

iGCSE Physics – Paper 2 – May 2023 - Mark Scheme

Part A – Multiple Choice (25 questions)

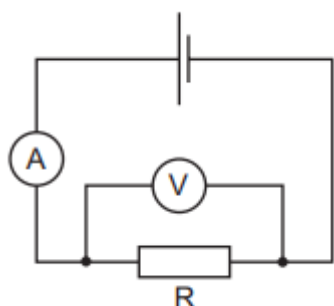
Question 1

Which row of the table is correct for both force and velocity?

	Force	Velocity
a)	Scalar	Scalar
b)	Scalar	Vector
c)	Vector	Scalar
d)	Vector	Vector

Question 2

A student sets up a circuit to determine the resistance of a resistor R. The meter readings are 5.0 A and 10.0 V.



What is the resistance of the resistor R?

- A. $0.5 \, \Omega$ B. $50.0 \, \Omega$ C. $2.0 \, \Omega$ D. $5.0 \, \Omega$

Question 3

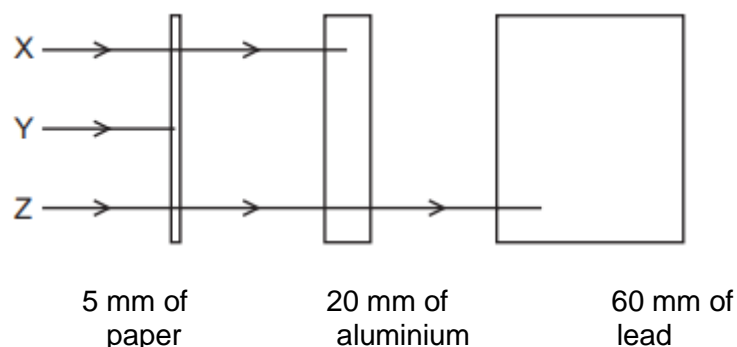
A student uses a piece of metallic wire as a resistor. From the same material, he then makes a second resistor.

The student wants the second resistor to be **higher in resistance** than the first, what should they ensure in the second wire?

- A. It is shorter and thicker
B. It is longer and thinner
C. It is longer and thicker
D. It is shorter and thinner

Question 4

The diagram below shows the different paths of various types of radiation (X, Y and Z).



In the table below, which row correctly matches X, Y and Z?

	X	Y	Z
A	α -rays	β -rays	γ -rays
B	α -rays	γ -rays	β -rays
C	γ -rays	α -rays	β -rays
D	β -rays	α -rays	γ -rays

Question 5

A radioactive rock sample contains 500mg of a radioactive isotope that emits α -rays.

The half-life of this isotope is ten days.

What mass of this isotope would you be expect to have after twenty days?

- A. 500 mg B. 250 mg C. 125 mg D. 60.25 mg

Question 6

Which instrument shown in the table below has the greatest ranges of frequencies?

Instrument	Lowest Frequency (Hz)	Highest Frequency (Hz)
A) Flute	40	2500
B) Piano	30	4100
C) Trumpet	60	1900
D) Saxophone	130	4800

Question 7

The saxophone is made of a brass alloy. The volume of the alloy that is needed to make the saxophone is 1000 cm^3 . The density of the alloy used to make the saxophone is calculated to be 9 g/cm^3 .

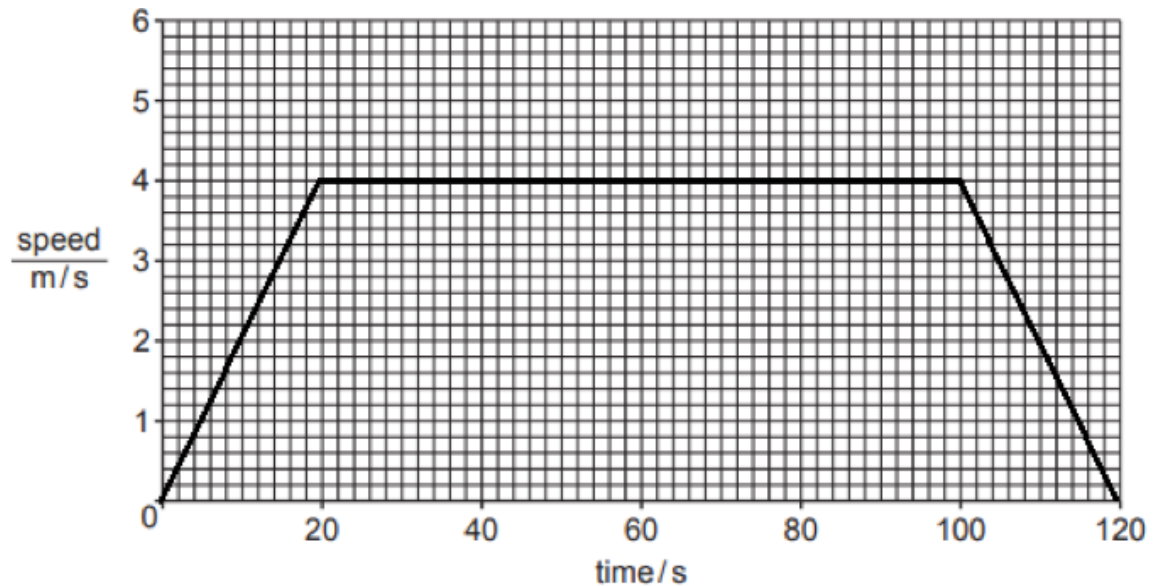
What mass of brass alloy was used in producing the saxophone?

- A) 0.009 g

- B) 111 g
- C) 9000 g
- D) 991 g

Questions 8-10

The graph below shows the journey of a boy jogging along a straight road.



Using the graph, answer the following questions:

Question 8

At what time did the boy start running at a constant speed?

