OCR
Oxford Cambridge and RSA

Wednesday 22 May 2024 – Morning

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

J259/01 Breadth in physics (Foundation Tier)

Time allowed: 1 hour 45 minutes

F

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

* J 2 5 9 0 1 *

* 1 3 7 6 9 3 2 6 5 2 *

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

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

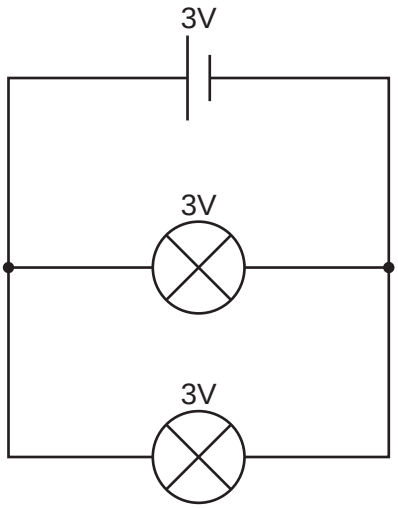
Last name _____

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 **36** pages.

ADVICE
- Read each question carefully before you start your answer.

1 A student builds a circuit with two lamps connected in parallel.



(a)

(i) What feature of the circuit makes it a parallel circuit?

Tick (✓) **one** box.

It has a 3 V cell. ☐

It has branches. ☐

It has two identical lamps. ☐

[1]

(ii) A third lamp is now connected in parallel.

What happens to the brightness of the original lamps?

Tick (✓) **one** box.

Lamps get brighter. ☐

Lamps get dimmer. ☐

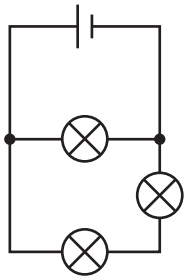
Lamps stay the same brightness. ☐

[1]

(b) The student now uses the same equipment to build a circuit with all three lamps in series.

Which circuit diagram shows this circuit?

Tick (✓) **one** box.



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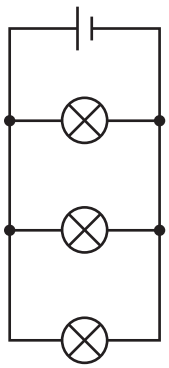

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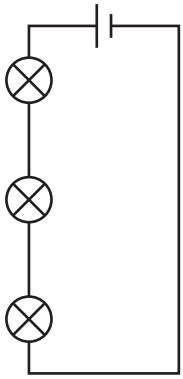

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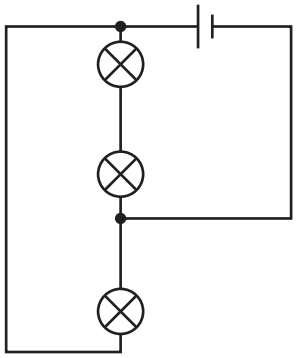

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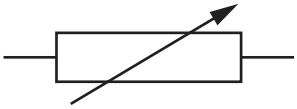
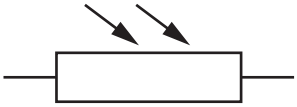
[1]

(c) The student then uses some resistors to control the brightness of the lamps.

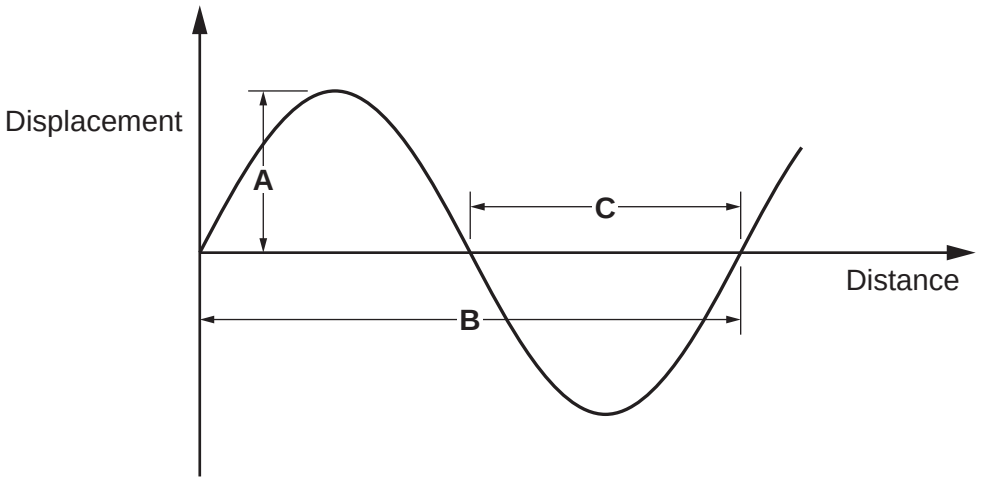
Draw a line from each **circuit symbol** to the **type of resistor** it represents.

