



Oxford Cambridge and RSA

**Thursday 22 May 2025 – Morning**

**GCSE (9–1) Physics B (Twenty First Century Science)**

**J259/01 Breadth in physics (Foundation Tier)**

**Time allowed: 1 hour 45 minutes**

**You must have:**

- a ruler (cm/mm)
- the Equation Sheet for GCSE (9–1) Physics B (inside this document)

**You can use:**

- a scientific or graphical calculator
- an HB pencil



Please write clearly in black ink. **Do not write in the barcodes.**

Centre number

|  |  |  |  |  |
|--|--|--|--|--|
|  |  |  |  |  |
|--|--|--|--|--|

Candidate number

|  |  |  |  |
|--|--|--|--|
|  |  |  |  |
|--|--|--|--|

First name(s)

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Last name

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**INSTRUCTIONS**

- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answers should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

**INFORMATION**

- The total mark for this paper is **90**.
- The marks for each question are shown in brackets [ ].
- This document has **32** pages.

**ADVICE**

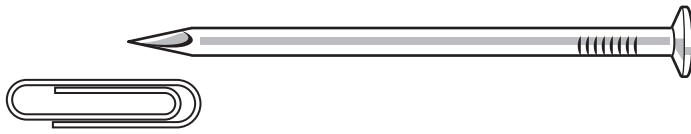
- Read each question carefully before you start your answer.

## 2

1 A student is experimenting with an iron nail and a bar magnet.

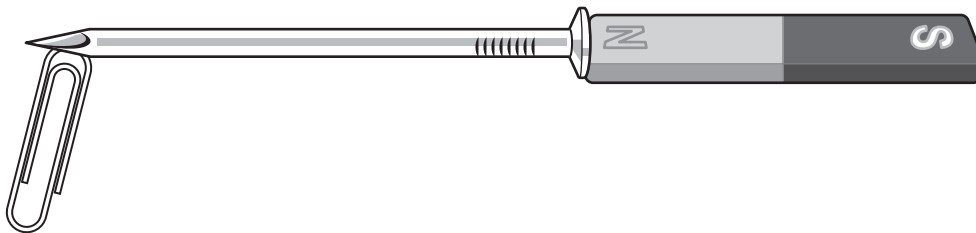
(a) First, they place a paper clip close to the iron nail.

The nail does **not** attract the paper clip.



Then they place a bar magnet touching the end of the nail.

The nail now attracts the paper clip, so the paper clip is attached to the nail.



(i) Which of these is a correct description of the **nail**?

Tick (✓) **one** box.

Electromagnet

☐

Induced magnet

☐

Permanent magnet

☐

[1]

(ii) What happens to the **paper clip** when the bar magnet is taken away?

Tick (✓) **one** box.

It becomes a permanent magnet.

☐

It falls off the nail.

☐

It stays permanently attached to the nail.

☐

[1]

3

(iii) Paperclips can be made from different metals.

Which **two** of these metals could the paperclip in this experiment be made from?

Tick (✓) **two** boxes.

Copper

☐

Nickel

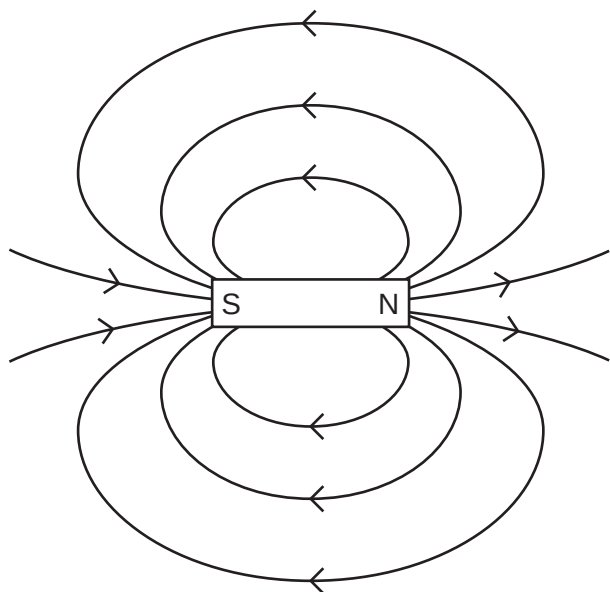
☐

Steel

☐

[1]

(b) The diagram shows the magnetic field around a bar magnet.



Complete the table to show the property of a magnetic field that is shown by each feature of the diagram.

Tick (✓) **one** box in each row.

| Feature of the diagram | Direction of magnetic field | Poles of the magnet | Type of magnet | Strength of magnetic field |
|------------------------|-----------------------------|---------------------|----------------|----------------------------|
| Arrows                 |                             |                     |                |                            |
| Distance between lines |                             |                     |                |                            |
| S and N                |                             |                     |                |                            |

[3]

4

- (c) Explain why a magnetic compass can be used to support the idea that the Earth's core is magnetic.