- A) 10 s B) 20 s C) 60 s D) 100 s

Question 9

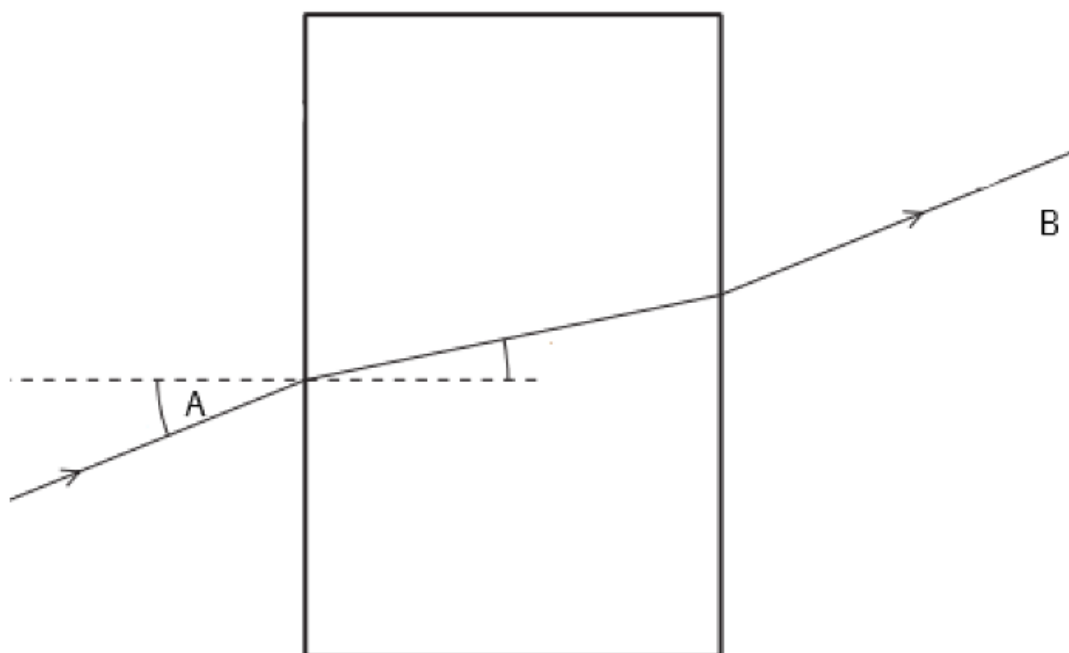
What distance did the boy travel from $t=20$ s to $t=100$ s?

- A) 80 m B) 120 m C) 320 m D) 60 m

Question 10

What was the total distance the boy travelled in his journey?

- A) 460 m B) 240 m C) 400 m D) 80 m



Question 11

A light ray travels through a Perspex block as shown.

The angle shown at A is called

- A) The normal B) The angle of incidence C) The angle of dispersion
- D) The angle of refraction

Question 12

The light ray at B is called....

- A) The incidence ray
- B) The normal
- C) The dispersed ray
- D) The refracted ray

Question 13

A toy car has a mass of 0.20 kg and accelerates at 4.0 m/s^2 . What is the amount of force required to produce this acceleration?

- A) 8.0 N B) 4.2 N C) 3.8 N D) 0.8 N

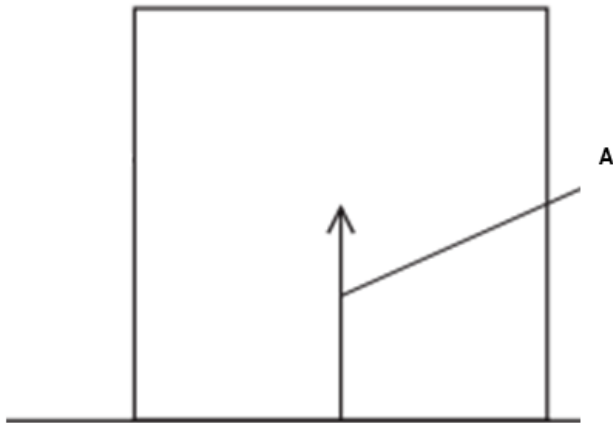
Question 14

A sound wave travels a distance of 260 m in a time of 0.6 seconds. What is the speed of the sound wave?

- A) 433 m/s B) 156 m/s C) 260 m/s D) 510 m/s

Question 15

A box is sitting on a floor with one of the forces acting on it labelled A.



What is producing this force?

- A) The 'normal' force
- B) The frictional force
- C) The force of the floor pushing on the box
- D) The force of gravity

Question 16

A student during an experiment does work by pulling a wooden box across a horizontal floor.

They then repeat the experiment and pull a second box along the same floor.

Identify the correct row that shows that the student is now doing twice as much work.

	Force used to pull box	Distance the box is pulled
(A)	Stays the same	Is doubled
(B)	Stays the same	Is halved
(C)	Is doubled	Is doubled
(D)	Is doubled	Is halved

Question 17

On a warm, summer day, a student places a bottle of soft drink on the ground and then covers it with a wet cloth.

Why does this help reduce the temperature of the soft drink?

- (A) The water has a very thermal capacity
- (B) The water is always cooler than the air surrounding it
- (C) The water helps to insulate the soft drink from the warm air around it
- (D) Some water evaporates from the cloth so that the water remaining becomes colder

Question 18

A student decides to do an experiment and melt some ice. The student melts 500 g of ice at 0°C . The student finds out that the specific latent heat of fusion of ice is $3.34 \times 10^4 \text{ J/kg}$.

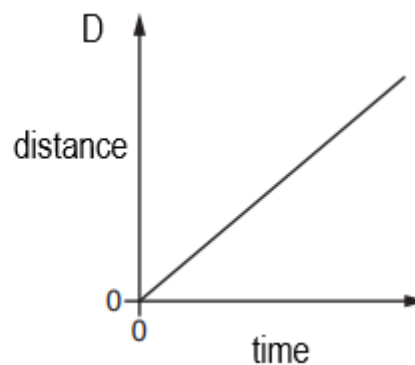
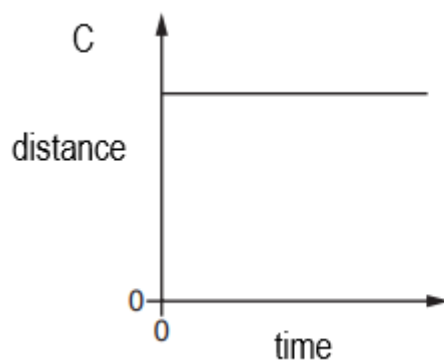
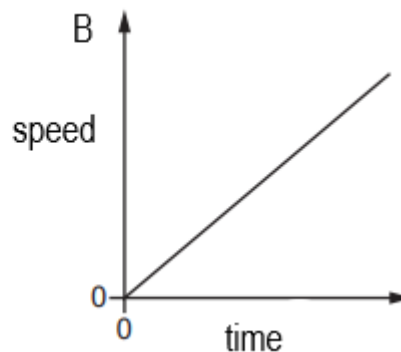
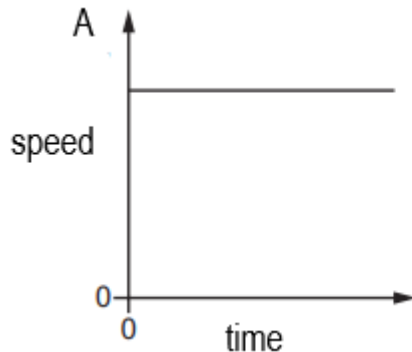
What is the amount of thermal energy required to melt all of the ice at 0°C ?

