



Surname _____

Other Names _____

Centre Number _____

Candidate Number _____

Candidate Signature _____

AS PHYSICS

Paper 2

7407/2

Thursday 8 June 2017 Afternoon

Time allowed: 1 hour 30 minutes

For this paper you must have:

- a pencil and a ruler
- a scientific calculator
- a Data and Formulae booklet.

At the top of the page, write your surname and other names, your centre number, your candidate number and add your signature.

[Turn over]



J U N 1 7 7 4 0 7 / 2 0 1

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INSTRUCTIONS

- Use black ink or black ball-point pen.
- Answer ALL questions.
- You must answer the questions in the spaces provided. Do NOT write on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

INFORMATION

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a scientific calculator where appropriate.
- A Data and Formulae Booklet is provided as a loose insert.

DO NOT TURN OVER UNTIL TOLD TO DO SO



SECTION A

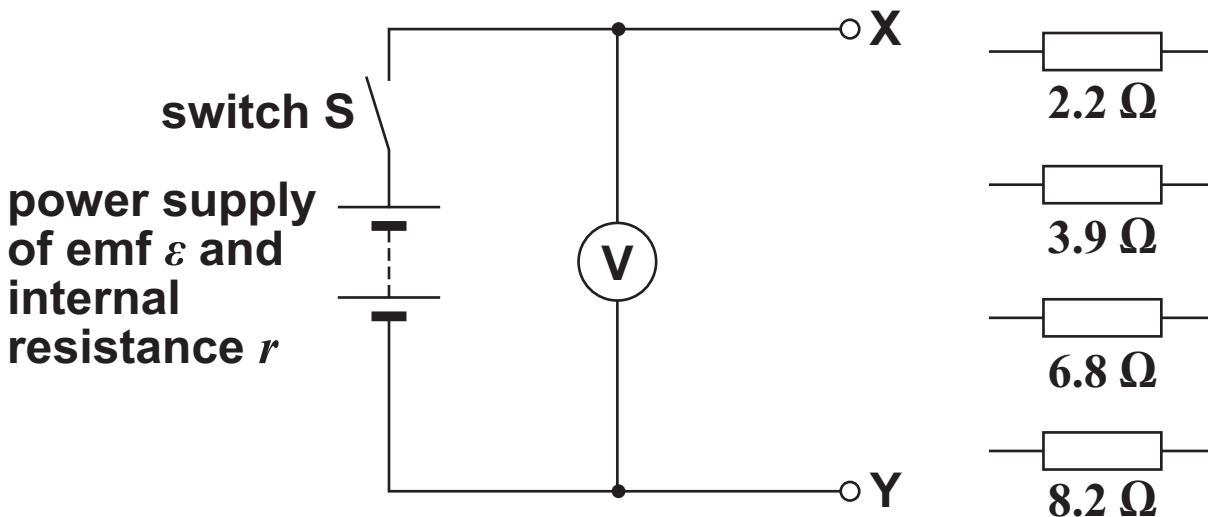
Answer ALL questions in this section.

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This question is about an experiment to determine the internal resistance of a power supply.

A student is given the circuit and the four resistors of known resistance shown in FIGURE 1.

FIGURE 1



The student can change the external resistance R of the circuit between terminals X and Y. This is done by connecting different combinations of TWO resistors in series or in parallel between X and Y. This method can produce 12 DIFFERENT VALUES for R .



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Calculate the largest value of R that the student can obtain using TWO resistors.
[1 mark]

largest value of $R =$ _____ Ω

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Calculate the smallest value of R that the student can obtain using TWO resistors.
[2 marks]

smallest value of $R =$ _____ Ω

[Turn over]



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With switch S closed (in the on position) and no resistors connected between X and Y the voltmeter reading V is 1.62 V.

The student concludes that this voltmeter reading equals the emf \mathcal{E} of the power supply.

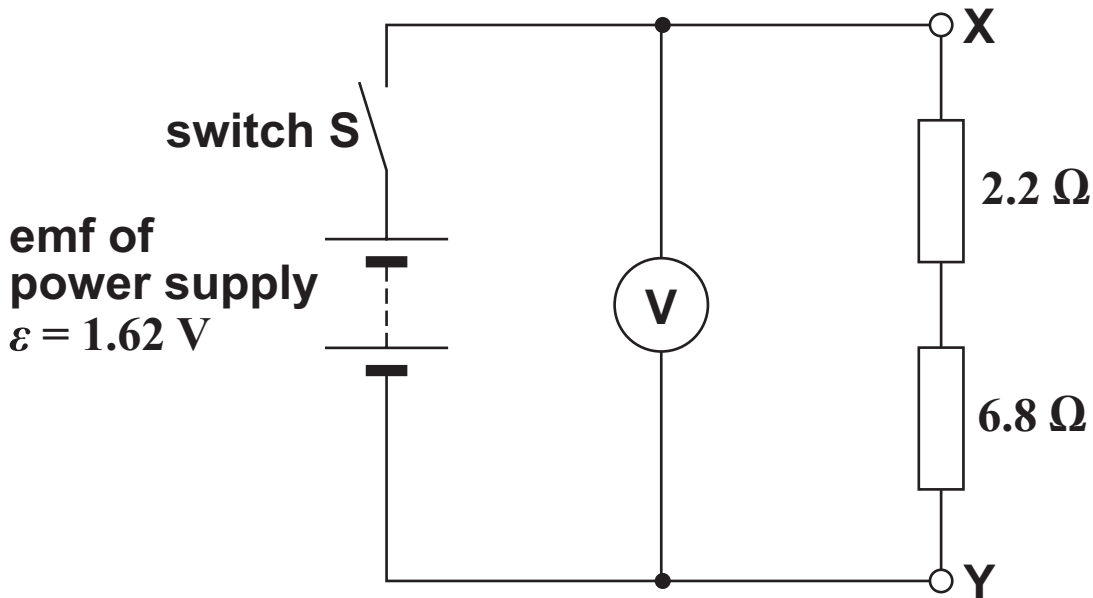
State why the student's conclusion that $\mathcal{E} = 1.62 \text{ V}$ was correct. [1 mark]

[Turn over]



0 1 · **4** **FIGURE 2** shows one particular combination and arrangement of two resistors that the student could use.

FIGURE 2



When S is closed the voltmeter reading V is 1.14 V .

Explain why V is less than 1.62 V when S is closed. [1 mark]



01 . 5

It can be shown that

$$\varepsilon - V = r \times \frac{V}{R}$$

where r is the internal resistance of the power supply.

Determine $(\varepsilon - V)$ and $\frac{V}{R}$ for this circuit using the data given in question 01.4.
[1 mark]

$$(\varepsilon - V) = \underline{\hspace{15cm}} \text{ V}$$

$$\frac{V}{R} = \underline{\hspace{15cm}} \text{ V } \Omega^{-1}$$

[Turn over]



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 The student obtains values of V for five further different values of R .

These data were used to produce the graph of $(\varepsilon - V)$ against $\frac{V}{R}$ in FIGURE 3.