.....

.....

.....

..... [2]

5

2 Kettles are used to heat water to boiling point.

(a) What is the **useful** output energy store of a kettle?

Tick (✓) **one** box.

|               |                          |
|---------------|--------------------------|
| Gravitational | <input type="checkbox"/> |
| Magnetic      | <input type="checkbox"/> |
| Nuclear       | <input type="checkbox"/> |
| Thermal       | <input type="checkbox"/> |

[1]

(b) The table shows some electrical information about a mains electric kettle used at home and a travel kettle.

| Mains electric kettle | Travel kettle |
|-----------------------|---------------|
| 10A                   | 8A            |
| 230V                  | 12V           |
| 2000W                 | 100W          |

(i) Which piece of information gives the power rating of the mains electric kettle?

Tick (✓) **one** box.

|       |                          |
|-------|--------------------------|
| 10A   | <input type="checkbox"/> |
| 230V  | <input type="checkbox"/> |
| 2000W | <input type="checkbox"/> |

[1]

(ii) Both kettles are used to boil the same volume of water.

Complete the sentence to explain the time taken for each kettle.

Use words from the list.

|               |                    |                 |
|---------------|--------------------|-----------------|
| <b>energy</b> | <b>frequency</b>   | <b>less</b>     |
| <b>more</b>   | <b>temperature</b> | <b>the same</b> |

The travel kettle will take ..... time to boil the water because it transfers less ..... per second.

[2]

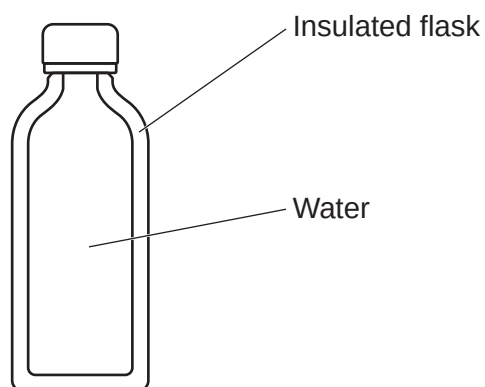
6

- (c) Hot water is poured from a kettle into an insulated flask.

The water fills the flask.

The lid is screwed on.

The diagram shows a cross-section through the flask.



The water stays hot in the flask.

Complete the sentences to describe this flask system.

Use words from the list.

|                  |                  |                 |
|------------------|------------------|-----------------|
| <b>closed</b>    | <b>changing</b>  | <b>constant</b> |
| <b>decreased</b> | <b>increased</b> | <b>open</b>     |

The flask system stays at the same temperature because the total energy  
is .....

This means the flask system can be referred to as .....

[2]

- (d) Some household appliances are operated for a longer time than a kettle.

Which of these is the correct calculation to find the energy transferred, in **kWh**, when a 1500 W appliance is used for 2 hours?

Use the equation: energy transferred = power  $\times$  time

Tick (✓) **one** box.

$3.0 \text{ kWh} = 1.5 \text{ kW} \times 2 \text{ h}$

☐

$3000 \text{ kWh} = 1500 \text{ W} \times 2 \text{ h}$

☐

$180\,000 \text{ kWh} = 1500 \text{ W} \times 120 \text{ min}$

☐

[1]

(e) The table shows data about four household appliances.

| Appliance                                                                                         | Rating | Average time used per day |
|---------------------------------------------------------------------------------------------------|--------|---------------------------|
| <br>Desk fan     | 500 W  | 1 hour                    |
| <br>Kettle       | 2000 W | 15 minutes                |
| <br>Lamp         | 50 W   |                           |
| <br>Television | 100 W  | 5 hours                   |

(i) Complete the sentences to describe the energy transfer of the appliances.

Put a ring around each correct option.

The wasted energy store of the desk fan is **electrical** / **kinetic** / **thermal** energy.

The lamp transfers energy to the surroundings by **electrical work** / **mechanical work** / **radiation**.  
[2]

(ii) All the appliances in the table are used for different amounts of time per day, but they each transfer 0.5 kWh of energy per day.

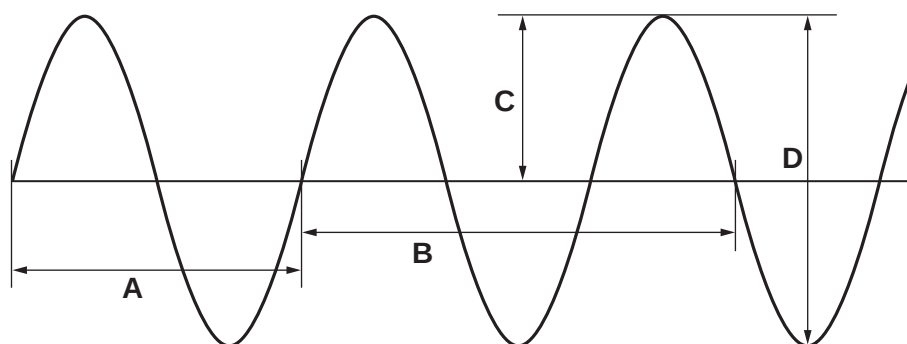
Calculate the average time used per day for the **lamp**.