- A) $3.34 \times 10^4 \text{ J}$
- B) $1.17 \times 10^4 \text{ J}$
- C) $1.67 \times 10^5 \text{ J}$
- D) $1.17 \times 10^5 \text{ J}$

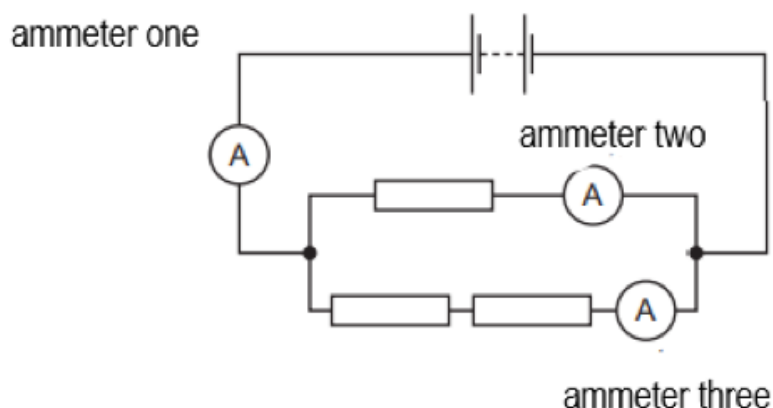
Question 19

A bicycle is travelling along a straight, level road, with a constant acceleration.

Which graph below shows the motion of the bicycle?



Question 20



Rank the magnitude of readings on the three ammeters from smallest to biggest.

	Smallest	Middle	Largest
(a)	Ammeter 3	Ammeter 2	Ammeter 1
(b)	Ammeter 1	Ammeter 3	Ammeter 2
(c)	Ammeter 2	Ammeter 3	Ammeter 1
(d)	Ammeter 1	Ammeter 2	Ammeter 3

Question 21

An engineer is interested in finding a device that changes the voltage of an electrical supply from 240 V a.c. down to 20 V a.c.

What type of device should they use?

- (A) A voltmeter
- (B) A relay
- (C) A transformer
- (D) A generator

Question 22

Which of the following below statements about electromagnetic induction is correct?

- (A) The effect can only occur when a magnet is moved towards a conductor
- (B) The effect can only occur when a magnet is moved away from a nearby conductor
- (C) A strong magnet held stationary close to a stationary conductor results in a greater effect than a weak magnet
- (D) The effect can only occur when a magnet and a conductor are both moved with the same speed and in the same direction

Question 23

A physics student decides to measure the potential difference across a device and the current in the device.

Which calculation below gives the resistance of the device?

- (A) Potential difference \times current
- (B) Potential difference \div current
- (C) Current \div potential difference
- (D) Current $+$ potential difference

Question 24

Which metal is commonly used for the core of an electromagnet?

- (A) Steel
- (B) Magnesium
- (C) Copper
- (D) Iron

Question 25

As a liquid is heated, it starts to expand.

How does this result in the formation of a convection current?

- (A) The density of the heated liquid increases
- (B) The density of the heated liquid decreases
- (C) The mass of the heated liquid molecules increases
- (D) The mass of the heated liquid molecules decreases

Mark Scheme:

Question 1:

Which row of the table is correct for both force and velocity?

Answer: D (Force: Vector, Velocity: Vector)

Mark Allocation:

- 1 mark for the correct answer.
-

Question 2:

A student sets up a circuit to determine the resistance of a resistor R . The meter readings are 5.0 A and 10.0 V. What is the resistance of the resistor R ?

Answer: B) 2.0 Ω

Calculation:

$$R = \frac{V}{I} = \frac{10.0}{5.0} = 2.0 \Omega$$

Mark Allocation:

- 1 mark for the correct formula and substitution.
- 1 mark for the correct final answer.

Question 3:

How can a second resistor with higher resistance be made using the same material?

Answer: B) It is longer and thinner.

Mark Allocation:

- 1 mark for the correct answer.
-

Question 4:

Which row correctly matches the radiations X, Y, and Z?

Answer: C) X: Beta, Y: Gamma, Z: Alpha

Mark Allocation:

- 1 mark for correctly identifying the shielding properties of each radiation.

Question 5:

A radioactive isotope emits γ -rays and has a half-life of 10 days. What mass remains after 20 days?

Answer: B) 125 mg

Calculation:

- After 1 half-life (10 days), 500 mg \rightarrow 250 mg.
- After 2 half-lives (20 days), 250 mg \rightarrow 125 mg.

Mark Allocation:

- 1 mark for correctly identifying the number of half-lives.
 - 1 mark for the correct final answer.
-

Question 6:

Which instrument has the greatest range of frequencies?

Answer: D) Guitar

Mark Allocation:

- 1 mark for the correct answer.

Question 7:

The saxophone is made of brass alloy. The volume needed is 1000 cm^3 and the density is 8.5 g/cm^3 . What is the mass of the brass alloy?

Answer: C) 8500 g

Calculation:

$$\text{Mass} = \text{Density} \times \text{Volume} = 8.5 \times 1000 = 8500 \text{ g.}$$

Mark Allocation:

- 1 mark for the correct formula and substitution.
- 1 mark for the correct final answer.

Question 8:

At what time did the boy start running at constant speed?

Answer: C) 60 s

Explanation:

- The graph shows constant speed as a horizontal section starting at 60 s.

Mark Allocation:

- 1 mark for the correct interpretation of the graph.
-

Question 9:

What distance did the boy travel from $t = 20$ s to $t = 100$ s?

Answer: B) 320 m

Calculation:

- The distance is the area under the speed-time graph:
 - From 20 s to 60 s: $\text{Area} = \frac{1}{2} \times 40 \text{ s} \times 4 \text{ m/s} = 80 \text{ m}$.
 - From 60 s to 100 s: $\text{Area} = 40 \text{ s} \times 6 \text{ m/s} = 240 \text{ m}$.
 - Total distance: $80 + 240 = 320 \text{ m}$.

Question 10:

What was the total distance traveled by the boy?

Answer: D) 460 m

Calculation:

- Add up all areas under the graph:
 - From 0 s to 20 s: $\text{Area} = \frac{1}{2} \times 20 \text{ s} \times 4 \text{ m/s} = 40 \text{ m}$.
 - Add previous result (320 m): $40 + 320 = 460 \text{ m}$.

Mark Allocation:

- 1 mark for correctly identifying the area from 0 s to 20 s.
- 1 mark for summing all areas for the total distance.

Question 11:

The angle shown at A is called...

Answer: B) The angle of incidence

Mark Allocation:

- 1 mark for the correct answer.
-

Question 12:

The light ray at B is called...

Answer: D) The refracted ray

Mark Allocation:

- 1 mark for the correct answer.
-

Question 13:

A toy car has a mass of 0.20 kg and accelerates at 4.0 m/s^2 . What is the amount of force required?

Answer: C) 0.8 N

Question 14:

A sound wave travels 260 m in 0.5 s. What is the speed of the sound wave?