Plot the point you determined in question 01.5 on FIGURE 3 and add a suitable best-fit line. [1 mark]

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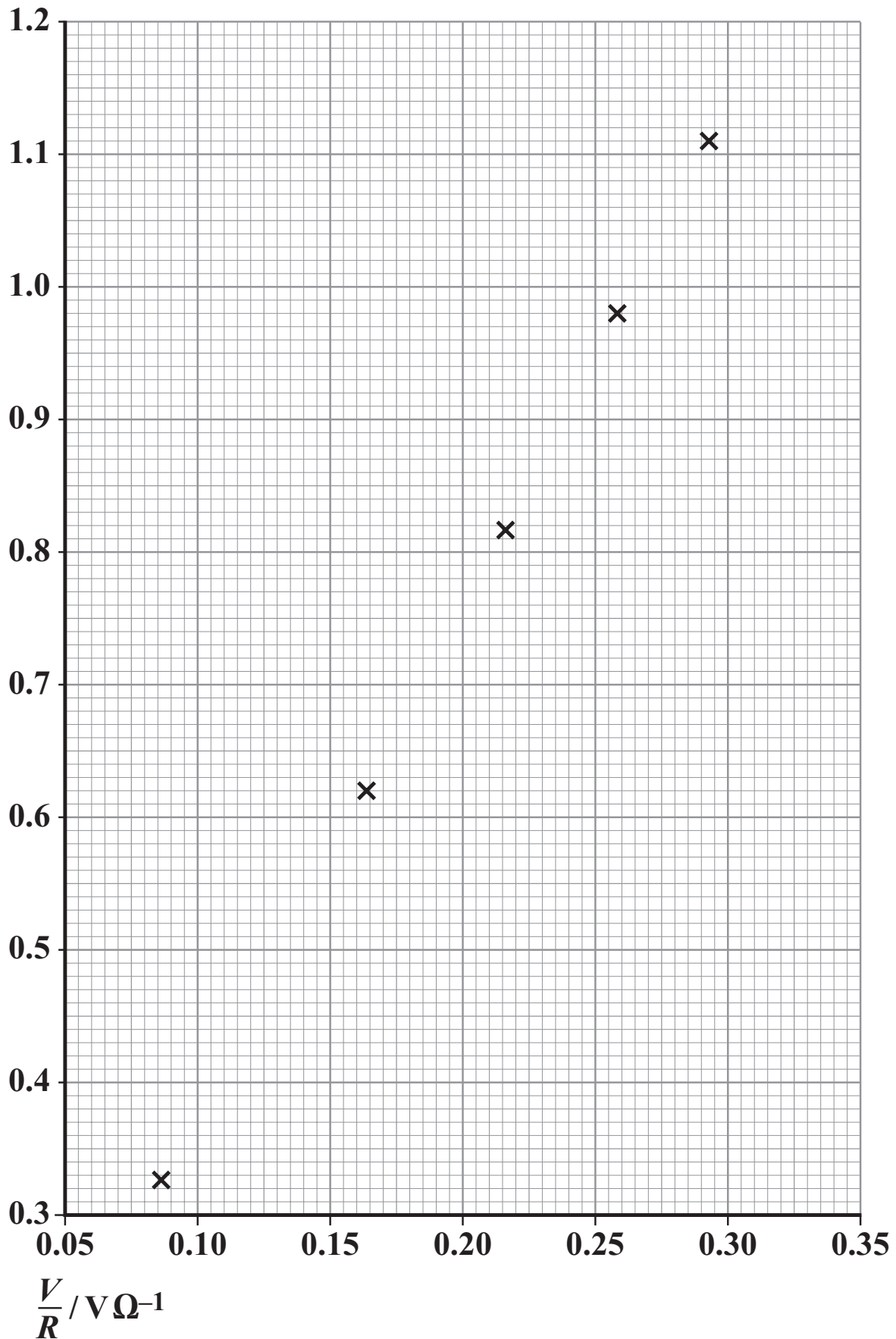
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 Use FIGURE 3 to determine r . [2 marks]

$r =$ _____ Ω



FIGURE 3

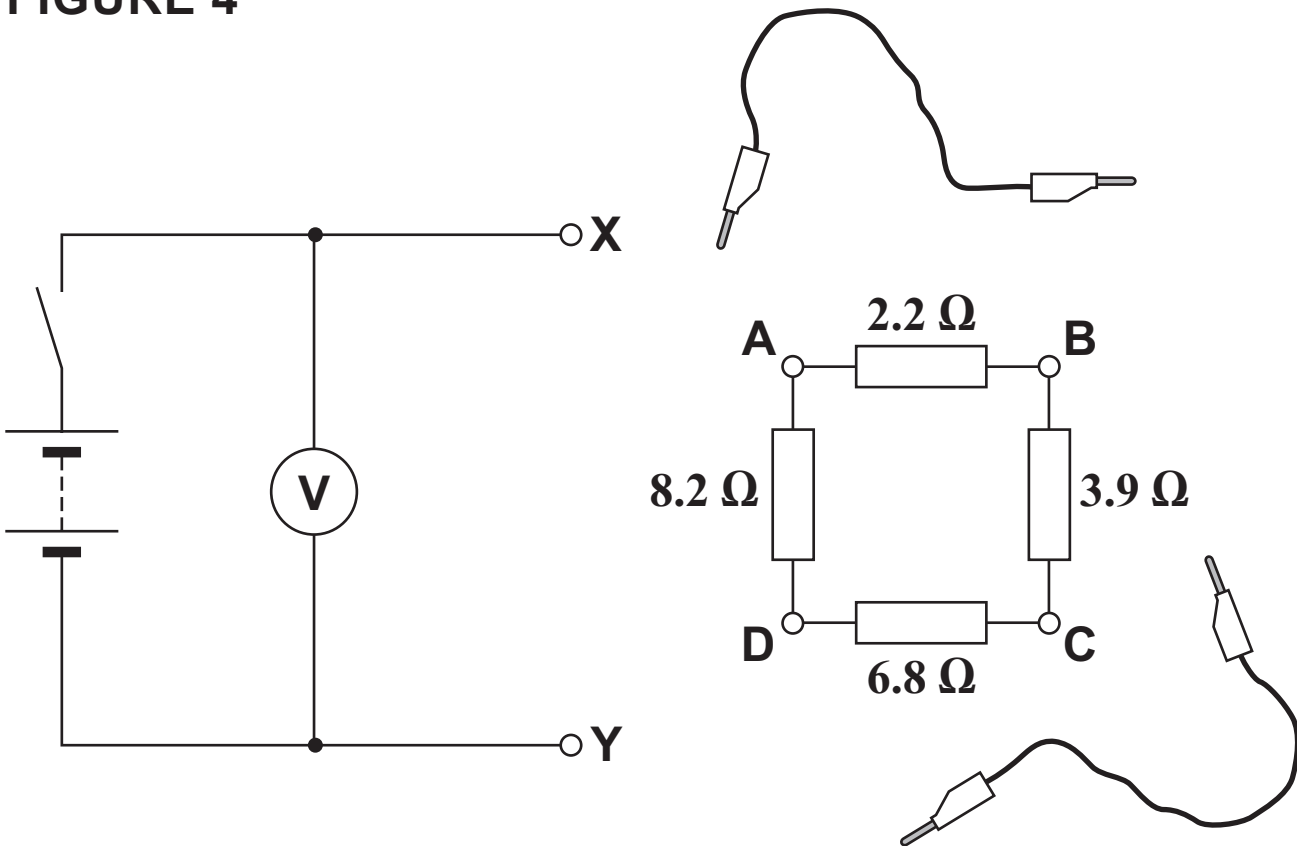
 $(\varepsilon - V) / V$ 

[Turn over]



0 1 . 8 FIGURE 4 shows a different method for varying the resistance R described in question 01 on page 4.

FIGURE 4



The four resistors are connected in a loop with sockets A, B, C and D at each junction. Two leads are used to connect the resistor loop to X and Y.