Circuit symbol	Type of resistor
 ■	Light dependent resistor
	Thermistor
 ■	Variable resistor

[2]

2 Waves transfer energy in many ways.

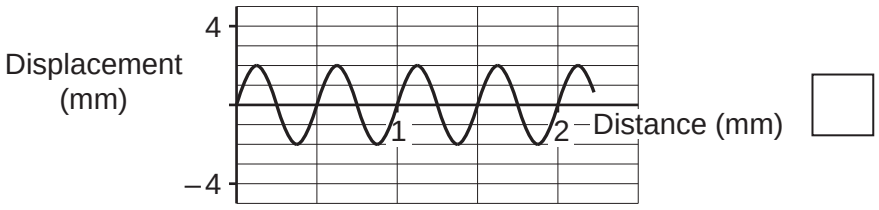
(a) Which length, **A**, **B** or **C**, on the diagram represents the wavelength of the wave?



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

(b) Which wave has the greatest amplitude?

Tick (✓) **one** box.



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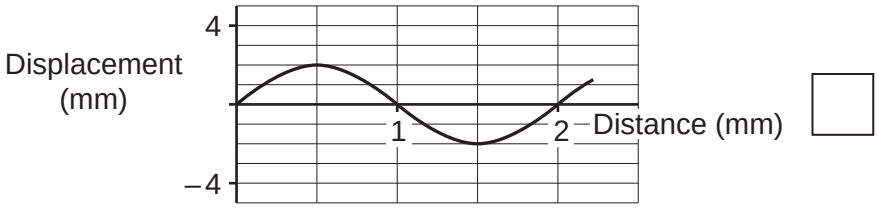

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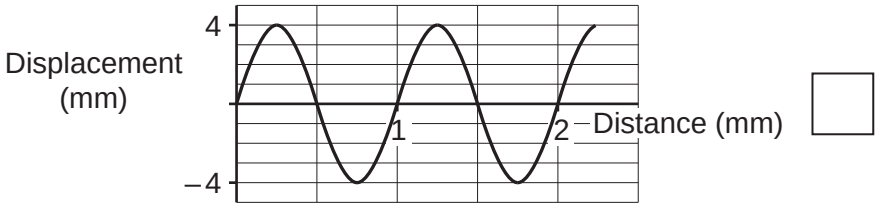

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[1]

(c) Some waves are formed on the surface of water.

In 2 seconds, 7 waves pass a point.

Calculate the frequency of the wave.

Give the unit.

Frequency = ... Unit ..... **[3]**

(d) Microwaves can be used for both communication and heating.

Draw lines to connect **each use** to one **example** of that use.

Use	**Example**
	Cooking food
Communication	Detecting broken bones
	Lighting a room
Heating	Mobile phone
	Night vision

[2]

(e) Complete the sentences about electromagnetic waves.

Use words from the list.

frequency	**light**	**longitudinal**	**speed**	**transverse**	**ultrasound**

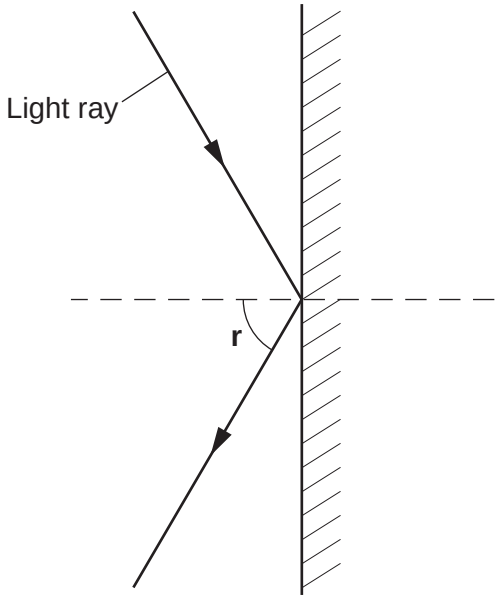
Microwaves and ..... are both electromagnetic waves.

All electromagnetic waves are ..... and travel at the same

..... in space.

[3]

(f) Waves reflect when they hit materials. The diagram shows a light ray reflecting.



(i) What does this symbol in the diagram mean? 

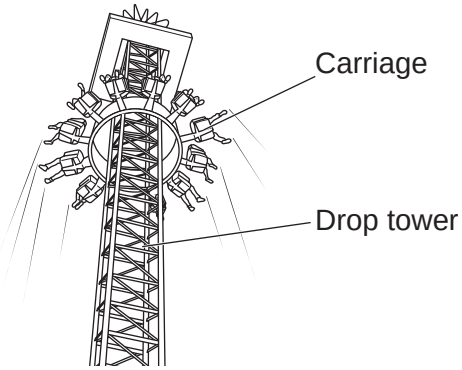
..... **[1]**

(ii) The angle of reflection, **r**, is labelled on the diagram.

Label the angle of incidence, **i**, on the diagram. **[1]**

3 The diagram shows a fairground ride called the Drop Tower.

Riders are pulled to the top of the tower in a carriage.
The carriage is then released and drops back to the bottom.



(a) A petrol generator provides electricity for the ride.

How is the useful energy stored in petrol?

Tick (✓) **one** box.