Answer: D) 520 m/s

Calculation:

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}} = \frac{260}{0.5} = 520 \text{ m/s}.$$

Mark Allocation:

- 1 mark for using $\text{Speed} = \frac{\text{Distance}}{\text{Time}}$.
 - 1 mark for the correct calculation and final answer.
-

Question 15:

What is producing the force labeled A ?

Answer: A) The "normal" force

Mark Allocation:

- 1 mark for the correct answer.

Question 16:

A student pulls a wooden box along a floor. They double the distance the box is pulled. Which row in the table correctly describes the effect on work done?

Answer: B) Force stays the same, Distance is doubled

Mark Allocation:

- 1 mark for identifying that work done depends on force and distance.
 - 1 mark for the correct answer.
-

Question 17:

Why does covering a wet cloth over a soft drink reduce its temperature?

Answer: D) Some water evaporates from the cloth so that the water remaining becomes colder

Explanation:

Evaporation causes cooling as it requires heat energy, which is taken from the cloth and the surrounding environment.

Mark Allocation:

- 1 mark for the correct answer.

Question 18:

What is the thermal energy required to melt 500 g of ice at 0°C?

Answer: C) 1.67×10^5 J

Calculation:

$$Q = mL = 0.500 \text{ kg} \times 3.34 \times 10^5 \text{ J/kg.}$$

$$Q = 1.67 \times 10^5 \text{ J.}$$

Mark Allocation:

- 1 mark for using $Q = mL$.
 - 1 mark for the correct calculation and final answer.
-

Question 19:

Which graph shows the motion of the bicycle traveling at constant acceleration?

Answer: B) Speed-Time graph showing a straight line with positive slope

Mark Allocation:

- 1 mark for correctly identifying a linear speed-time graph for constant acceleration.

Question 20:

Rank the magnitude of readings on the three ammeters from smallest to largest.

Answer: A) Ammeter 3 < Ammeter 1 < Ammeter 2

Explanation:

- Ammeter 2 measures the total current leaving the battery, so it has the largest reading.
- Ammeter 1 measures the current in one branch, and Ammeter 3 measures a smaller branch current.
- By Kirchhoff's Current Law, $I_{\text{total}} = I_1 + I_3$.

Mark Allocation:

- 1 mark for correctly ranking the ammeters based on current.
-

Question 21:

What type of device should an engineer use to change the voltage of an electrical supply?

Answer: C) A transformer

Mark Allocation:

- 1 mark for selecting the correct device used for voltage transformation.

Question 22:

Which statement about electromagnetic induction is correct?

Answer: D) The effect can only occur when a magnet and a conductor are both moved with the same speed and in the same direction.

Explanation:

- Electromagnetic induction occurs due to the relative motion between a magnet and a conductor, which induces an e.m.f. and current. If both move with the same speed and direction, there is no relative motion, and thus no induction occurs.

Mark Allocation:

- 1 mark for identifying the correct principle of electromagnetic induction.
-

Question 23:

Which calculation gives the resistance of the device?

Answer: B) Potential difference ÷ current

Explanation:

- Ohm's Law relates resistance (R), voltage (V), and current (I) as:

$$R = \frac{V}{I}.$$

Mark Allocation:

- 1 mark for correctly applying Ohm's Law.

Question 23:

Which calculation gives the resistance of the device?

Answer: B) Potential difference ÷ current

Explanation:

- Ohm's Law relates resistance (R), voltage (V), and current (I) as:

$$R = \frac{V}{I}.$$

Mark Allocation:

- 1 mark for correctly applying Ohm's Law.
-

Question 24:

Which metal is commonly used for the core of an electromagnet?

Answer: D) Iron

Explanation:

- Iron is highly magnetic and provides high permeability, making it ideal for electromagnet cores.

Mark Allocation:

- 1 mark for identifying iron as the best choice for the core material.

Question 25:

How does heating a liquid form a convection current?

Answer: B) The density of the heated liquid decreases

Explanation:

- Heating causes the liquid molecules to gain energy and move farther apart, reducing density. The warmer, less dense liquid rises, and cooler, denser liquid sinks, forming a convection current.

Mark Allocation:

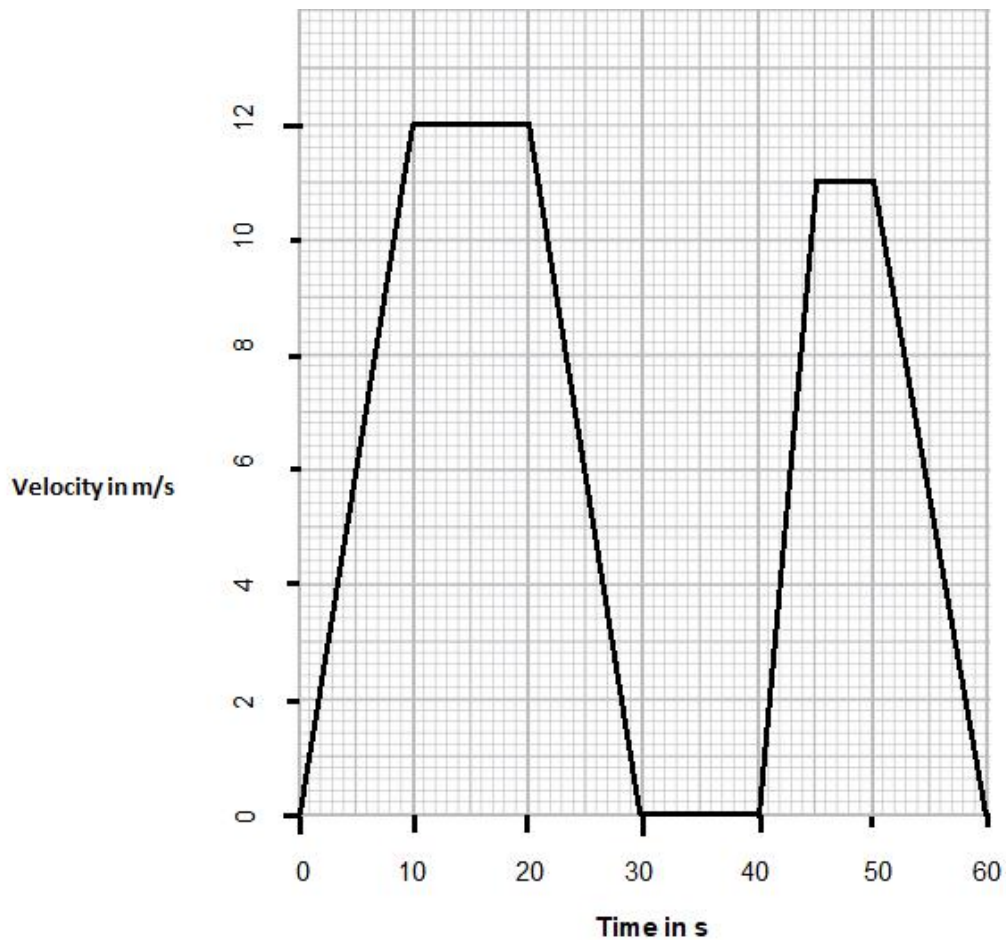
- 1 mark for understanding the role of density changes in convection currents.