Give your answer in hours.

Average time used per day = ..... hours [2]

**3** Lasers are very intense light waves.

**(a)** The diagram shows a light wave.



**(i)** Which letter, **A**, **B**, **C** or **D**, shows the wavelength of the wave?

..... [1]

**(ii)** Which letter, **A**, **B**, **C** or **D**, shows the amplitude of the wave?

..... [1]

**(iii)** Which property of a wave gives the time it takes to complete one full cycle?

Tick (✓) **one** box.

Frequency

☐

Period

☐

Speed

☐

Wavelength

☐

[1]

9

(b) A student uses a laser to investigate how light reflects from a mirror.

(i) State **one** risk of using a laser.

.....  
 ..... [1]

(ii) The laser is directed towards the mirror at different angles of incidence and the student measures the angle of reflection.

The table shows the student's results.

| Angle of incidence (°) | Angle of Reflection (°) |          |          | Mean Angle of Reflection (°) |
|------------------------|-------------------------|----------|----------|------------------------------|
|                        | Repeat 1                | Repeat 2 | Repeat 3 |                              |
| 20                     | 18                      | 21       | 18       | 19                           |
| 30                     | 29                      | 30       | 31       | 30                           |
| 40                     | 39                      | 40       | 38       |                              |
| 50                     | 52                      | 48       | 50       | 50                           |

Calculate the mean angle of reflection when the angle of incidence is 40°.

Mean angle of reflection = .....° [2]

(iii) The laser is now directed at the mirror so that the angle of incidence is 60°.

Predict the angle of reflection.

Explain how the data in the table supports your answer.

Angle of reflection = .....°

Explanation .....

.....  
 .....  
 ..... [2]

10

(c) A laser produces a beam of red light.

The wave speed of the red light is  $3.0 \times 10^8 \text{ m/s}$ .

The wavelength of the red light is  $750 \times 10^{-9} \text{ m}$ .

Calculate the frequency of the red light.

Use the equation: frequency =  $\frac{\text{wave speed}}{\text{wavelength}}$

Give your answer in **standard form**.

Frequency = ..... Hz [3]

**11**

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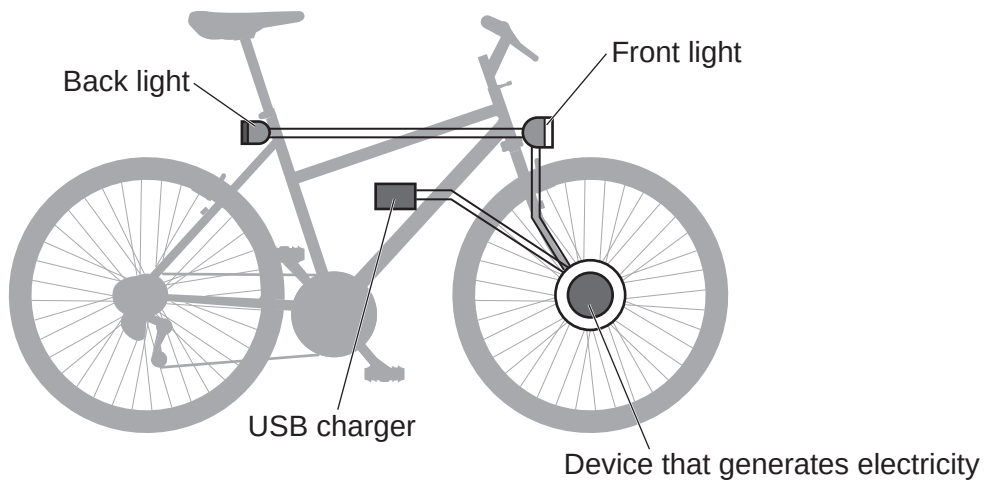
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**Turn over for the next question**

12

- 4 A bike is fitted with a device which uses the motion of the front wheel to generate electricity. The electricity generated is used to power lights and a USB charger.

The diagram below shows a simplified layout for the device on the bike.



The rotation of the wheel creates the spinning motion needed to induce a potential difference in a coil of wire.

- (a) What must be spinning near the coil of wire to induce a potential difference?

Tick (✓) **one** box.