Chemical store ☐

Electromagnetic store ☐

Electrostatic store ☐

Kinetic store ☐

[1]

(b) The total mass of the carriage with 12 riders is 2340 kg.

The total mass of the 12 riders is 840 kg.

(i) Calculate the mean mass of each rider.

Mean mass = ... kg **[2]**

(ii) Calculate the mass of the empty carriage.

Mass = ... kg **[1]**

(c) The carriage and 12 riders are pulled up through a height of 60 m to get to the top of the ride.

Calculate the change in gravitational potential energy of the carriage and 12 riders when it has reached the top.

Use the equation:
gravitational potential energy = mass × gravitational field strength × height.

gravitational field strength = 10 N / kg.

Gravitational potential energy = ... J **[2]**

(d) The pulley lifts the carriage and riders at a power of 15 000 W.

What is the definition of power?

Tick (✓) **one** box.

The energy transferred in 10 seconds. ☐

The height gained in one second. ☐

The rate of change of speed. ☐

The rate of energy transfer. ☐

[1]

(e) The carriage has brakes to slow it down before it stops at the bottom.

The brakes transfer 20 kJ of energy during a 2 s time period.

Calculate the power of the ride transferred during this braking.

Use the Equation Sheet.

Power = ... W **[4]**

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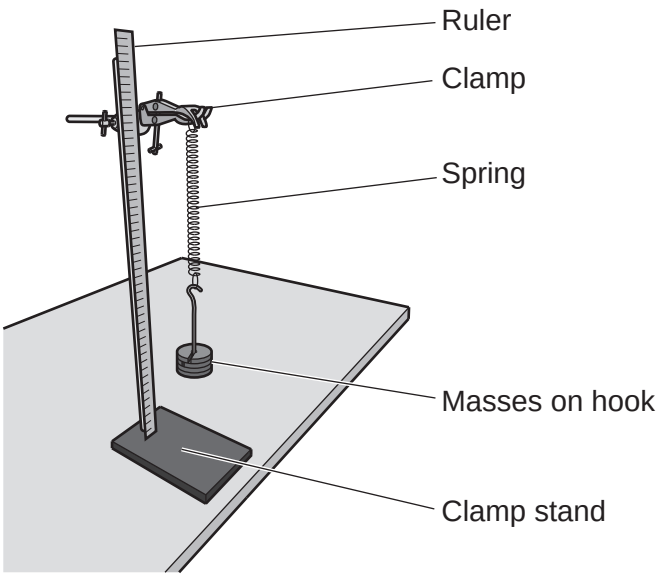
Turn over for the next question

4 A student investigates how a spring stretches when masses are added.

Fig. 4.1 shows how the student sets up her equipment.

Fig. 4.1



(a) Identify a hazard and suggest a way to minimise the risk.

.....

.....

.....

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

(b) The student uses her equipment and follows a method to collect data.

The statements below show the steps in her method.

A Hang a hooked mass on the spring.

B Repeat for a larger mass.

C Measure and record the extension.

D Remove the mass from the spring.

E Wait for the mass to stop bouncing.

F Check the spring has returned to its original length.

Write the letters in the boxes to show the correct order of the steps.

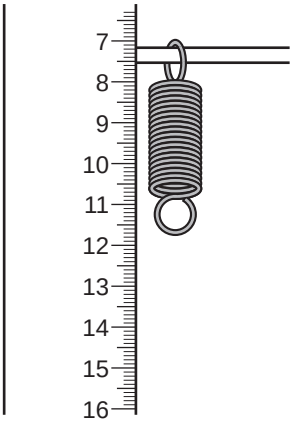
The first step has been done for you.

A					

[3]

(c) **Fig. 4.2** shows a close-up of the apparatus.

Fig. 4.2



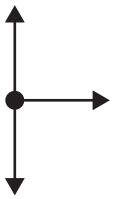
Suggest **one** change the student can make to get more valid data.

.....

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

(d) Which free body force diagram shows balanced forces on a stretched spring?

Tick (✓) **one** box.



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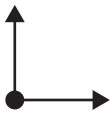

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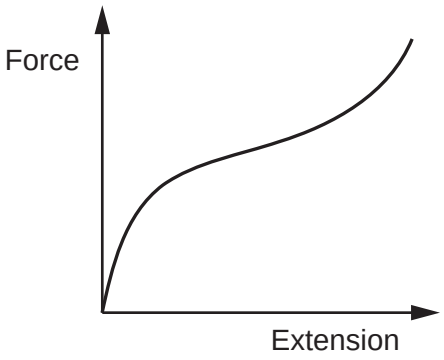
[1]

(e) A rubber band behaves in a different way to a spring.

This is a force-extension graph for a rubber band.



Complete the sentence about the rubber band.