Discuss whether this method is an improvement over the method described in question 01. In your answer, you should refer to the number of different values that can be obtained for R . [2 marks]



[Turn over]



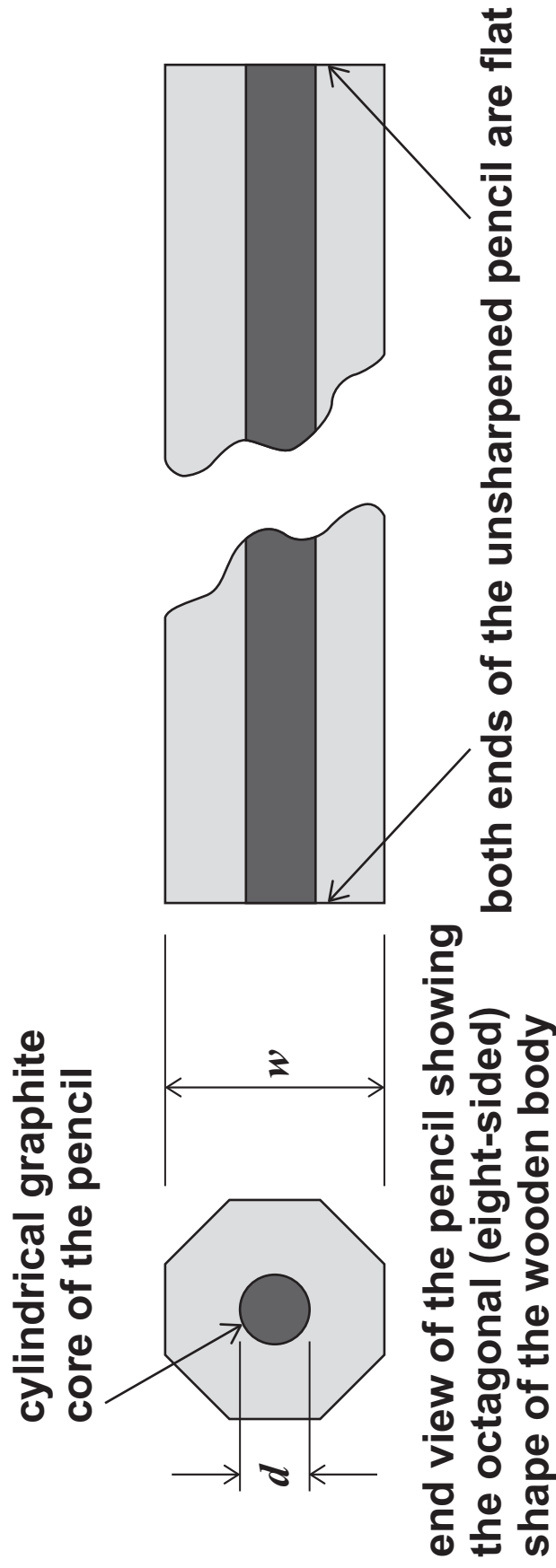


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A pencil, unsharpened at both ends, has a cylindrical graphite core of uniform diameter d surrounded by an octagonal (eight-sided) wooden body.

FIGURE 5 shows an end view and a cross-sectional slice along the length of the pencil.

FIGURE 5



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A student used a micrometer to measure the width w at several points along the length of the pencil.

Explain why the student used this procedure to determine a value for w .
[1 mark]

[Turn over]



0 2 · **2** The student's results are shown in
TABLE 1.

TABLE 1

| w_1 / mm | w_2 / mm | w_3 / mm | w_4 / mm | w_5 / mm |
|-------------------|-------------------|-------------------|-------------------|-------------------|
| 7·23 | 7·10 | 7·06 | 7·20 | 7·16 |

**Determine the percentage uncertainty in the
result the student obtains for w . [2 marks]**

percentage uncertainty = _____ %



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The cross-sectional area A of the end of the pencil is given by

$$A = 0.83 w^2$$

The volume of the cylindrical core is known to be 9.0% of the volume of the unsharpened pencil.

The cylindrical core of the graphite has a diameter d .

Determine d . [2 marks]

$$d = \underline{\hspace{15cm}} \text{ mm}$$

[Turn over]



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A student investigates the rate at which a similar pencil wears away through use.

The student measures the length of the pencil using a sliding vernier scale placed alongside a fixed scale. The fixed scale has a precision of 1 mm.

FIGURE 6, on page 20, shows the vernier scale in the zero position.

FIGURE 7, on page 21, shows the pencil (which is now sharpened) placed next to the fixed scale.

The position of the vernier scale is adjusted so that the length of the pencil can be read.

Read and record the length of the pencil shown in FIGURE 7. [1 mark]

length of pencil = _____ mm



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 The pencil is then removed from the scale and is used to draw 20 lines on a sheet of paper. Each line has a length 25 cm.

The pencil is then replaced next to the fixed scale and the vernier scale adjusted so the new length of the pencil can be read, as shown in FIGURE 8, on page 21.

Read and record the new length of the pencil shown in FIGURE 8. [1 mark]

new length of pencil = _____ mm

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 $L_{1/2}$ is the length of the line that could be drawn which would cause the original length of the pencil to be halved.

Calculate $L_{1/2}$

Ignore any decrease in length as a result of sharpening the pencil. [2 marks]

$L_{1/2} =$ _____ m

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[Turn over]