Part B (65 marks total)

Question 1

A car travels on a straight road on a bright and sunny day.

The graph shows how the velocity of the car changes throughout its journey.



- a) i) Determine the velocity of the car after 25 s

Velocity = m/s

(1 mark)

- ii) How long does the car remain stationary throughout the entire journey?

Time = s

(1 mark)

- b) i) Write down the equation linking the change in velocity, time taken, and acceleration.

(1 mark)

Equation

- ii) Calculate the acceleration of the car from $t=0$ to $t=10$ s. Make sure you include the unit for acceleration.

Acceleration Unit

(2 marks)

- c) i) State the equation that relates time taken, distance travelled and the average speed.

Equation

(1 mark)

- c) ii) The car travels a total distance of 400 m during the entire journey.

Calculate the car's average speed over the entire journey.

Average speed = m/s

(2 marks)

- c) iii) Passengers in the car report that it travelled further in the first 30 seconds of the journey than it did during the last 30 seconds.

Explain the passenger's statement using the graph.

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(2 marks)

[Total = 10 marks]

Question 1:

(a) (i) Determine the velocity of the car after 25 s. [1 mark]

- **Correct Process:**
Use the velocity-time graph to read the value at $t = 25$ s.
- **Answer:**
Velocity = 10 m/s.

Mark Allocation:

- 1 mark for correctly identifying the velocity from the graph.
-

(a) (ii) How long does the car remain stationary during its journey? [1 mark]

- **Correct Process:**
Identify flat sections on the velocity-time graph where velocity = 0.
- **Answer:**
Time = 6 s (stationary from $t = 30$ s to $t = 36$ s).

Mark Allocation:

- 1 mark for correctly summing the duration where velocity = 0.
-

(b) (i) Write down the equation linking change in velocity, time, and acceleration. [1 mark]

- **Equation:**

$$a = \frac{\Delta v}{\Delta t}.$$

Mark Allocation:

- 1 mark for writing the correct equation.

(c) (i) State the equation that relates time taken, distance traveled, and average speed. [1 mark]

- Equation:

$$\text{Average Speed} = \frac{\text{Total Distance}}{\text{Time}}.$$

Mark Allocation:

- 1 mark for writing the correct equation.
-

(c) (ii) Calculate the car's average speed over the entire journey. [2 marks]

- Correct Process:

$$\text{Average Speed} = \frac{\text{Total Distance}}{\text{Total Time}} = \frac{400}{60} = 6.67 \text{ m/s}.$$

- Answer:

Average Speed = 6.67 m/s.

Mark Allocation:

- 1 mark for the correct substitution.
 - 1 mark for the correct final answer.
-

(c) (iii) Explain why the car traveled further in the first 30 seconds than the last 30 seconds. [2 marks]

- Correct Process:

- From $t = 0 \text{ s}$ to $t = 30 \text{ s}$, the car travels at higher velocities for most of the time, covering more distance.
- From $t = 30 \text{ s}$ to $t = 60 \text{ s}$, the car decelerates and remains stationary for 6 seconds, covering less distance.

Question 2

The Moon takes about 27 days to fully orbit the Earth.

- (a) Explain the differences between the orbit of a planet and the orbit of a moon.

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(2 marks)

(b) The radius of the orbit of the Moon is approximately 384 000 km.

Calculate the orbital speed of the Moon as it orbits the Earth. Provide a suitable unit.

Orbital speed = unit

(3 marks)

Question 2:

(a) Explain the differences between the orbit of a planet and the orbit of a moon. [2 marks]

- Key Points:

1. A planet orbits a star (e.g., Earth orbits the Sun).
2. A moon orbits a planet (e.g., the Moon orbits the Earth).

Mark Allocation:

- 1 mark for identifying that planets orbit stars.
 - 1 mark for identifying that moons orbit planets.
-

(b) Calculate the orbital speed of the Moon. [3 marks]

- Correct Process:

Use the formula for orbital speed:

$$v = \frac{2\pi r}{T}$$

Substituting values:

$$r = 384,000 \text{ km} = 3.84 \times 10^8 \text{ m}, \quad T = 27 \text{ days} = 27 \times 24 \times 3600 \text{ s}.$$

$$v = \frac{2\pi(3.84 \times 10^8)}{27 \times 24 \times 3600}$$
$$v \approx 1.02 \text{ km/s}.$$

Answer:

Orbital speed = 1.02 km/s.

Mark Allocation:

- 1 mark for correct formula.
- 1 mark for correct substitution.
- 1 mark for correct final answer with units. (↓)

- (c) Golf was the first sport played on the moon. An astronaut named Alan Shepard reportedly hit a golf ball for 'miles and miles'.

The golf ball had a mass of approximately 50 g and he transferred 60 J of energy to it.

- i) State the equation that links mass, velocity and kinetic energy.

Equation

(1 mark)

- ii) Using this equation, calculate the initial velocity of the ball.

Initial velocity = m/s

(3 marks)

Question (c):

(i) State the equation that links mass, velocity, and kinetic energy. [1 mark]

- Correct Answer:

$$KE = \frac{1}{2}mv^2$$

Mark Allocation:

- 1 mark for correctly stating the equation.
-

(ii) Using this equation, calculate the initial velocity of the ball. [3 marks]

- Given Data:

$$KE = 60 \text{ J}, m = 50 \text{ g} = 0.05 \text{ kg}.$$

- Rearrange Equation:

$$v = \sqrt{\frac{2KE}{m}}$$

- Substitute Values:

$$v = \sqrt{\frac{2 \times 60}{0.05}} = \sqrt{2400} \approx 49.0 \text{ m/s}.$$

Answer:

Initial velocity = 49.0 m/s.

Mark Allocation:

- 1 mark for rearranging the equation.
- 1 mark for correct substitution.
- 1 mark for the correct final answer with units.

d) On its journey, as the ball reached its highest point it had gained 15 J of potential energy.

- i) Calculate the kinetic energy of the ball at its highest point.

Kinetic energy = J

(1 mark)

- ii) State the equation that links mass, g (gravitational field strength), gravitational potential energy and height together.

(1 mark)

Equation

(iii) On its journey, the ball reached its highest point and had 15 J of potential energy. Calculate the kinetic energy of the ball at its highest point. [1 mark]

- Given Data:

Total initial energy = 60 J, potential energy at highest point = 15 J.

