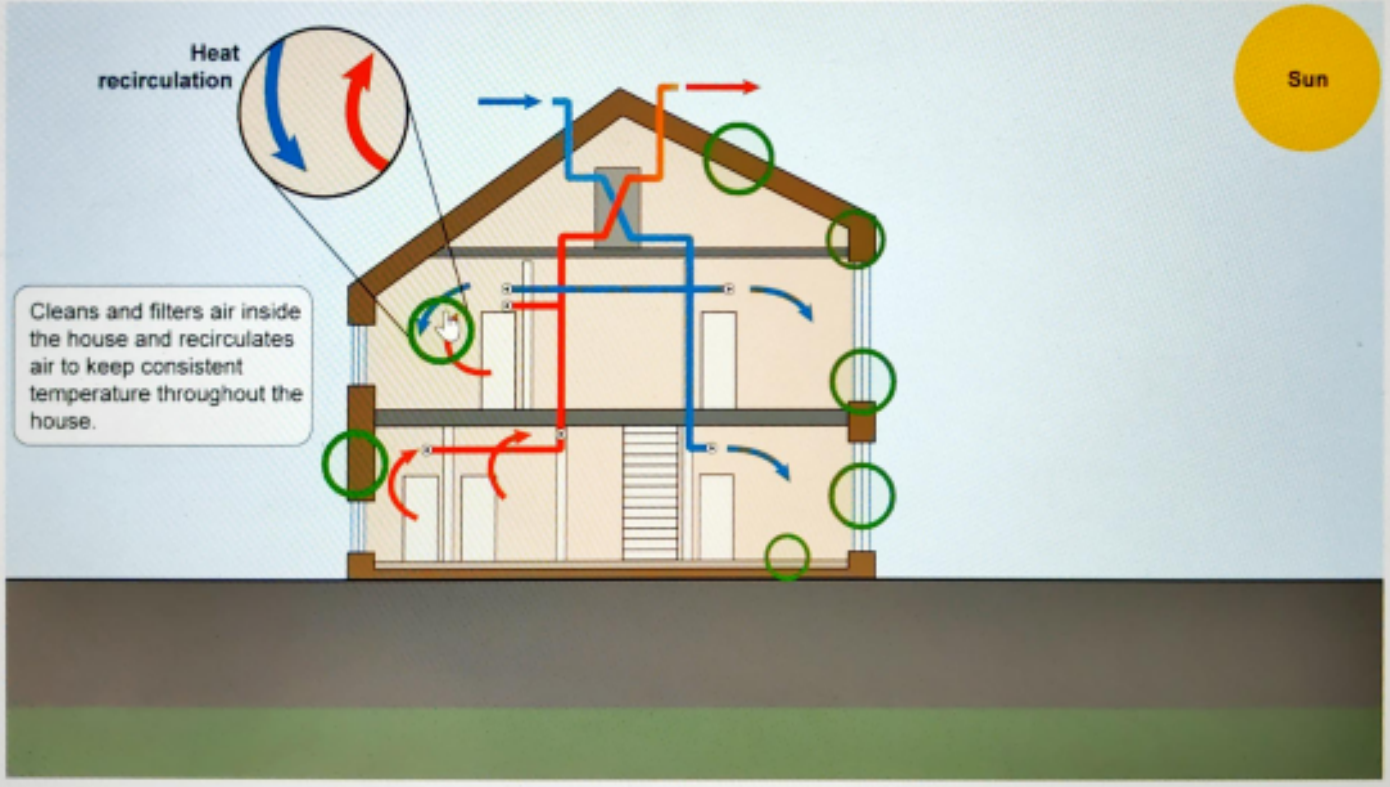