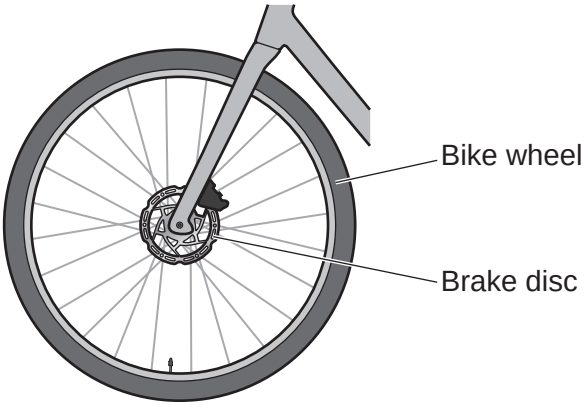
Put a (ring) around the correct option.

The force-extension relationship for a rubber band is

linear / non-linear / directly proportional.

[1]

5 The diagram shows a brake disc on a bike wheel.



The brake disc gets hot when the brakes are used to stop the bike.

(a) Complete the sentence to explain why brakes get hot.

Use words from the list.

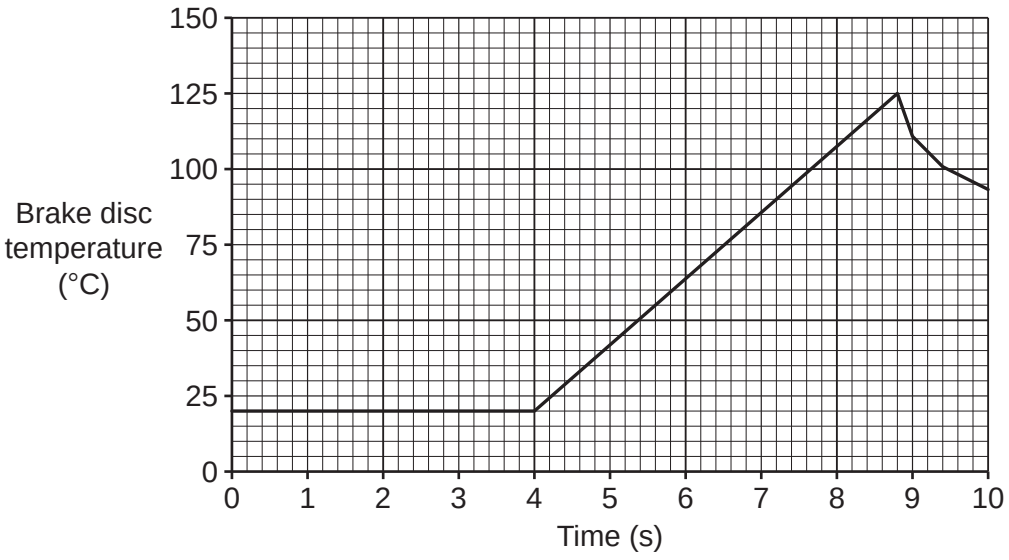
chemical	**elastic**	**gravitational**	**kinetic**	**thermal**

The brakes transfer energy from the ..... store of the bike to the

..... store of the brake disc.

[2]

(b) The graph shows the temperature of the brake disc on part of a bike journey.



What time did the rider apply the brakes?

Use data from the graph.

Time = ... s **[1]**

(c) Find the maximum temperature increase of the brake disc during braking.

Use data from the graph.

Temperature increase = ... °C **[2]**

(d) Use your answer to part **(c)** to calculate the change in internal energy of the brake disc while the bike slows down.

The specific heat capacity of the brake disc is 500 J / kg °C.
The mass of the brake disc is 200 g.

Use the equation:
change in internal energy = mass × specific heat capacity × change in temperature

Change in internal energy = ... J **[3]**

(e) Complete the sentence to define specific heat capacity.

Use words from the list.

energy	**joule**	**kilogram**	**mass**	**temperature**	**time**

Specific heat capacity is the ..... needed to change the ..... of one

..... of a material by 1 °C.

[3]

(f) When the rider stops applying the brakes, the brake disc will cool down.

Predict the temperature of the brake disc once it has stopped cooling down.

Use data from the graph.

Temperature = ... °C **[1]**

6 Radium-223 is a radioactive isotope used in medical treatment.

(a) Complete the nuclear equation to show the decay of radium-223 (Ra) to radon (Rn).

$$^{223}_{88}\text{Ra} \rightarrow {}^{4}_{2}\alpha + {}^{\cdots\cdots}_{\cdots\cdots}\text{Rn}$$

[2]

(b)

(i) Which of these is the correct definition of half-life?

Tick (✓) **one** box.