- Calculation:

$$KE = \text{Total Energy} - \text{Potential Energy} = 60 - 15 = 45 \text{ J.}$$

Answer:

Kinetic energy = 45 J.

Mark Allocation:

- 1 mark for correctly calculating the remaining kinetic energy.
-

(iv) State the equation that links mass (m), gravitational field strength (g), gravitational potential energy (GPE), and height (h). [1 mark]

- Correct Answer:

$$GPE = mgh$$

Mark Allocation:

- 1 mark for correctly stating the equation.

- iii) Calculate the maximum height that the ball can reach.
(Assume the gravitational field strength of the moon, $g=1.6 \text{ N/kg}$).

Maximum height of the ball = m

(2 marks)

(iii) Calculate the maximum height the ball can reach.

(Assume the gravitational field strength of the Moon, $g = 1.6 \text{ N/kg}$).

[2 marks]

Solution:

1. Use the Gravitational Potential Energy Formula:

$$GPE = mgh \implies h = \frac{GPE}{mg}.$$

2. Substitute Values:

Given:

$$GPE = 15 \text{ J}, m = 0.05 \text{ kg}, g = 1.6 \text{ N/kg}.$$

$$h = \frac{15}{0.05 \times 1.6} = \frac{15}{0.08} = 187.5 \text{ m}.$$

Answer:

Maximum height = 187.5 m.

Mark Allocation:

- 1 mark for correctly rearranging and substituting into the equation $h = \frac{GPE}{mg}$.
- 1 mark for the correct final answer with units.

e) Suggest why the ball that the astronaut hit travelled further on the moon than it would have had he hit it on Earth.

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(2 marks)

[Total = 15 marks]

(iv) Suggest why the ball that the astronaut hit traveled further on the Moon than it would have on Earth.

[2 marks]

Explanation:

1. Gravitational Field Strength:

- The Moon's gravitational field strength ($g = 1.6 \text{ N/kg}$) is much weaker than Earth's ($g = 9.8 \text{ N/kg}$).
- This results in a smaller downward force acting on the ball, allowing it to stay in the air for longer.

2. Air Resistance:

- The Moon has no atmosphere, so there is no air resistance to slow the ball down, enabling it to travel a greater distance.

Mark Allocation:

- 1 mark for mentioning weaker gravity on the Moon.
- 1 mark for identifying the absence of air resistance.

Question 3

A group of students are investigating whether the distance that a toy car will travel along a horizontal floor, before it comes to a stop, depends on its mass.

The following equipment is available to the group:

A wooden ramp

Toy car

A selection of masses

Blocks to help support the ramp (shown below in the diagram)

Other items of common equipment from a physics laboratory

Task: To plan an experiment to investigate whether the distance the toy car travels along a horizontal floor before coming to a stop depends on its mass.

You should include in your plan:

- a brief explanation how you would carry out the investigation
- list any equipment that you would need to use that is not included in the list above
- state the key variables that you would need to control
- draw a table, or tables, with column headings to show how you would display your readings and measurements (readings/measurements are **not** required to be entered in the table)

You may add to the diagram below to help your description.



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1. Explanation of the Experiment (4 Marks)

- **Key Steps:**
 1. Set up the ramp as shown in the diagram, ensuring the slope is stable and consistent for each trial.
 2. Place the toy car at the top of the ramp and allow it to roll down freely onto the horizontal floor.
 3. Measure the distance traveled by the car on the horizontal floor until it comes to a stop.
 4. Repeat the experiment using different masses attached to the toy car to observe any variation in the stopping distance.
- **Equipment:**
 - Measuring tape or ruler to measure the distance traveled.
 - Stopwatch (if needed to measure time for consistency).
 - Additional masses to attach to the toy car.

Mark Allocation:

- 1 mark for describing the setup of the ramp and horizontal floor.
- 1 mark for explaining the process of releasing the car and measuring the distance.
- 1 mark for using different masses to vary the independent variable.
- 1 mark for listing any additional equipment (e.g., ruler, stopwatch).

2. Identification of Variables (3 Marks)

- **Independent Variable:**
 - The mass of the toy car (varied by attaching different masses).
- **Dependent Variable:**
 - The distance traveled by the toy car on the horizontal floor.
- **Control Variables:**
 - The height of the ramp (kept constant to ensure consistent starting energy).
 - The surface of the ramp and horizontal floor (same material to control friction).
 - The method of releasing the car (e.g., no external push).

Mark Allocation:

- 1 mark for identifying the independent variable.
- 1 mark for identifying the dependent variable.
- 1 mark for identifying appropriate control variables.

3. Data Collection and Display (3 Marks)

- **Table Design:**

The table should include the following columns:

- Mass of the toy car (kg).
- Distance traveled (m).
- Additional trials (to calculate averages for accuracy).

Mass of Car (kg)	Distance Traveled (m)	Trial 1 (m)	Trial 2 (m)	Average Distance (m)
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- **Data Collection:**

- Perform at least 2–3 trials for each mass to ensure reliable results.
- Record measurements to an appropriate level of precision.

Mark Allocation:

- 1 mark for providing a clear and organized table structure.
 - 1 mark for mentioning multiple trials and averaging results.
 - 1 mark for correct units (e.g., kg, m).
-

4. Additional Considerations (2 Marks)

- **Mention sources of error and how to minimize them:**

- Friction on the surface should be consistent and minimized.
- The toy car should always be released without an external push.
- Ensure measurements are precise by using proper measuring tools.

Mark Allocation:

- 1 mark for addressing possible sources of error.
- 1 mark for suggesting improvements to ensure accuracy.

[6 marks total]

Question 4

Radon-222 is radioactive. It can be represented as $^{222}_{86}\text{Rn}$

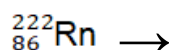
(a) For a neutral atom of radon-222, state the following:

- i) The number of protons,
- ii) The number of neutrons,
- iii) The number of electrons,

(3 marks)

(b) A radon-222 nucleus decays by α - particle emission to a polonium (Po) nucleus.

Complete the equation for the decay of radon-222.



(1 mark)

(c) Radon-222 has a half-life of approximately 3.8 days.

At a point in time, the radioactive sample contains 6.4×10^6 radon-222 nuclei.

Determine the number of α - particles emitted by the radon nuclei after a further 7.6 days.

(3 marks)

[7 marks total]

(a) For a neutral atom of radon-222, state the following: [3 marks]

Answers:

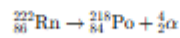
1. Number of protons: 86
2. Number of neutrons: $222 - 86 = 136$
3. Number of electrons: 86 (equal to the number of protons in a neutral atom).

Mark Allocation:

- 1 mark for correctly identifying the number of protons.
 - 1 mark for correctly calculating the number of neutrons.
 - 1 mark for correctly identifying the number of electrons.
-

(b) Complete the equation for the decay of radon-222 by α -particle emission: [1 mark]

Decay Equation:



Mark Allocation:

- 1 mark for correctly identifying both the resulting polonium-218 nucleus (${}_{84}^{218}\text{Po}$) and the α -particle (${}_2^4\alpha$).