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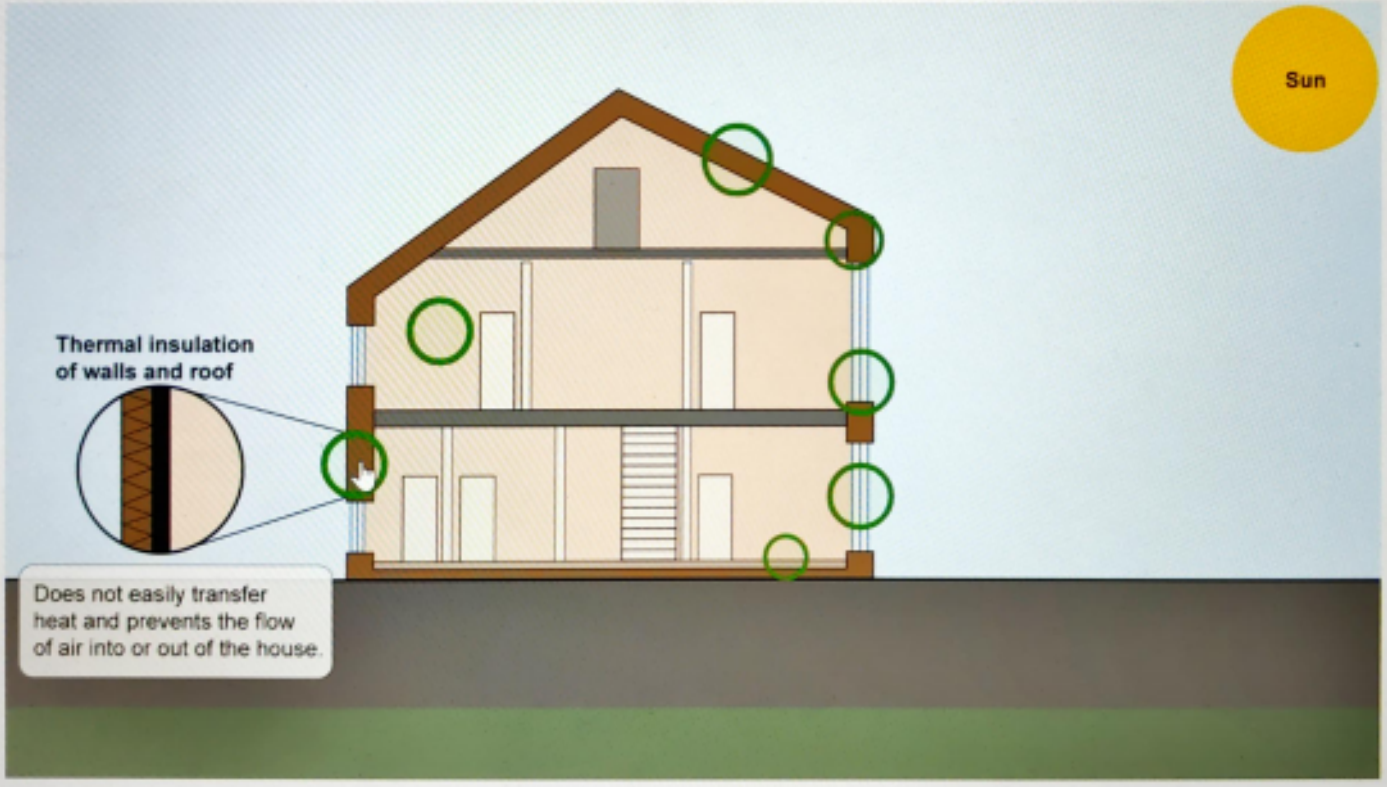