The activity after half the age of the sample. ☐

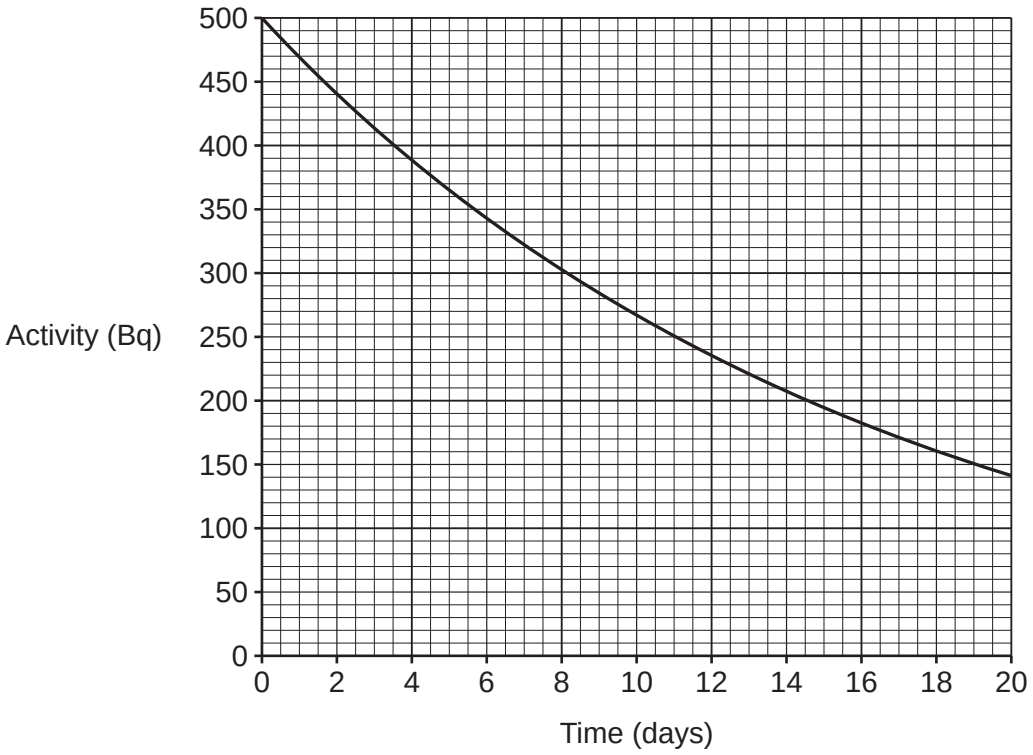
The time taken for the activity to reach 0.5Bq. ☐

The time taken for half a decay to happen. ☐

The time taken for the activity to fall to half. ☐

[1]

(ii) The graph shows the decay of radium-223.



Find the half-life of radium-223.

Use the graph.

Tick (✓) **one** box.

8 days ☐

10 days ☐

11 days ☐

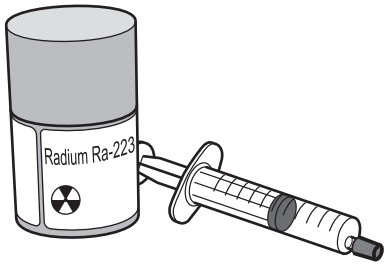
250 Bq ☐

[1]

(c) Radium-223 emits alpha particles.

It is injected into veins for medical treatment.

The diagram shows the radium-223 medicine and syringe.



(i) There is no lead shielding on the syringe.

Give a reason why this is safe.

.....

.....

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

(ii) Why is radium-223 far more effective at destroying unwanted tissue than beta or gamma-emitters?

Tick (✓) **one** box.

Alpha radiation is less harmful. ☐

Alpha radiation is more ionising. ☐

Alpha radiation is more penetrating. ☐

Alpha radiation is more stable. ☐

[1]

(d) Gamma emitting radioactive isotopes are used for scanning bones to check if the treatment was successful.

Table 6.1 shows some information about three isotopes that emit gamma radiation.

Table 6.1

Radioactive isotope	Half-life
Francium-232	5 seconds
Phosphorus-32	14 days
Technetium-99	6 hours

Which isotope from **Table 6.1** is most suitable for bone scans?

Explain your answer.

.....

.....

.....

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

(e) **Table 6.2** shows three possible things that can happen after a bone scan.

Show whether the statement describes an example of **contamination** or **irradiation**.

Tick (✓) **one** box in each row.

Table 6.2

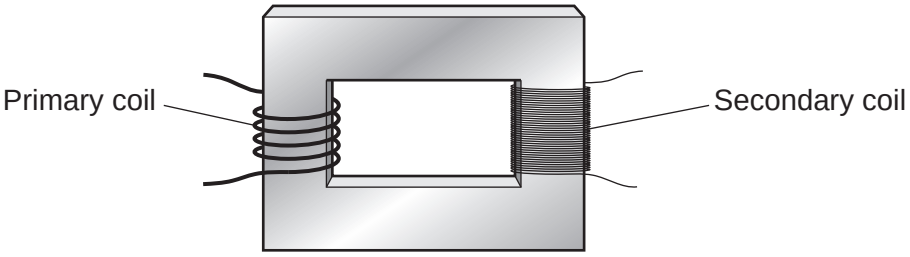
	Contamination	Irradiation
A radioactive substance is transferred to other people using the same towel.		
Gamma rays pass through the patient's body and are detected by gamma ray detectors.		
People close to the patient are exposed to gamma rays coming out of the patient's body.		

[2]

7 Transformers are used in the National Grid to change the potential difference of the electricity supply.

(a)

(i) The diagram shows a transformer that converts potential difference from 25 000 V to 400 000 V.



What type of transformer is this?

Tick (✓) **one** box.

Step-across transformer ☐

Step-along transformer ☐

Step-down transformer ☐

Step-up transformer ☐

[1]

(ii) The current in the 25 000 V primary coil of the transformer is 18 000 A.