FIGURE 6

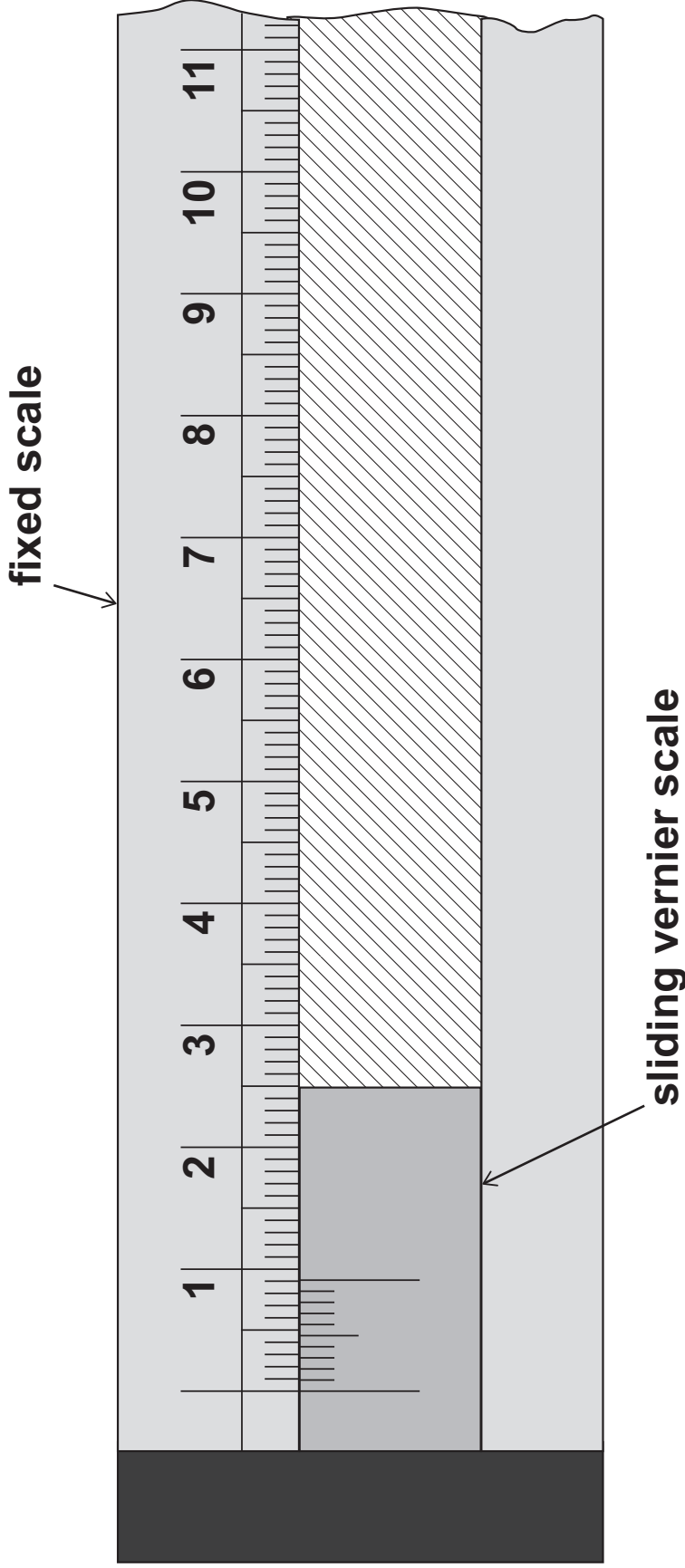


FIGURE 7

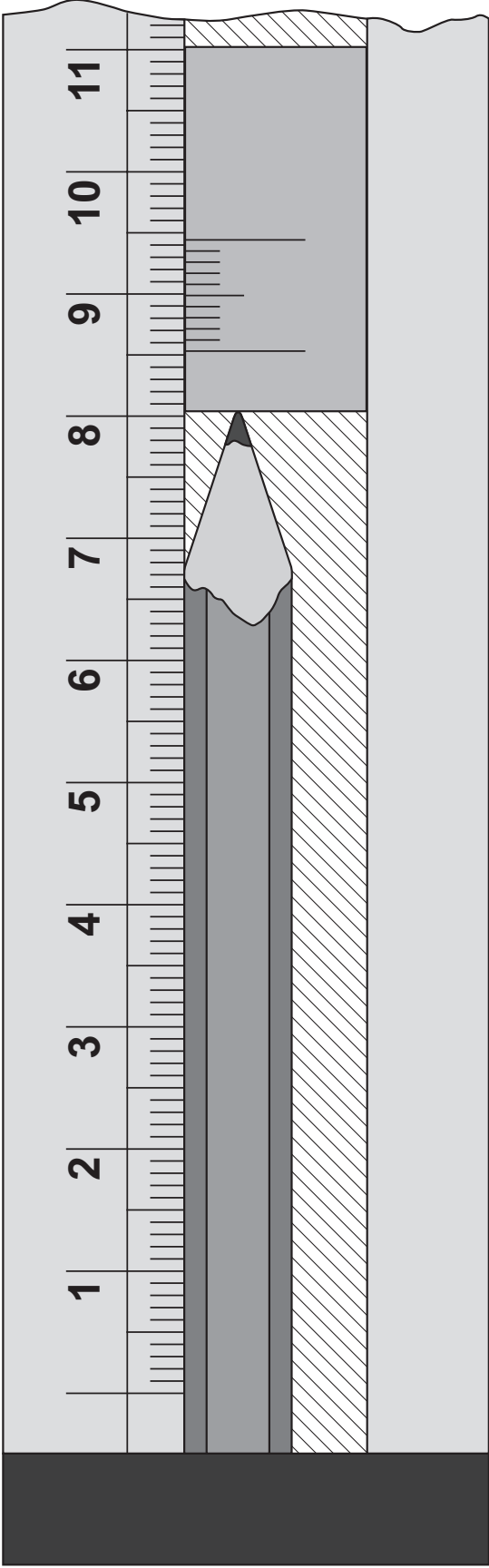
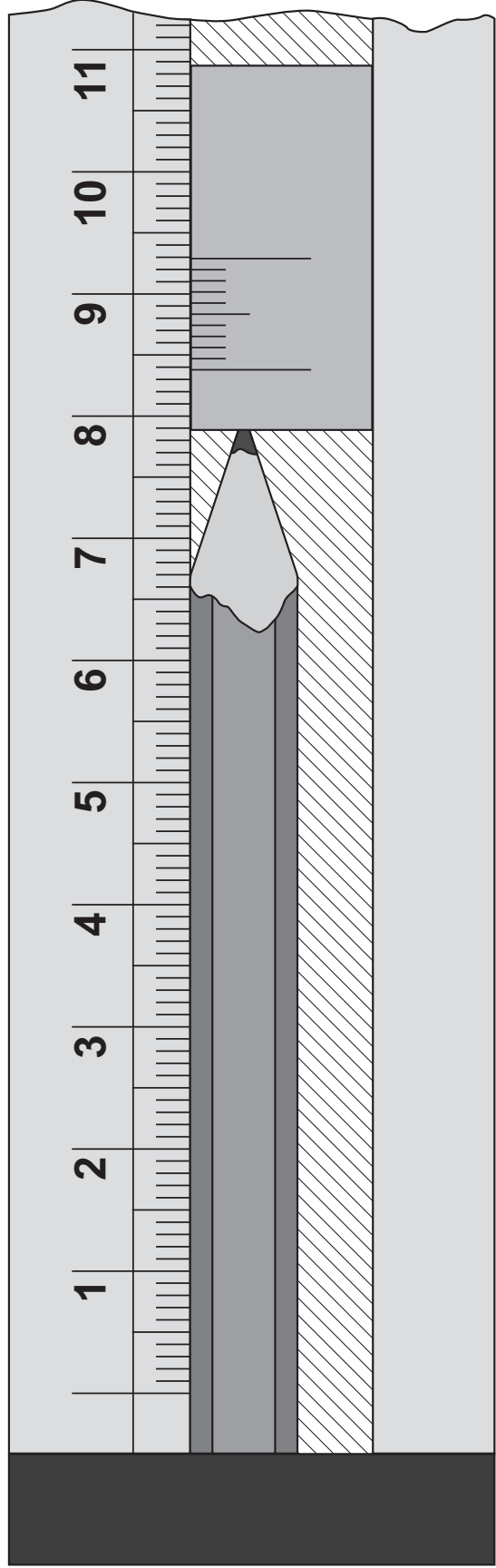


FIGURE 8



[Turn over]

SECTION B

Answer ALL questions in this section.

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A gravimeter is an instrument used to measure the acceleration due to gravity. The gravimeter measures the distance fallen by a free-falling mirror in a known time.

To do this, monochromatic light is reflected normally off the mirror, creating interference between the incident and reflected waves. The mirror is released from rest and falls, causing a change in the phase difference between the incident and reflected waves at a detector.