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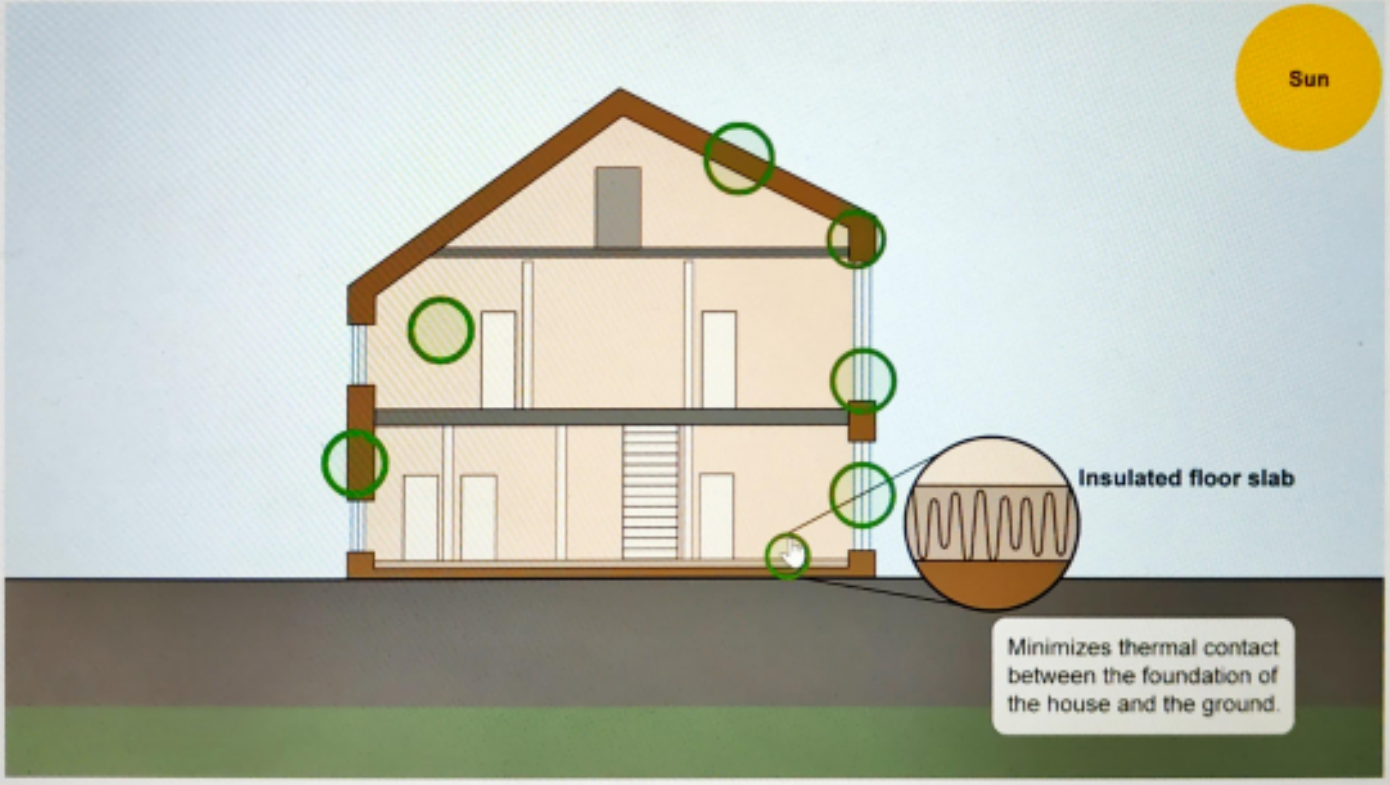

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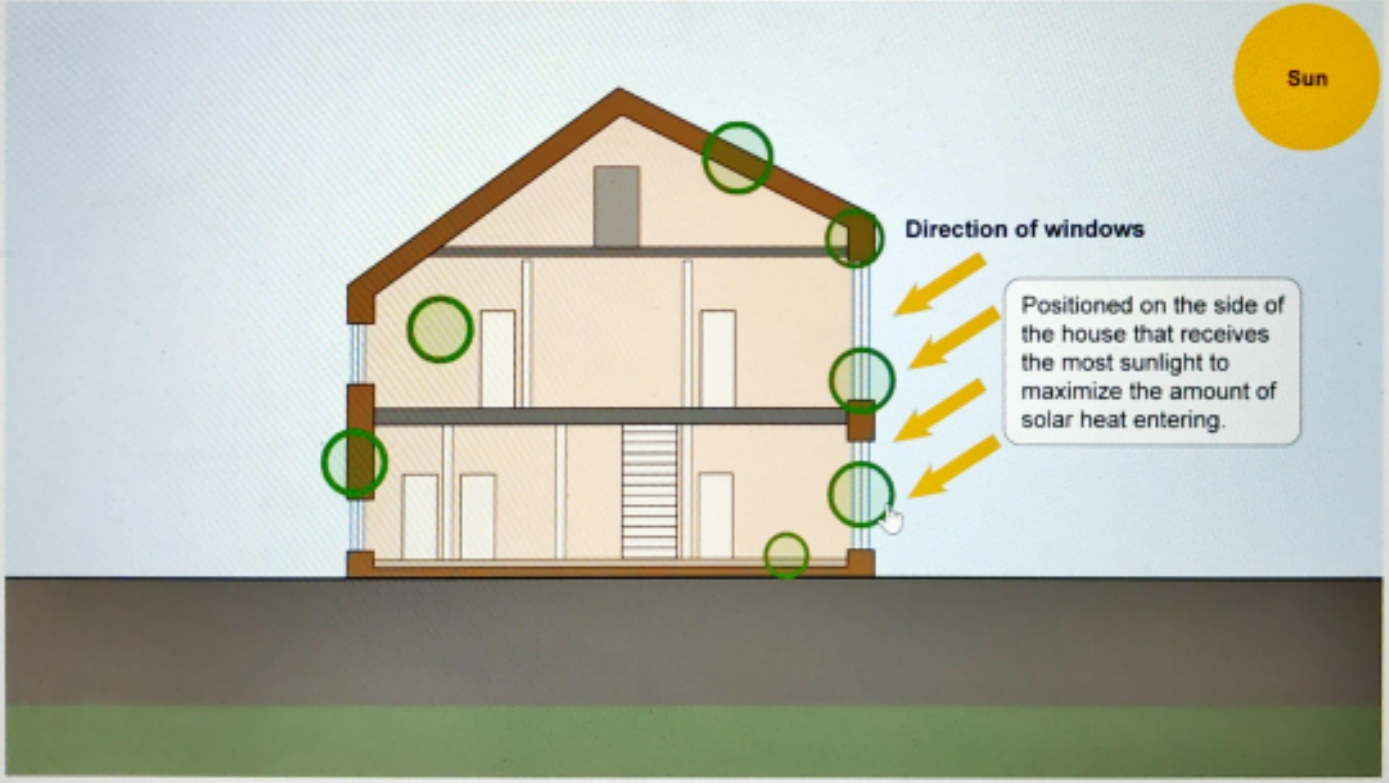