A battery

☐

A current

☐

A magnet

☐

A transformer

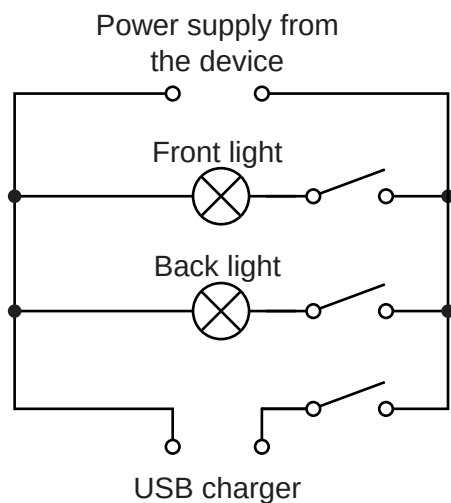
☐

[1]

13

- (b) The circuit diagram shows how the lights and the USB charger are connected to the device.

The switches shown are all open.



- (i) A component can be added to the circuit to measure current.

**Draw** the symbol for the component that measures current.

[1]

- (ii) When the bike lights and USB charger are each operating at 5 V, what is the potential difference across the power supply from the device?

Potential difference = ..... V [1]

- (iii) Complete the sentences to describe the energy transfers in the circuit.

Use words from the list.

|        |         |      |                      |       |
|--------|---------|------|----------------------|-------|
| closed | current | open | potential difference | power |
|--------|---------|------|----------------------|-------|

When a ..... flows in the circuit, energy is transferred from the power supply to each component.

A component will get no energy if the switch in that loop is .....

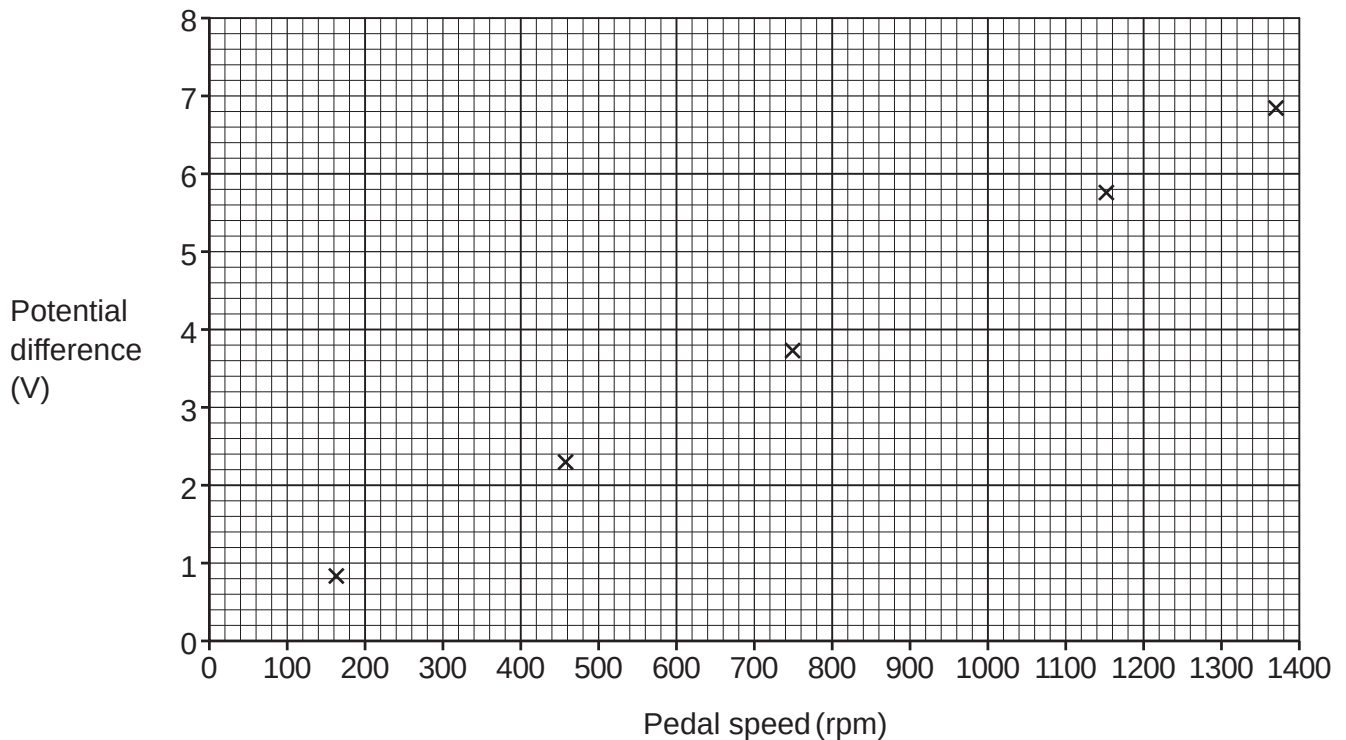
[2]

14

(c) When the bike is pedalled faster, the potential difference increases.