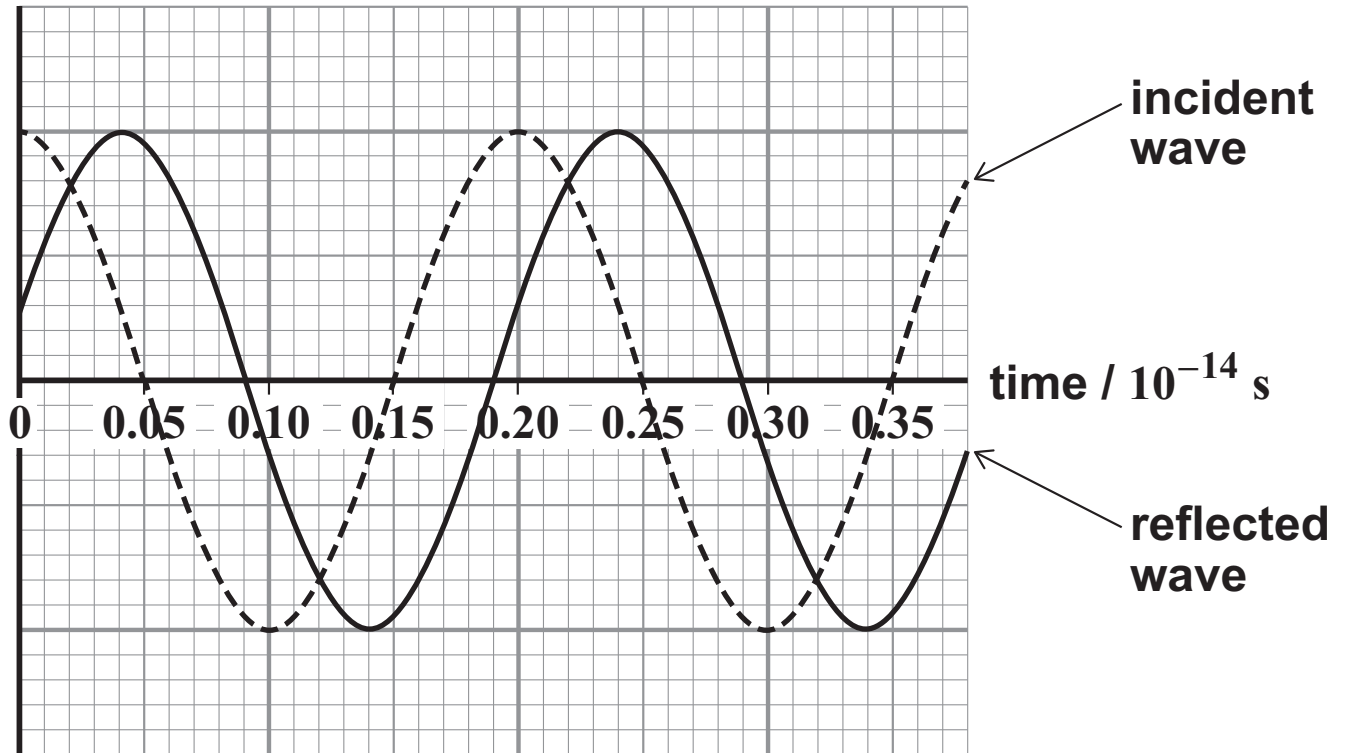
At the point of release of the mirror, the waves are in phase, resulting in a maximum intensity at the detector. The next maximum is produced at the detector when the mirror has fallen through a distance equal to half a wavelength of the light. The gravimeter records the number of maxima detected in a known time as the mirror falls. These data are used by the gravimeter to compute the acceleration of the free-falling mirror.

FIGURE 9 illustrates the phase relationship between the incident and reflected waves at the detector for one position of the mirror.



FIGURE 9

electric field
strength



[Turn over]



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Show that the wavelength of the light is 600 nm. [3 marks]



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Determine the phase difference, in rad, between the incident and reflected waves shown in FIGURE 9. [2 marks]

phase difference = _____ rad

[Turn over]



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A maximum is detected each time the mirror travels a distance equal to half a wavelength of the light.

In one measurement 2.37×10^5 maxima are recorded as the mirror is released from rest and falls for 0.120 s.

Using an appropriate equation of motion, calculate the acceleration due to gravity that the gravimeter computes from these data.

State your answer to 3 significant figures.
[3 marks]

wavelength of the light = 600 nm

acceleration due to gravity = _____ m s⁻²



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[Turn over]

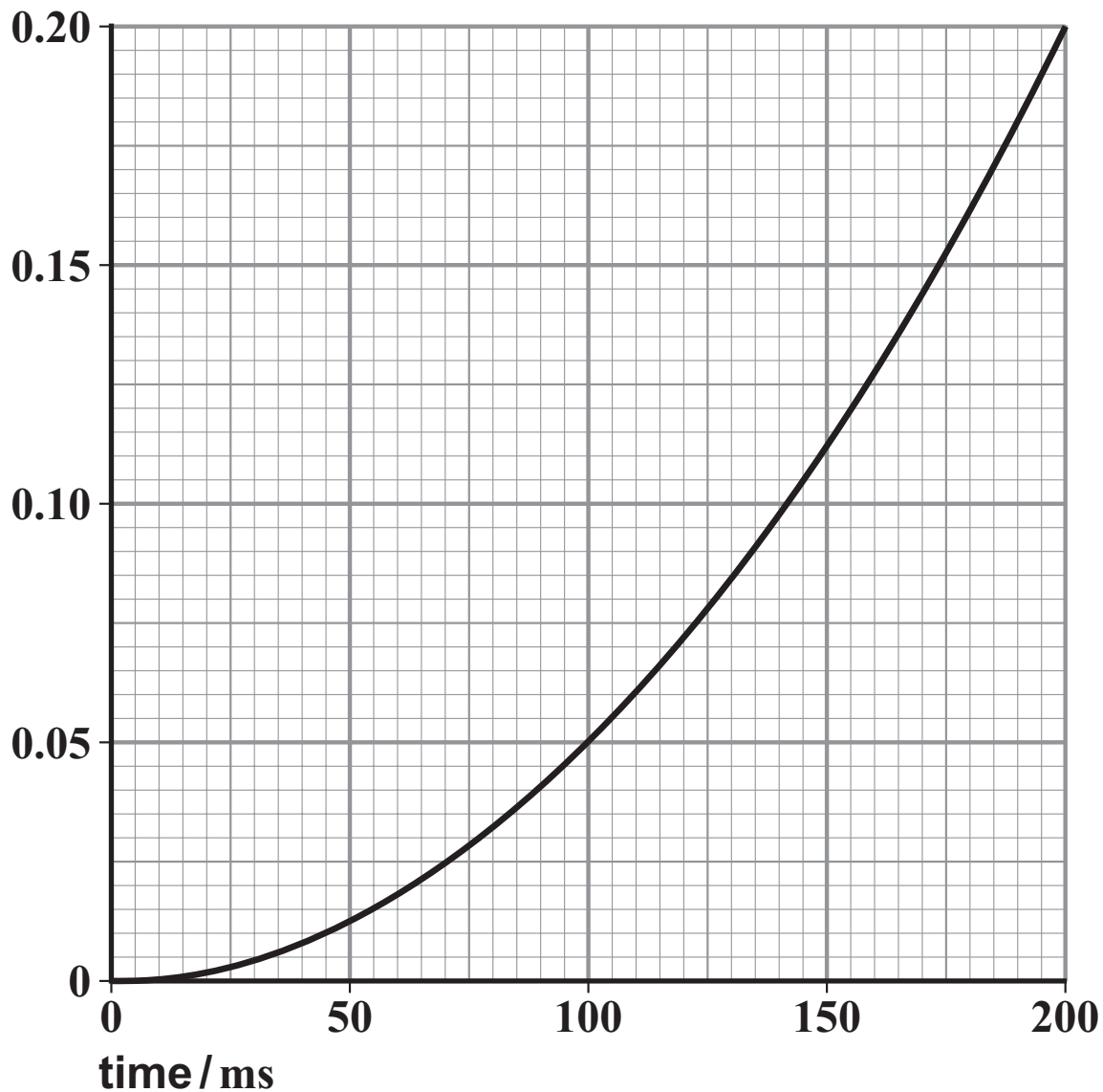


03 · 4

FIGURE 10 is a graph that the gravimeter could produce to show how the distance travelled by the mirror varies with time as it falls.