(c) Determine the number of α -particles emitted after 7.6 days: [3 marks]

Solution:

1. Determine the number of half-lives:

Half-life of radon-222 is 3.8 days.

Time elapsed = 7.6 days.

$$\text{Number of half-lives} = \frac{7.6}{3.8} = 2.$$

2. Calculate the remaining nuclei:

Initial nuclei = 6.4×10^6 .

After 1 half-life:

$$N = \frac{6.4 \times 10^6}{2} = 3.2 \times 10^6.$$

After 2 half-lives:

$$N = \frac{3.2 \times 10^6}{2} = 1.6 \times 10^6.$$

3. Calculate the number of α -particles emitted:

Total nuclei decayed:

$$\Delta N = \text{Initial nuclei} - \text{Remaining nuclei} = 6.4 \times 10^6 - 1.6 \times 10^6 = 4.8 \times 10^6.$$

Each decay emits one α -particle.

Number of α -particles emitted = 4.8×10^6 .

Answer:

4.8×10^6 α -particles.

Mark Allocation:

- 1 mark for calculating the number of half-lives.
- 1 mark for determining the remaining nuclei after 2 half-lives.
- 1 mark for calculating the total number of α -particles emitted.

Question 5

Nuclear fission is a process that is used in nuclear power stations to release large amounts of thermal energy.

(a) Describe how the thermal energy that is released is then used to generate electricity.

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(3 marks)

(b) Describe two environmental problems that result in using nuclear power stations.

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2.....

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(2 marks)

[5 marks total]

Question 5: Nuclear Fission and Environmental Impacts

(a) Describe how the thermal energy released is then used to generate electricity. [3 marks]

1. Thermal Energy to Steam (1 mark):

- The thermal energy heats water in the reactor, turning it into high-pressure steam.

2. Steam to Mechanical Energy (1 mark):

- The steam drives a turbine, which converts thermal energy into mechanical energy.

3. Mechanical to Electrical Energy (1 mark):

- The turbine is connected to a generator, which converts mechanical energy into electrical energy.
-

(b) Describe two environmental problems that result from using nuclear power stations. [2 marks]

1. Radioactive Waste (1 mark):

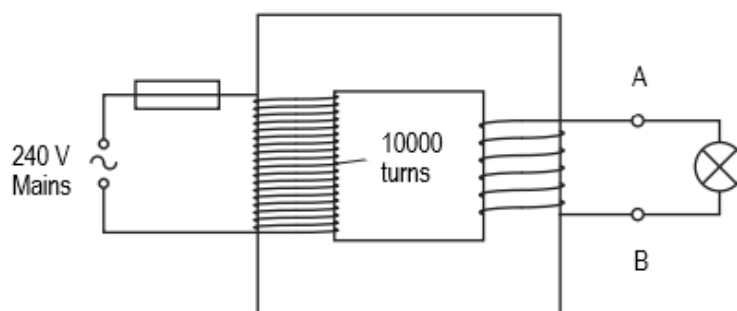
- The disposal of radioactive waste is challenging and can remain hazardous for thousands of years.

2. Nuclear Accidents (1 mark):

- Potential for catastrophic accidents, such as meltdowns, which can release harmful radiation into the environment.
-

Question 6

A transformer belonging to an engineer is shown below.



There are 10000 turns in the primary coil of the transformer. The primary coil is connected to a 240 V mains supply. A 8.0 V lamp is connected to the secondary coil is operating at full brightness.

- (a) Calculate the number of turns in the secondary coil.

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(2 marks)

- (b) i) The current in the lamp is 2.0 A. Assume the transformer is operating with a 100% efficiency.

Determine the current in the primary circuit.

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(2 marks)

- b) ii) The primary circuit contains a 2.0 A fuse.
Calculate the maximum number of lamps that can be joined in parallel in the secondary circuit without blowing the fuse. Assume that the lamps are identical to the lamp in (b).

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(2 marks)

[6 marks total]

Question 8: Transformer Calculations

(a) Calculate the number of turns in the secondary coil. [2 marks]

- Given Data:

Primary voltage (V_p) = 240 V,

Secondary voltage (V_s) = 4.8 V,

Primary turns (N_p) = 10,000.

- Formula:

$$\frac{V_p}{V_s} = \frac{N_p}{N_s} \implies N_s = \frac{N_p \cdot V_s}{V_p}.$$

- Calculation:

$$N_s = \frac{10,000 \times 4.8}{240} = 200 \text{ turns.}$$

Answer: $N_s = 200$ turns.

Mark Allocation:

- 1 mark for correct formula.
 - 1 mark for correct calculation and answer.
-

(b)(i) Determine the current in the primary circuit. [2 marks]

- Given Data:

Secondary current (I_s) = 2.0 A,

Efficiency = 100%.

$$\text{Power (Primary)} = \text{Power (Secondary)}.$$

- Calculation:

$$V_p \cdot I_p = V_s \cdot I_s \implies I_p = \frac{V_s \cdot I_s}{V_p}.$$

$$I_p = \frac{4.8 \times 2.0}{240} = 0.04 \text{ A.}$$

Answer: $I_p = 0.04$ A.



(b)(ii) Calculate the maximum number of lamps that can be placed in parallel without blowing the fuse. [2 marks]

- Given Data:

Fuse current = 2.0 A,

Current per lamp (I_x) = 2.0 A.

- Calculation:

Since the secondary circuit fuse can handle 2.0 A, the maximum number of lamps is:

$$\text{Maximum lamps} = \frac{\text{Fuse Current}}{\text{Current per lamp}} = \frac{2.0}{2.0} = 1.$$

Answer: 1 lamp.

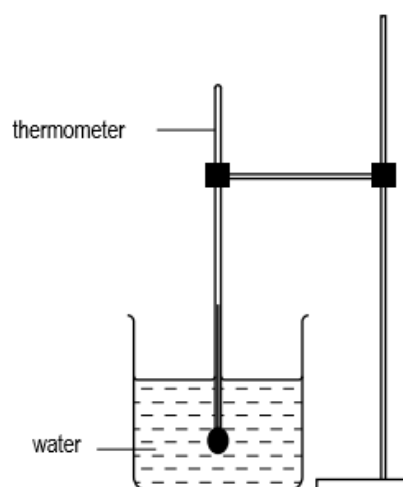
Mark Allocation:

- 1 mark for correct calculation.
- 1 mark for correct answer.

Question 7

A student performs an experiment to investigate water cooling and sets it up as shown below.

A student places a thermometer into a beaker containing 200 cm³ of hot water.