The graph shows the potential difference at different pedal speeds.

The pedal speed is measured in revolutions per minute (rpm).



(i) Draw a line of best fit on the graph.

[1]

(ii) Find the pedal speed for a potential difference of 5V.

Use your line of best fit.

Pedal speed = ..... rpm [1]

15

- (d) A mobile phone is plugged into the USB charger.
- (i) Calculate the charge that flows through the USB charger when:
- the current through the USB charger is 0.5A.
  - the phone is charged for 1200s.

Use the equation: charge = current  $\times$  time

Charge = ..... C [2]

- (ii) What quantity needs to be multiplied by potential difference to find the power of the USB charger?

Tick (✓) **one** box.

|            |                          |
|------------|--------------------------|
| Charge     | <input type="checkbox"/> |
| Current    | <input type="checkbox"/> |
| Resistance | <input type="checkbox"/> |
| Time       | <input type="checkbox"/> |

[1]

- (iii) Calculate the energy output of the USB charger.

- The charge passing through the USB charger is 2000C.
- The potential difference across the USB charger is 5V.

Use the Equation Sheet.

Give your answer in kJ.

Energy = ..... kJ [4]

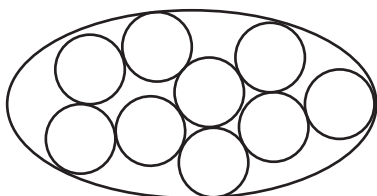
## 16

- 5 A bag containing fluid is used in a remote-control fish.

The bag is stretchy so its size can change.

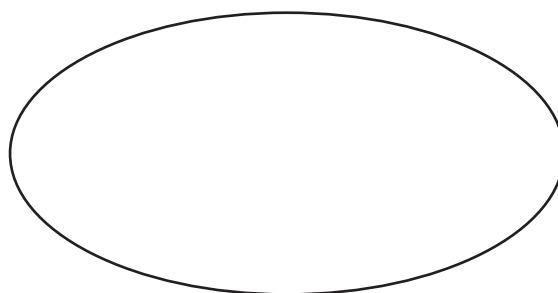
The fluid in the bag changes between liquid and gas to control the depth of the fish in the water.

- (a) The diagram shows nine particles inside the bag when the fluid is a **liquid**.



- (i) The bag becomes larger when the fluid becomes a gas.

Complete the diagram below to show how the same particles are arranged in the bag when the fluid is a **gas**.



[2]

- (ii) Calculate the density of the fluid in the bag when it is a liquid.

- There is 0.45 g of fluid in each bag.
- The volume of the fluid when liquid is  $0.3 \text{ cm}^3$ .

Use the Equation Sheet.

Density = .....  $\text{g/cm}^3$  [3]

17

(iii) When the fluid in the bag is a gas it has a volume of  $4\text{ cm}^3$ .

Explain why the fluid has a higher density as a liquid than as a gas.

You can include a calculation in your answer.

.....

.....

.....

..... [2]

(b) Calculate the energy needed to change the state of the fluid from liquid into gas.

- The mass of the fluid is  $0.00045\text{ kg}$ .
- The specific latent heat is  $200\,000\text{ J/kg}$ .

Use the Equation Sheet.

Energy to change from liquid to gas = ..... J [3]

(c) Which statements about the fluid in the bag are **true** and which are **false**?

Tick (✓) **one** box in each row.

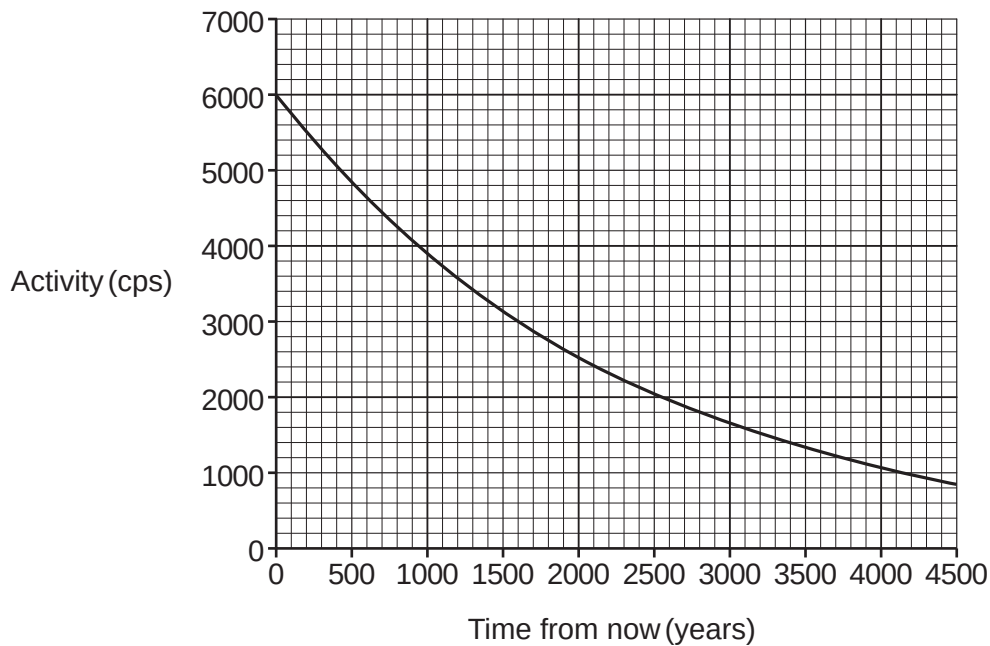
|                                                            | True | False |
|------------------------------------------------------------|------|-------|
| The change of state is a chemical change.                  |      |       |
| The liquid and the gas are two different substances.       |      |       |
| The mass of the liquid is the same as the mass of the gas. |      |       |