FIGURE 10

distance / m



Determine the gradient of the line when the time is 0.12 s. [2 marks]

gradient = _____

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State what this gradient represents.
[1 mark]

11

[Turn over]





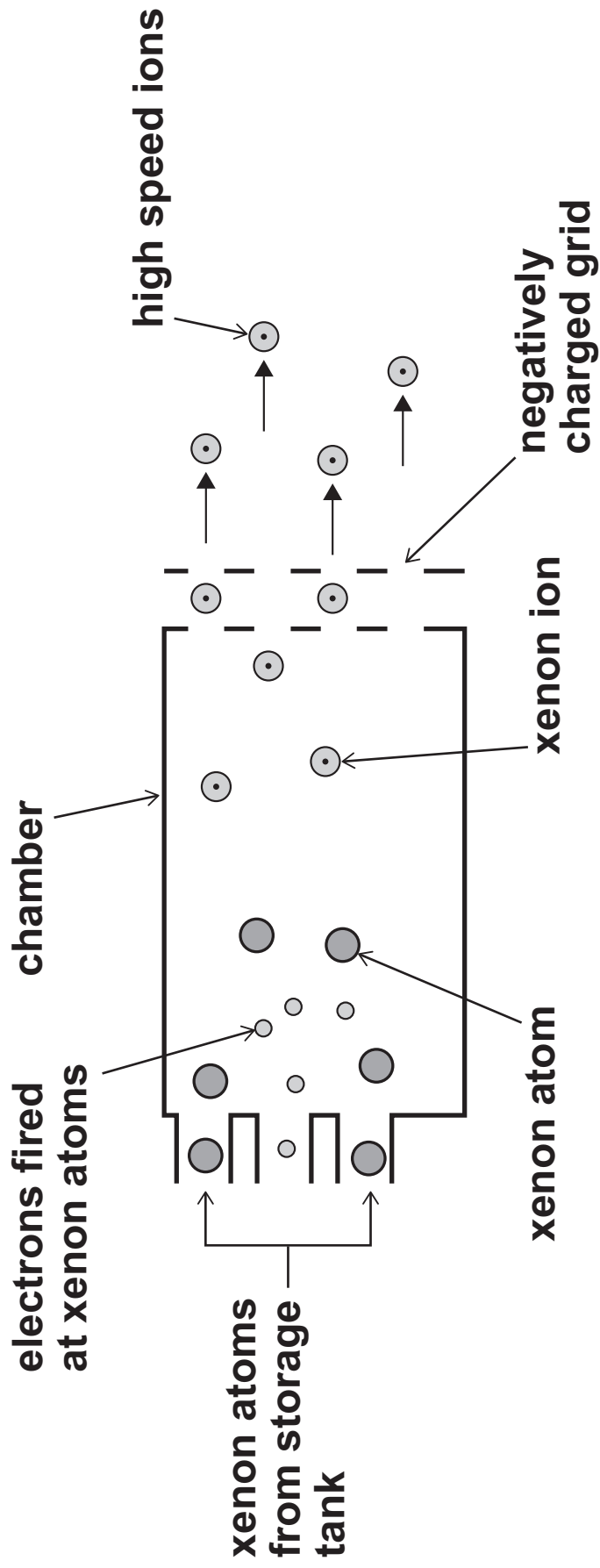
0 4

FIGURE 11 represents an ion propulsion unit used on a spacecraft launched in 1998.

Atoms of xenon-131 ($^{131}_{54}\text{Xe}$) were injected from a storage tank into a chamber where they became ionised due to collisions with electrons.

A negatively charged grid attracted the xenon ions, accelerating them out of the back of the ion propulsion unit and causing the spacecraft to be propelled forward.

FIGURE 11



not to scale

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The mass of a Xe^+ ion is 2.18×10^{-25} kg.

Calculate the specific charge of a Xe^+ ion.

Give an appropriate unit for your answer.
[2 marks]

specific charge = _____ unit _____

[Turn over]



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The storage tank contained 79 kg of xenon. When the ion propulsion unit was switched on it had an average power output of 2.1 kW.

Each xenon ion gained 1300 eV of energy as it was accelerated and ejected out of the propulsion unit.

Calculate the energy, in J, gained by each xenon ion. [1 mark]

energy = _____ J



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Determine the length of time the ion propulsion unit operated before all of the 79 kg of xenon was used up. [3 marks]

mass of xenon atom = 2.18×10^{-25} kg

time = _____ s

[Turn over]



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|---|---|
| 0 | 4 |
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Ion propulsion units could use helium ions instead of xenon ions.

An ion of helium-4 (He^+) has a much higher specific charge than an ion of xenon-131 (Xe^+). Both ions would gain 1300 eV of kinetic energy in being accelerated and ejected from an ion propulsion unit.

**Suggest whether helium ions or xenon ions are better to use as a propellant in future space programmes. In your answer you should compare the relative speeds and momentum changes of the ions.
[3 marks]**



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[Turn over]



SECTION C

Each of Questions 5 to 34 is followed by four responses, A, B, C and D.


For each question select the best response.

Only ONE answer per question is allowed.

For each answer completely fill in the circle alongside the appropriate answer.

CORRECT METHOD 

WRONG METHODS 

If you want to change your answer you must cross out your original answer as shown. 

If you wish to return to an answer previously crossed out, ring the answer you now wish to select

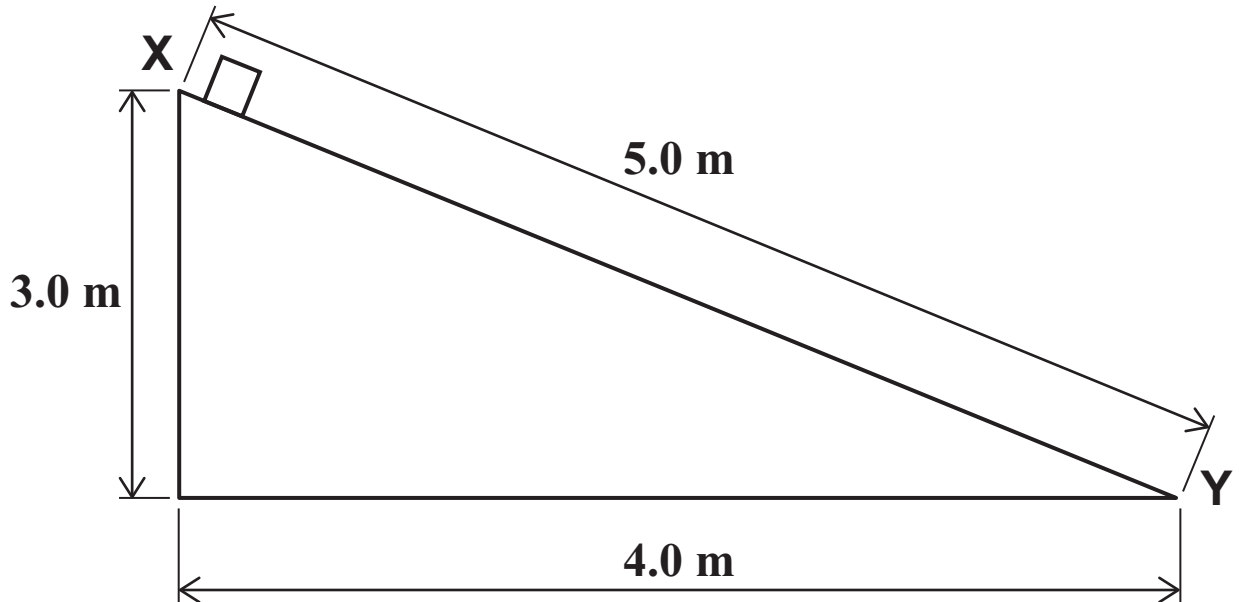
as shown. 