(a) (i) Record the temperature of the hot water (θ_H) as shown on the thermometer. Write your value in the table below for time $t = 0\text{s}$ (labelled (a) i)).

(1 mark)

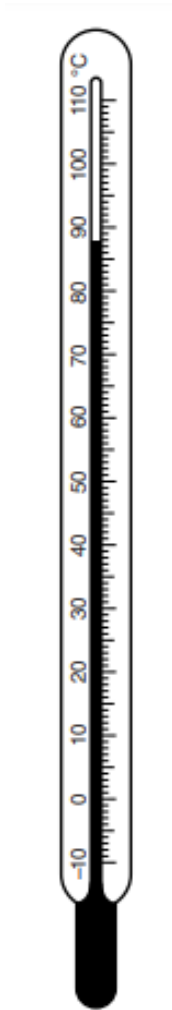


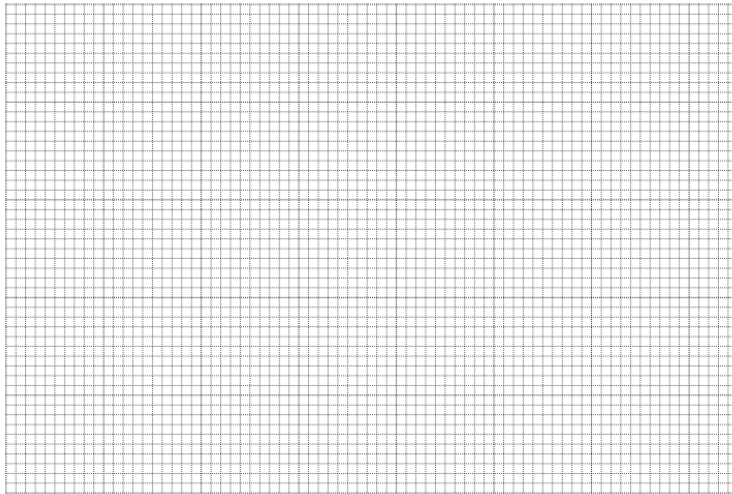
Table: Experimental results

$t /$ _____	$\theta /$ _____
0	<u> a)i) </u>
30	70
60	66
90	62
120	59
150	56

Complete the heading for the columns in the table above.

(2 marks)

- (a) ii) Plot a graph of $\theta/^\circ\text{C}$ (y-axis) against t/s (x-axis). Make sure you include a title and label the axis.



(4 marks)

Question 7: Water Cooling Experiment

- (a)(i) Record the temperature of the hot water at $t = 0$. [1 mark]

- Answer:

From the thermometer, the initial temperature (θ) is 70°C .

Mark Allocation:

- 1 mark for correctly reading and recording the temperature.
-

- (a)(ii) Complete the headings for the table. [2 marks]

- Correct Headings:

- t : Time (s)
- θ : Temperature ($^\circ\text{C}$)

Mark Allocation:

- 1 mark for correctly labeling time (t) and its unit (s).
 - 1 mark for correctly labeling temperature (θ) and its unit ($^\circ\text{C}$).
-

- (a)(iii) Plot a graph of θ (y-axis) against t (x-axis). Include a title and label the axes. [3 marks]

1. Graph Details:

- Title: "Temperature of Water Over Time."
- X-axis: Time (t , seconds).
- Y-axis: Temperature (θ , $^\circ\text{C}$).

2. Plot Points:

- Use the data from the table to plot points on the graph accurately.

3. Trendline:

- Draw a smooth curve or line showing the temperature decrease over time.

(b) i) State the shape of the best-fit graph line that you have drawn above.

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(1 mark)

ii) Describe what the shape of the graph line describes to you about the change, if any, in the rate of cooling of the water in the experiment.

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(2 marks)

d) Describe briefly how a student should read a measuring cylinder to obtain an accurate value for the volume of water. Add a diagram to help your response.

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(3 marks)

[13 marks total]

(i) State the shape of the best-fit graph line that you have drawn. (1 mark)

- **Answer:**
The graph shows a curved line sloping downwards (exponential decay).

Mark Allocation:

- 1 mark for correctly describing the shape as a curve indicating exponential decay.
-

(ii) Describe what the shape of the graph line describes about the change, if any, in the rate of cooling of the water. (2 marks)

- **Key Points:**
 - The rate of cooling is **faster at the beginning** when the water is hot.
 - As the water cools, the rate of cooling **slows down**.

Mark Allocation:

- 1 mark for identifying that cooling is faster initially.
 - 1 mark for stating that cooling slows as the water temperature decreases.
-

(d) Describe how a student should read a measuring cylinder to obtain an accurate value for the volume of water. Add a diagram to help your response. (3 marks)

- **Key Steps:**
 1. Place the measuring cylinder on a flat surface to ensure it is level.
 2. Ensure the eye level is at the same height as the liquid's meniscus.
 3. Read the bottom of the meniscus for the accurate measurement.
- **Diagram Requirements:**
 - Include a measuring cylinder with a meniscus clearly drawn.
 - Label the correct position of the eye and the meniscus.

Mark Allocation:

- 1 mark for ensuring the cylinder is on a level surface.
 - 1 mark for correctly describing eye level alignment.
 - 1 mark for mentioning the meniscus and providing a labeled diagram.
-

Question 8: Charged Spheres

Part (a) Draw the possible resulting position of each sphere and thread. (1 mark)

- **Answer:**

The spheres will **repel each other** due to their positive charges, causing the threads to move outward and the spheres to separate.

Mark Allocation:

- 1 mark for correctly drawing the spheres and threads showing repulsion.

Part (b): Explain the positions of the spheres and threads that you have drawn. (2 marks)

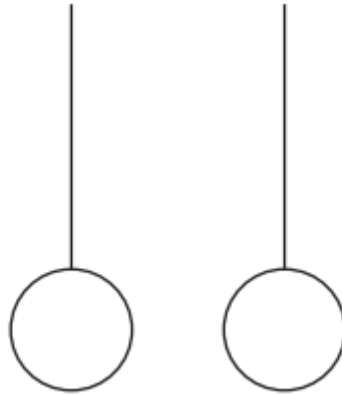
- **Key Explanation:**
 1. Both spheres are positively charged.
 2. Like charges repel each other, causing a repulsive force between the spheres.
 3. The repulsion moves the spheres apart, and the threads tilt outward to balance the forces.

Mark Allocation:

- 1 mark for stating that the spheres repel due to like charges.
- 1 mark for explaining the outward tilt of the threads as a result of the repulsive force.

Question 8

Two metallic conducting spheres are hanging suspended on insulating threads (shown below).



The two spheres are now both given positive charges. In the diagram below, draw a possible resulting position of each sphere and thread.

(1 mark)

Explain the positions of the spheres and threads that you have drawn.

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(2 marks)

[3 marks total]