[2]

18

- 6 Marie Curie discovered the radioactive element, radium. Her notebook from 1920 is still radioactive today.

- (a) The graph shows the change in activity of the radium on the notebook over the next 4500 years.



- (i) Why does the activity of a radioactive source decrease?

Tick (✓) **one** box.

Half-life decreases.

☐

Half-life increases.

☐

The number of undecayed nuclei decreases.

☐

The number of undecayed nuclei increases.

☐

[1]

- (ii) What will the activity of the radium on the notebook be 2500 years from now?

Use the graph.

Activity = ..... cps [1]

(iii) Find the half-life of radium.

Use the graph.

Half-life = ..... years [2]

(iv) Explain why the statement below is **not** correct.

The radium on the notebook will be **much** less radioactive in 100 years' time.

.....  
 .....  
 .....  
 ..... [2]

(b) Touching the notebook is a risk.

(i) Complete the sentence about this risk.

Use words from the list.

|                     |                   |                |                  |
|---------------------|-------------------|----------------|------------------|
| <b>contaminated</b> | <b>irradiated</b> | <b>neutral</b> | <b>undecayed</b> |
|---------------------|-------------------|----------------|------------------|

If the ..... radium nuclei get into broken skin on a person's hand, the person will become .....

[2]

(ii) The radium emits alpha and gamma radiation.

Suggest **one** safety precaution that can be taken for **each** type of radiation.

Safety precaution to lower the risk from **alpha** radiation: .....

.....

Safety precaution to lower the risk from **gamma** radiation: .....

.....

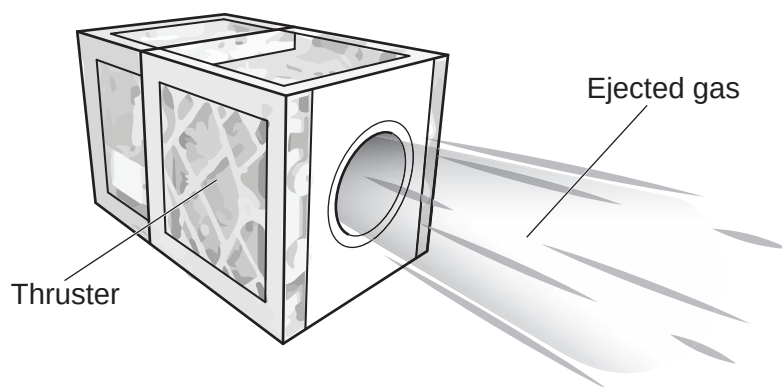
[2]

7 Satellites contain thrusters which change the height of a satellite orbiting the Earth.

(a) What force keeps satellites orbiting the Earth?

..... [1]

(b) The thruster ejects gas to change the speed of the satellite.



(i) Newton's third law explains the interaction between the ejected gas and the satellite.

Select Newton's third law.

Tick (✓) **one** box.

Energy cannot be created or destroyed.

☐

Every force has a reaction force equal in size and opposite in direction.

☐

Force is directly proportional to mass and to acceleration.

☐

Unless a net force acts on an object, it continues at a steady speed.

☐

[1]

(ii) Explain how the thruster ejecting a gas causes the satellite to change speed.

Use ideas about forces.

.....  
 .....  
 .....  
 ..... [2]

21

- (c) The computer on the satellite reports data about the gas molecules leaving the thruster.

The table shows the data.

| Initial speed (m/s) | Final speed (m/s) | Time (s)            |
|---------------------|-------------------|---------------------|
| 0                   | 40 000            | $2 \times 10^{-16}$ |

Explain why it is possible to calculate the acceleration of the gas molecules from this data but **not** the force acting on them.

It is possible to calculate acceleration because .....

.....

.....

It is **not** possible to calculate force because .....

.....

.....

[2]

- 8 A boat makes a journey along a canal.