The secondary coil has a potential difference of 400 000 V.

Calculate the current in the secondary coil.

Use the equation:

$$\text{current in secondary coil} = \frac{\text{potential difference across primary coil} \times \text{current in primary coil}}{\text{potential difference across secondary coil}}$$

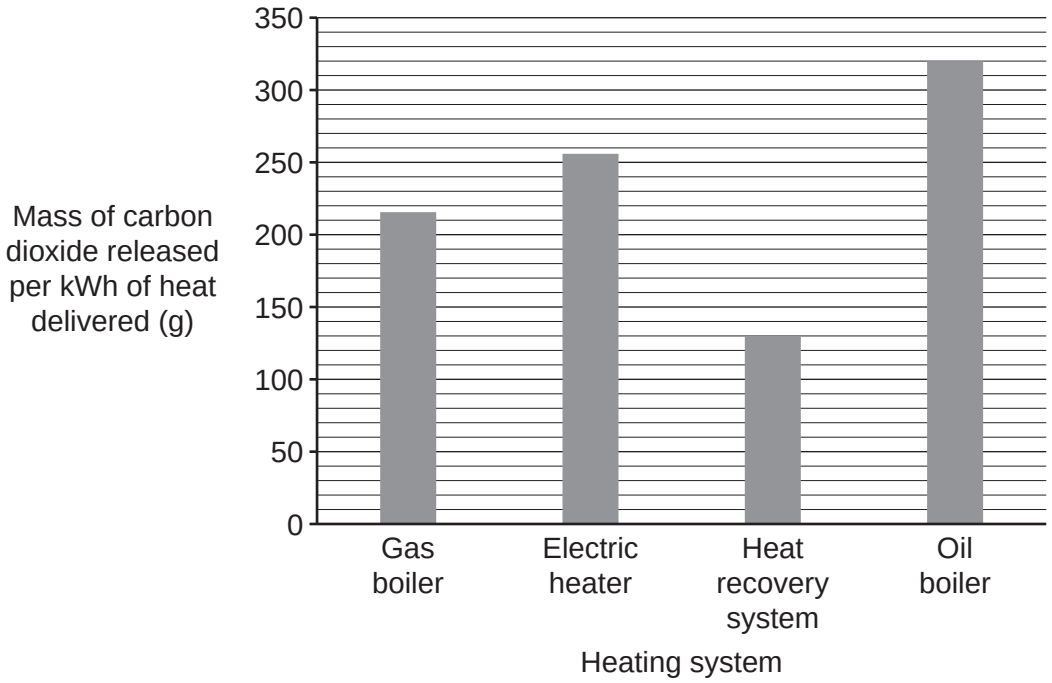
Give your answer to **2** significant figures.

Current = ... A **[3]**

(b) Transformers get hot.

The thermal energy store from large transformers in the National Grid can be used to provide heating for nearby homes. This is known as a heat-recovery system.

The graph shows the mass of carbon dioxide released by different heating systems per kWh of heat they deliver.



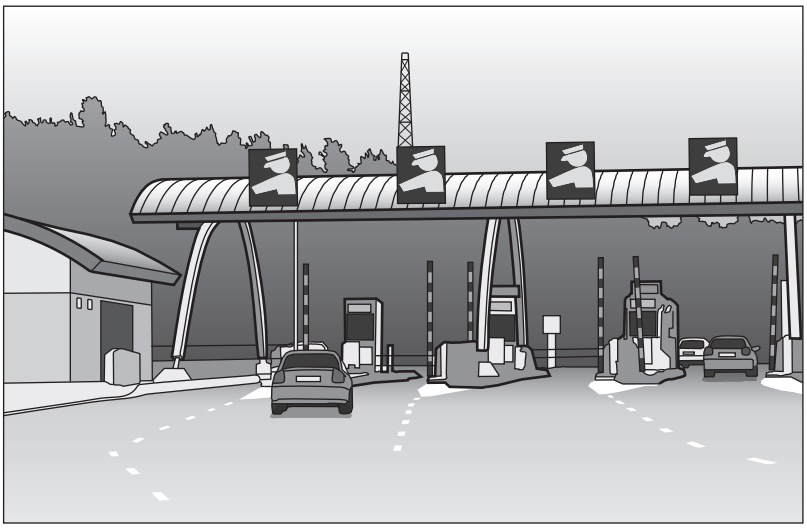
A homeowner changes from using a gas boiler to using the heat recovery system.

Calculate the percentage decrease in carbon dioxide released per kWh of heat.

Use data from the graph.

Percentage decrease = ... % **[3]**

8 Drivers pay to use a toll road. Cars stop at a payment point and then accelerate to the usual road speed.



(a) A car leaves the payment point and accelerates:
- for 11 s
- to a speed of 22 m / s.

The car is a typical family car.

(i) Calculate the car's acceleration.

Use the equation: $\text{acceleration} = \dfrac{\text{change in speed}}{\text{time taken}}$

Acceleration = ... m/s^2 **[2]**

(ii) Estimate the mass of a typical family car.