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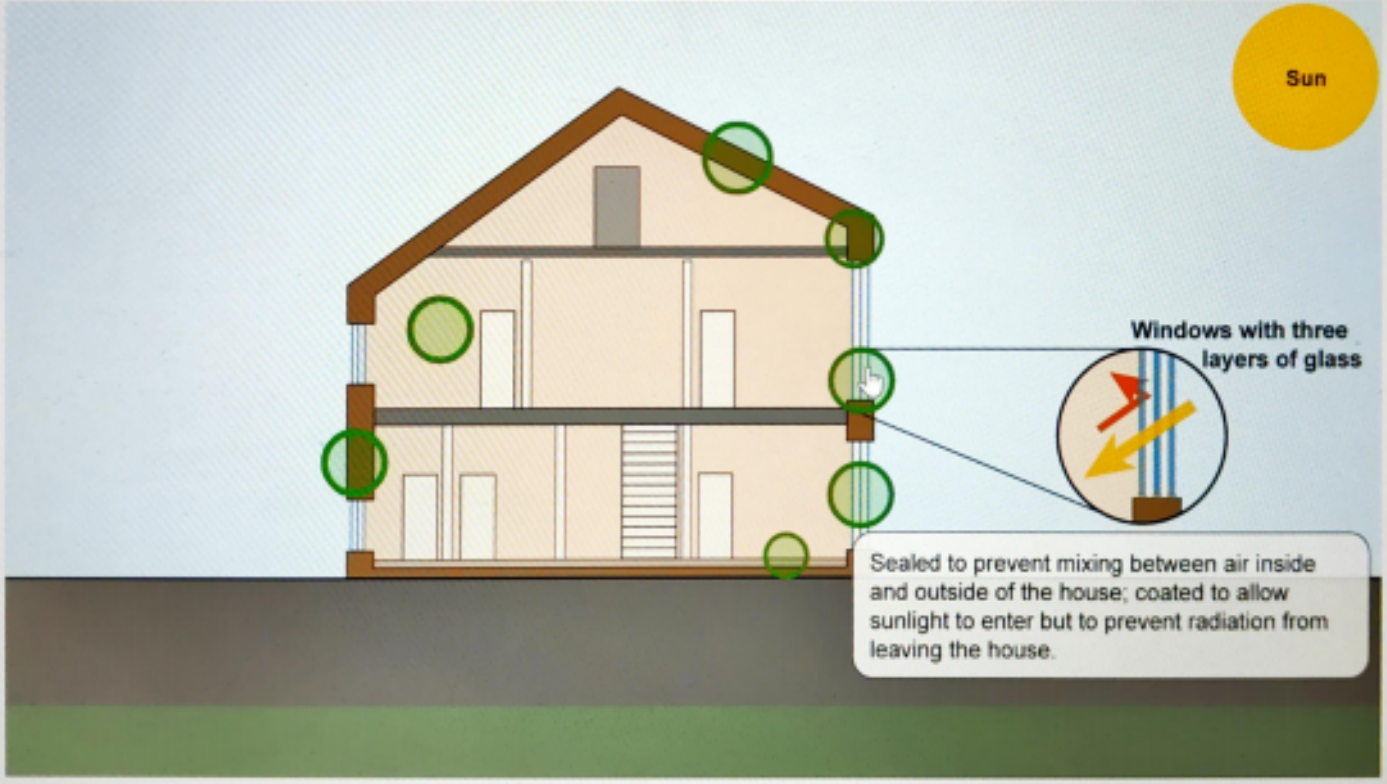