**Fig. 8.1** shows part of the canal **drawn to scale**.

The boat travels from **A** to **C** via **B**.

**Fig. 8.1**



- (a) The distance travelled from **A** to **C** is 5000 m.
- (i) Find the distance from **A** to **B**.

Use:

- **Fig. 8.1**
- a ruler.

Distance from **A** to **B** = ..... m [2]

- (ii) When the boat leaves **A**, the time is 09:23.  
When the boat reaches **B**, the time is 09:53.

Calculate the average speed of the boat for its journey from **A** to **B**.

Use the Equation Sheet.

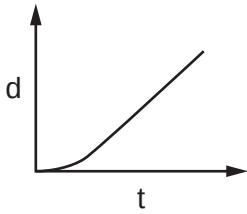
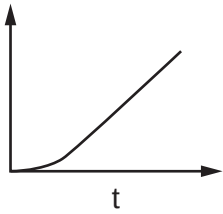
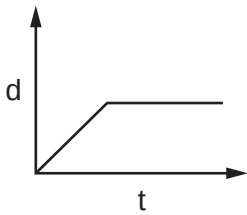
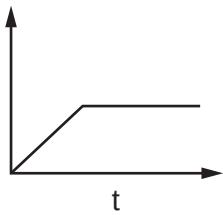
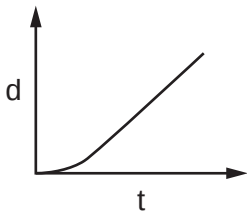
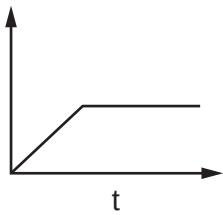
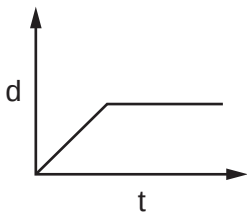
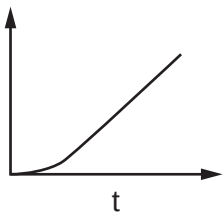
Give your answer in **m/s**.

Average speed = ..... m/s [3]

- (b) The boat sets off from **A** at constant acceleration and then reaches a constant speed.

Which row in the table shows the correct distance-time graph **and** speed-time graph for the motion of the boat from **A**?

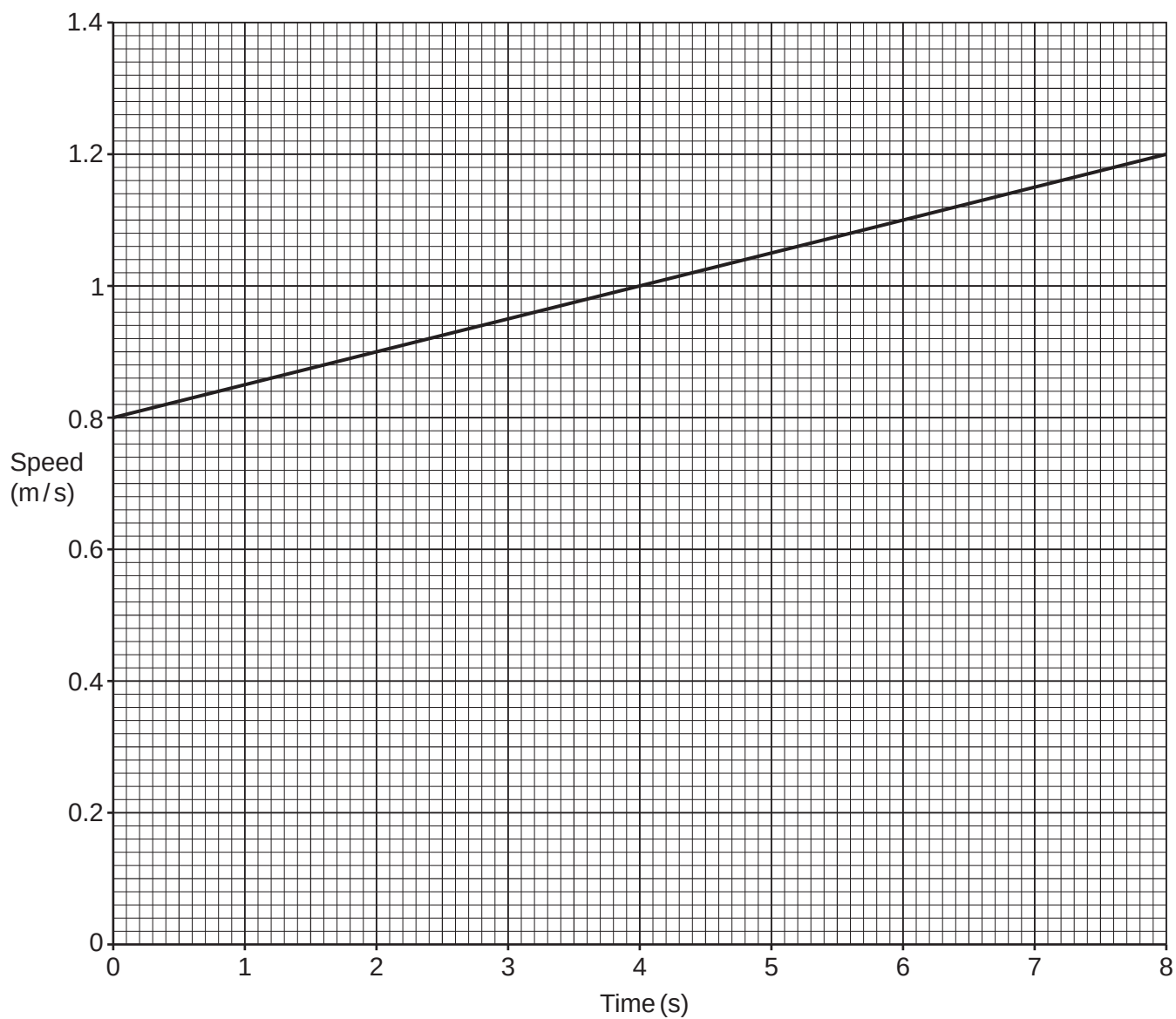
Tick (✓) **one** box.