You may do your working in the blank space around each question but this will not be marked.



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A mass of 2.5 kg is released from rest at X and slides down a ramp, of height 3.0 m, to point Y as shown.



When the mass reaches Y at the bottom of the ramp it has a velocity of 5.0 m s^{-1} .

What is the average frictional force between the mass and the ramp? [1 mark]

- A 8.5 N
- B 10.6 N
- C 14.7 N
- D 24.5 N

[Turn over]



0 6

Which row shows the correct interactions experienced by a hadron or a lepton? [1 mark]

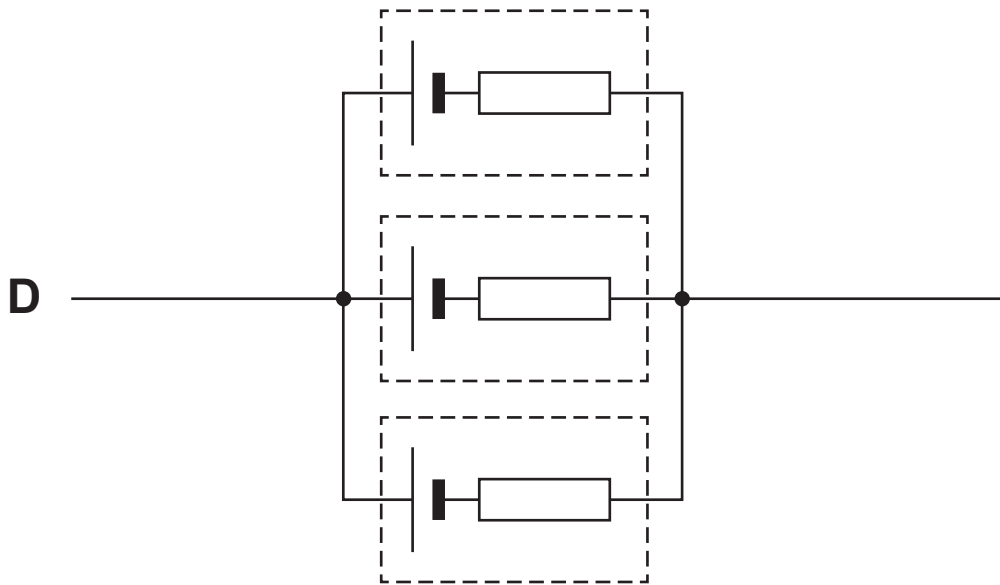
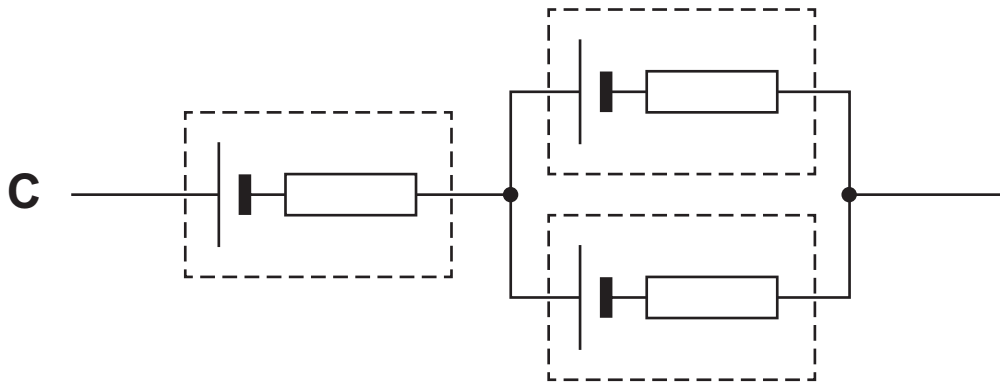
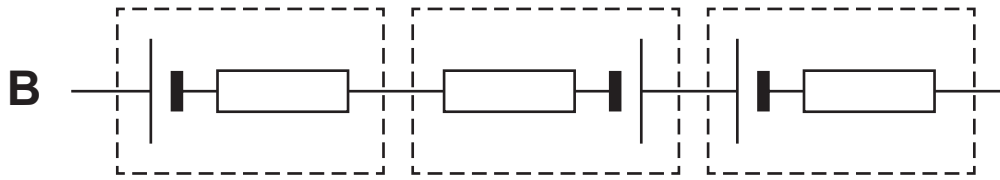
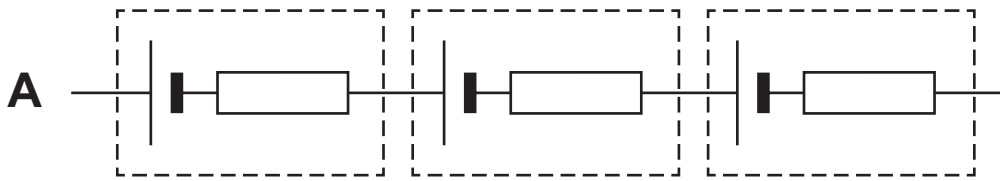
| | Particle | Strong interaction | Weak interaction |
|---|----------|--------------------|------------------|
| A | Hadron | Yes | Yes |
| B | Lepton | Yes | Yes |
| C | Hadron | Yes | No |
| D | Lepton | Yes | No |

0 7

Three cells each have an emf $\varepsilon = 1.5 \text{ V}$ and an internal resistance $r = 0.6 \Omega$.

Which combination of the cells shown opposite will deliver a total emf of 1.5 V and a maximum current of 7.5 A ? [1 mark]





A

B

C

D

[Turn over]



| | |
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| 0 | 8 |
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When a nucleus of the radioactive isotope ${}^{65}_{28}\text{Ni}$ decays, a β^- particle and an electron antineutrino are emitted.

How many protons and neutrons are there in the resulting daughter nucleus? [1 mark]

| | Number of protons | Number of neutrons |
|---|-------------------|--------------------|
| A | 28 | 65 |
| B | 29 | 65 |
| C | 29 | 36 |
| D | 30 | 35 |



0 9

A bullet of mass 10 g is fired with a velocity of 100 m s^{-1} from a stationary rifle of mass 4.0 kg. Consider the rifle and bullet to be an isolated system.

What are the recoil velocity of the rifle and the total momentum of the rifle and bullet just after firing? [1 mark]

| | Recoil velocity / m s^{-1} | Total momentum / kg m s^{-1} |
|-----------------------|--|--|
| <input type="radio"/> | A 0.25 | 0 |
| <input type="radio"/> | B 0.25 | 1.0 |
| <input type="radio"/> | C 0.40 | 0 |
| <input type="radio"/> | D 0.40 | 1.0 |

[Turn over]



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| 1 | 0 |
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Which row correctly shows electromagnetic radiations in order of decreasing wavelength?
[1 mark]

A gamma > ultraviolet > microwave

B ultraviolet > gamma > microwave

C microwave > ultraviolet > gamma

D gamma > microwave > ultraviolet

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Which statement is correct about the properties of an unpolarised electromagnetic wave as it passes through a polariser?
[1 mark]

A The wave remains unchanged.

B The wave does not pass through the polariser.