Question 7a (2 marks)

Passively heated houses are designed to reduce the amount of money people spend on energy while allowing them to keep their houses warm. Use your knowledge of physics to **outline** how passive houses are able to stay warm inside, while requiring less heat energy compared to actively heated houses.

B I U x_2 x^2 Ω Σ Styles

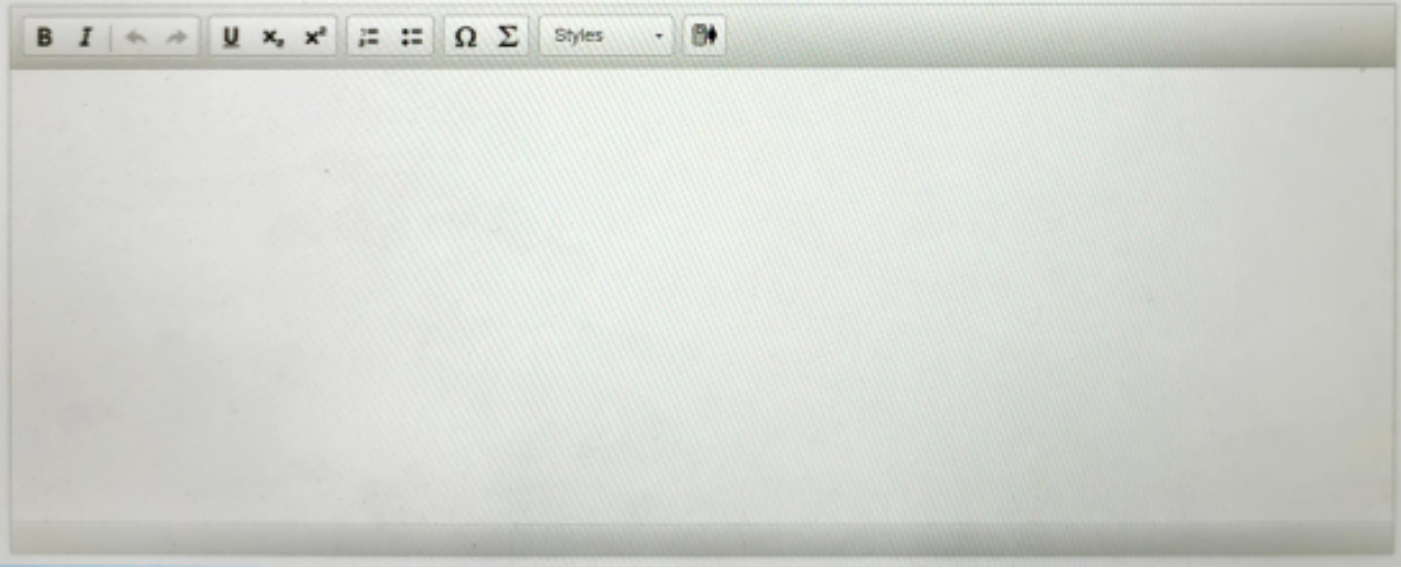
Question 7b (2 marks)

Outline how using three layers of glass in windows reduces heat loss by conduction.

B I U Styles

Question 7c (3 marks)

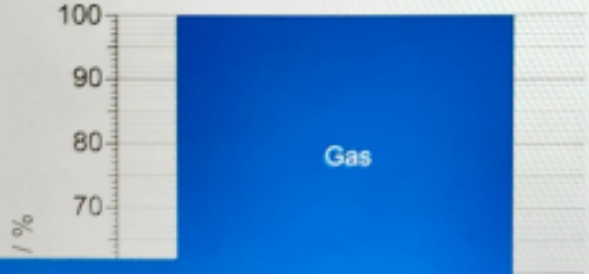
Passively heated houses are tested for airtightness by creating a pressure difference between the inside and the outside of the house. Use kinetic theory to **describe** how a higher pressure inside the house can help to locate the places where air can escape through the walls of the house.