| Distance-time                                                                       | Speed-time                                                                          |                          |
|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|--------------------------|
|    |    | <input type="checkbox"/> |
|    |    | <input type="checkbox"/> |
|   |   | <input type="checkbox"/> |
|  |  | <input type="checkbox"/> |

[1]

(c) Fig. 8.2 shows the speed–time graph for the boat for a short period.

Fig. 8.2



Calculate the acceleration of the boat.

Use Fig. 8.2.

Acceleration = .....  $\text{m/s}^2$  [3]

25

(d) The boat has a force acting on it from the wind.

Which of these is a typical value for the speed of wind?

Tick (✓) **one** box.

0.12m/s ☐

12m/s ☐

1200m/s ☐

120 000m/s ☐

[1]

26

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9 In the 1930s, scientists experimented with elements and split their nuclei.

(a) Complete the sentences about splitting the nucleus.

Use words from the list.

|                |               |                 |
|----------------|---------------|-----------------|
| <b>fission</b> | <b>fusion</b> | <b>negative</b> |
| <b>power</b>   | <b>stable</b> | <b>unstable</b> |

The nuclei of certain elements can be split into two smaller nuclei because they are .....

The process is called nuclear .....

[2]

- (b) The discovery that nuclei could be split developed over several years in the 1930s.

The table shows a timeline of some of the scientists involved and what they did.

| Year | Scientist                                                                                           | What they did                                                                                                                                                             |
|------|-----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1934 | Enrico Fermi<br>   | Fired neutrons at uranium nuclei which were captured by the uranium nuclei and made different elements.<br>Fermi thought he created elements <b>heavier</b> than uranium. |
| 1934 | Ida Noddack<br><small>© shethoughtit.icml.com, She Thought It. Item remove</small>                  | Published a paper suggesting that Fermi's elements might be <b>lighter</b> than uranium.<br>Her paper was ignored as she had no experimental data or theory.              |
| 1939 | Otto Hahn<br>    | Repeated Fermi's experiment and identified one of the elements that was made as the lighter element <b>barium</b> .                                                       |
| 1939 | Lise Meitner<br> | Calculated the energy changes for Hahn's data and confirmed that energy is <b>conserved</b> when splitting a uranium nucleus into a barium nucleus and another nucleus.   |

- (i) Suggest why Enrico Fermi's hypothesis was believed in 1934.

.....

..... [1]

- (ii) Explain why, by 1940, more scientists had confidence in the theory that nuclei can be split.

Use information from the table to support your answer.

.....

.....

.....

..... [2]

- (c) When uranium nuclei split, neutrons are released and a chain reaction happens.

Which statement correctly explains how a chain reaction happens?

Tick (✓) **one** box.

The neutrons released are absorbed by other uranium nuclei.

☐

The neutrons released contaminate the surroundings.

☐

The neutrons released link to form a chain.

☐

[1]

- (d) Which **two** statements describe how the energy is released when uranium nuclei split?

Tick (✓) **two** boxes.

As kinetic energy of the new particles.

☐

As kinetic energy of the uranium nuclei.

☐

As potential energy of the new particles.

☐

By emission of infrared radiation.

☐

By emission of ionising radiation.

☐

[2]

**END OF QUESTION PAPER**



This image shows a full page of primary-ruled paper. It features a vertical solid line on the left side, creating a narrow margin. The rest of the page is filled with horizontal dashed lines, providing a guide for letter height and placement. There are no markings, text, or illustrations on the page.