Tick (✓) **one** box.

250 kg ☐

1500 kg ☐

5000 kg ☐

20000 kg ☐

[1]

(iii) Calculate the resultant force on the car.

Use:
- your answers to parts **(a)(i)** and **(a)(ii)**
- the Equation Sheet.

Resultant force = ... N **[3]**

(b) After a few minutes the driver needs to perform an emergency stop.

Suggest **one** danger caused by large deceleration.

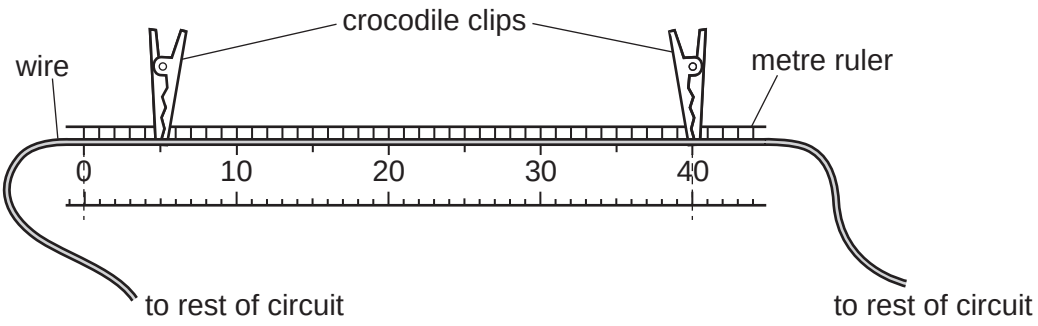
.....

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

9 A student wants to find the resistance of a piece of wire.

They clip the wire into a circuit with an **ammeter**, **voltmeter** and **variable power supply**.

The diagram shows how they clip the wire into the circuit.



(a) Draw a circuit diagram to show the full circuit they use.

Use:

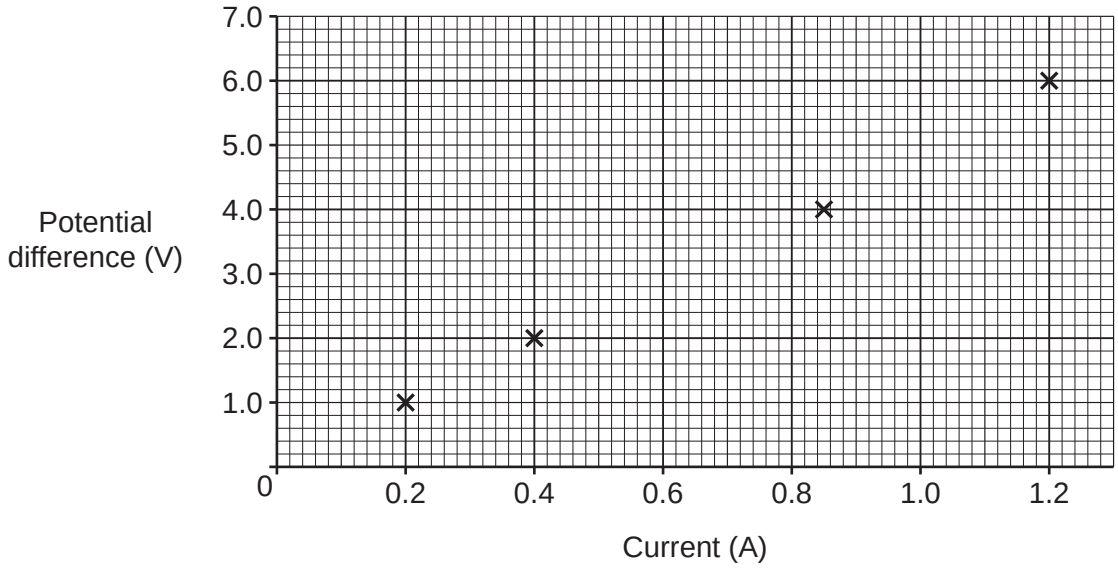
- this symbol for the wire —●—●—
- this symbol for the variable power supply —○ ○—

[3]

(b) The student records the data shown in the table and plots a graph.

Current (A)	Potential difference (V)
0.20	1.0
0.40	2.0
0.65	**3.2**
0.85	4.0
0.98	**4.8**
1.20	6.0

(i) Plot the **two** missing points on the graph.



[1]

(ii) Draw a line of best fit on the graph. **[1]**

(iii) Calculate the gradient of the line.

Gradient = ... **[2]**

(iv) Find the resistance of the wire.

Resistance = ... Ω **[1]**

(c) The student clips a new piece of the same wire in the circuit and repeats their method to find the resistance.
The new piece of wire is double the length.

Describe how the resistance of the new length of wire is different to the resistance of the original length of wire.

.....

.....

.....