Question 7d (1 mark)

The passively heated house concept was developed in Germany with an aim of reducing the environmental impact of housing. The diagram below shows the percentage of households using different sources of energy for heating in the last decade in Germany.

Household energy consumption for heating by energy



State the percentage of households using oil as a source of energy for heating.

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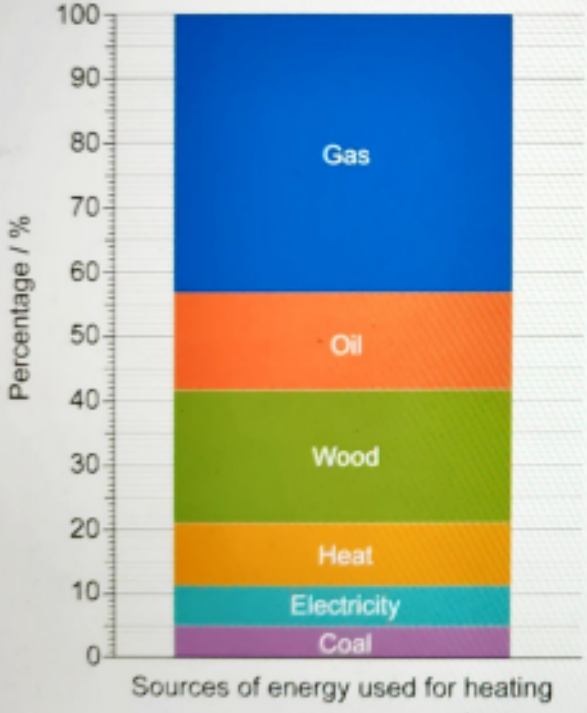
Household energy consumption for heating by energy



State the percentage of households using oil as a source of energy for heating.

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Question 7e (2 marks)

Suggest why the move to passive housing has a positive effect on the environment.

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Question 8 (13 marks)

The infographic below gives some information about passively heated houses.

Cost comparison of actively heated and passively heated buildings

- Typical costs to build: for an actively heated house €180 000, passively heated house €195 000.
- Passive houses save 90 % on heating costs, typically saving €822 per year on heating.
- Typical cost to upgrade a typical house to a passive house would be €15 000.
- Costs to upgrade are decreasing with increasing demand.

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The government of a country in a cold climate is considering giving money to people to upgrade their houses to meet the standards for passively heated houses.

Scroll down to continue

Regulating the passive house standard

- Governments are responsible for determining building regulations, urban planning strategy and infrastructure.
- Developing passive house standards is a slow and costly process.
- Legal standards guarantee the safety, quality and performance of passive houses.

The government of a country in a cold climate is considering giving money to people to upgrade their houses to meet the standards for passively heated houses.

Paying for heat

- Heating costs can be a large part of family expenditure and are likely to rise in the future.
- Households in "fuel poverty" may have to choose between paying their energy costs and purchasing other essential items, like food and clothing.
- Fuel poverty is also associated with adverse effects on physical and mental health from coping with cold temperatures.
- Fuel poverty is most common in low-income areas, where housing quality tends to be poor and residents have access to limited disposable income.

The government of a country in a cold climate is considering giving money to people to upgrade their houses to meet the standards for passively heated houses.

Air quality in passively heated houses

- Outdoor pollutants cannot enter a passively heated house because it is airtight.
- Passive houses need a well-maintained filter system to prevent build-up of indoor pollutants.
- If properly maintained, passively heated houses have higher air quality than actively heated houses.
- Indoor air pollutants can cause nausea, dizziness, shortness of breath, disorientation and long-term effects to health.
- Harmful indoor air pollutants can be produced from printers, copiers and fossil-fuel burning heaters.

The government of a country in a cold climate is considering giving money to people to upgrade their houses to meet the standards for passively heated houses.

Discuss and **evaluate** the implications of upgrading houses to passively heated standards.
In your answer you should include:

- positive and negative social and economic implications for individuals in the community
- positive and negative economic implications for governments and businesses
- a concluding appraisal giving your opinion.