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

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Turn over for the next question

10 The table shows information about some objects in the solar system.

Name	**Pluto**	**Charon**	**Earth**	**The Moon**
Type of object	dwarf planet	moon	planet	moon
Orbits around	The Sun	Pluto	The Sun	Earth
Diameter (km)	2370	1210	12 700	3480
Mass (kg)	1.3×10^{22}	1.6×10^{21}	6.0×10^{24}	7.4×10^{22}
Radius of orbit (km)	5.9×10^{9}	2.0×10^{4}	1.5×10^{8}	3.9×10^{5}
Gravitational force between the two objects (N)	5.0×10^{16}	3.5×10^{18}	3.5×10^{22}	1.9×10^{20}

(a) Name another **type** of object in the solar system that is **not** listed in the table.

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

(b) A student looked at the data and said:
'A moon is always approximately half the diameter of the object it orbits.'

Show that the student is **incorrect**.

Use data from the table.

.....

.....

.....

.....

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

(c) Explain the difference in the time taken for Pluto and Earth to orbit the Sun.

Use data from the table.

.....

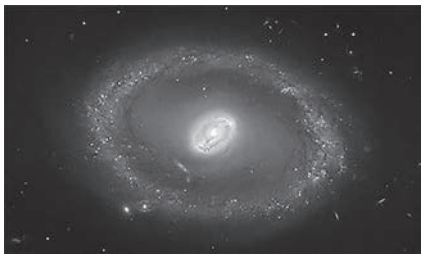
.....

.....

.....

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

(d) The photo shows the formation of a star from a cloud of dust and gas.



Complete the sentences to explain the formation of the solar system and the birth of the Sun.

Use words from the list.

chemical	**combustion**	**friction**	**fusion**	**gravity**	**magnetism**

The objects in the solar system were formed over long periods of time from clouds of dust and gas drawn together by the force of ..... .

Particles at the centre collapsed together forcefully and increased the pressure and temperature until ..... reactions began, forming the Sun. **[2]**

(e) The diagrams represent the processes inside a star.

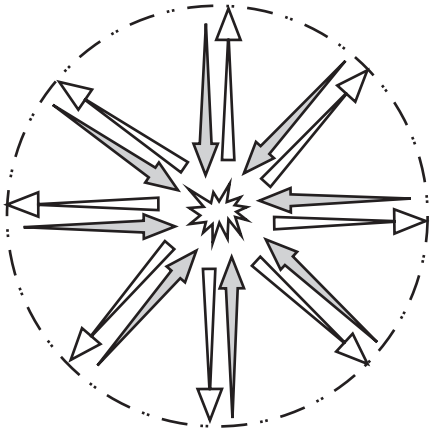
Which diagram shows how these processes keep a star, like the Sun, stable in size and shape for millions of years?

Tick (✓) **one** box.

Pressure

Gravity

☐



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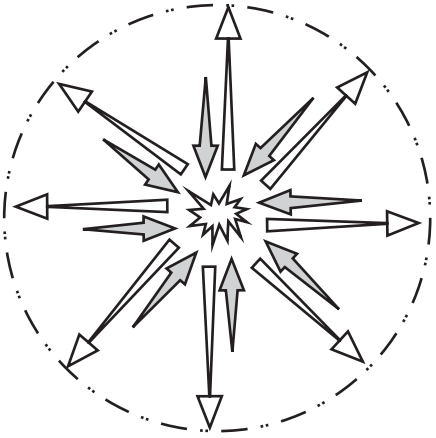

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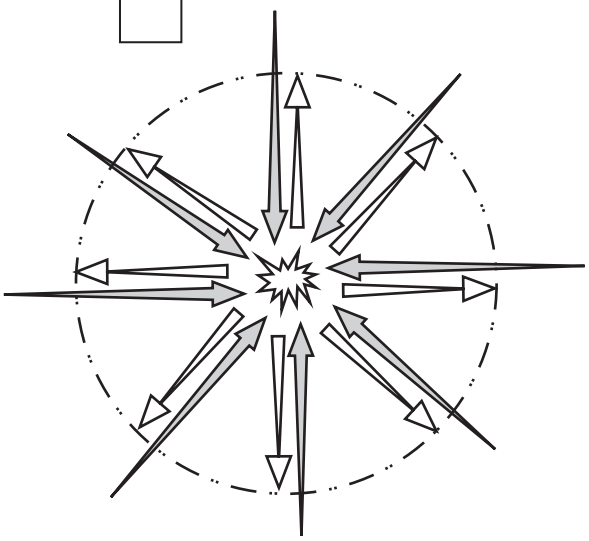

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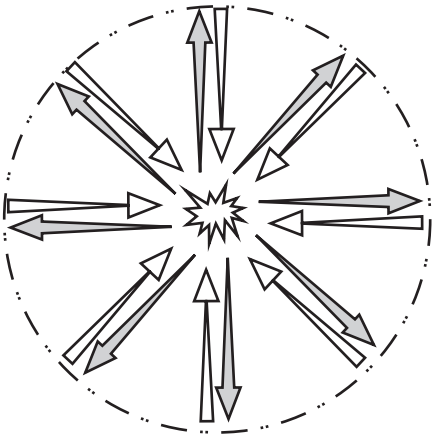

[1]

END OF QUESTION PAPER

EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.