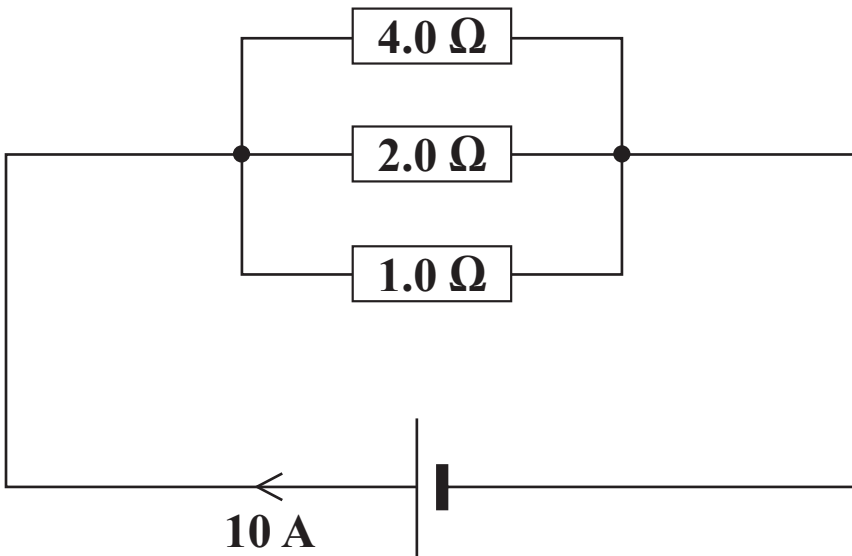
C The wave's electric field oscillates along the direction of travel.

D The intensity of the wave is reduced.



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The current in the cell is 10 A as shown.



What is the current in the 2.0 Ω resistor?
[1 mark]

A 0.35 A

B 2.86 A

C 3.50 A

D 7.14 A

[Turn over]



| | |
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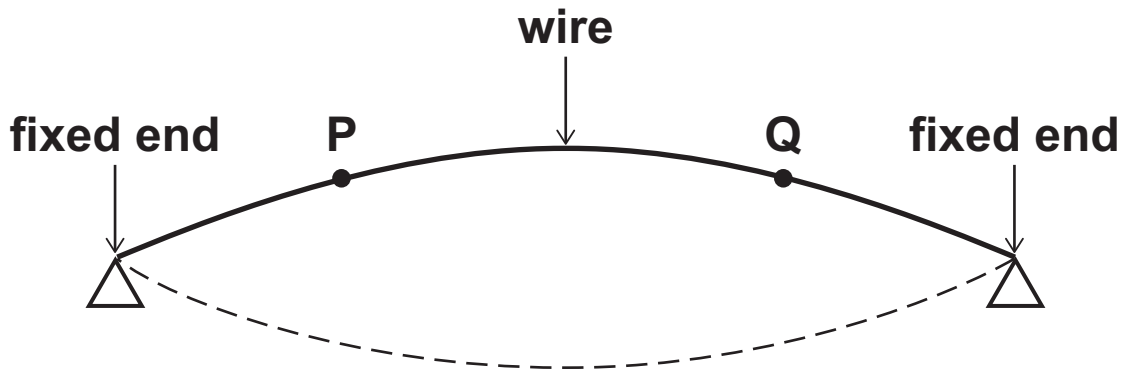
What interactions are involved in the production of a strange particle and its decay into non-strange particles? [1 mark]

| | Production | Decay |
|---|------------|--------|
| A | strong | weak |
| B | strong | strong |
| C | weak | strong |
| D | weak | weak |



| | |
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| 1 | 4 |
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A uniform wire, fixed at both ends, is plucked in the middle so that it vibrates at the first harmonic as shown.



What is the phase difference between the oscillations of the particles at P and Q?
[1 mark]



A zero



B $\frac{\pi}{4}$ rad



C $\frac{\pi}{2}$ rad



D $\frac{3\pi}{4}$ rad

[Turn over]



1 5

Which row correctly states whether momentum, mass and velocity are scalar or vector quantities? [1 mark]

| | Momentum | Mass | Velocity |
|---|----------|--------|----------|
| A | scalar | scalar | vector |
| B | vector | scalar | scalar |
| C | scalar | vector | scalar |
| D | vector | scalar | vector |

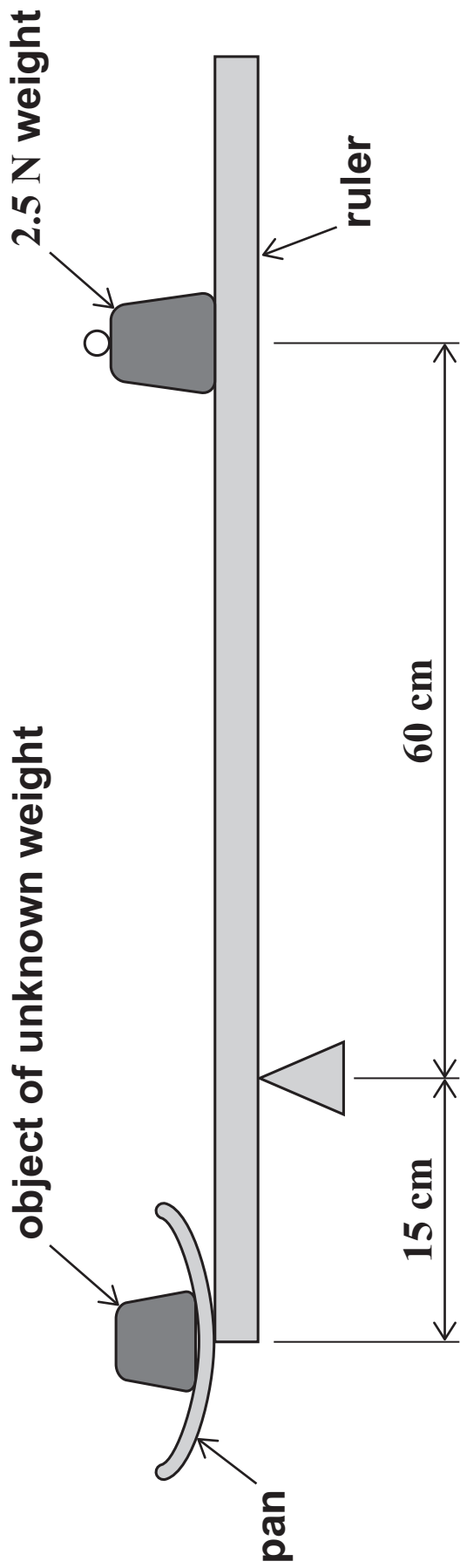
1 6

The diagram opposite shows a uniform metre ruler of weight 1.5 N pivoted 15 cm from one end for use as a simple balance.

A scale pan of weight 0.5 N is placed at the end of the ruler and an object of unknown weight is placed in the pan. The ruler moves to a steady horizontal position when a weight of 2.5 N is added at a distance of 60 cm from the pivot as shown.

What is the weight of the object? [1 mark]





- A 9.5 N
- B 10.0 N
- C 13.0 N
- D 13.5 N

[Turn over]

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What is the name given to a material that breaks without deformation when a force is applied to it? [1 mark]

A Plastic

B Brittle

C Stiff

D Elastic



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| 1 | 8 |
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A battery of negligible internal resistance and an emf of 12 V is connected in series with a heating element. The heating element has a resistance of 6.5Ω when in operation.

What is the energy transferred by the heating element when operating for 5 minutes?

[1 mark]

A 111 J

B 390 J

C 6650 J

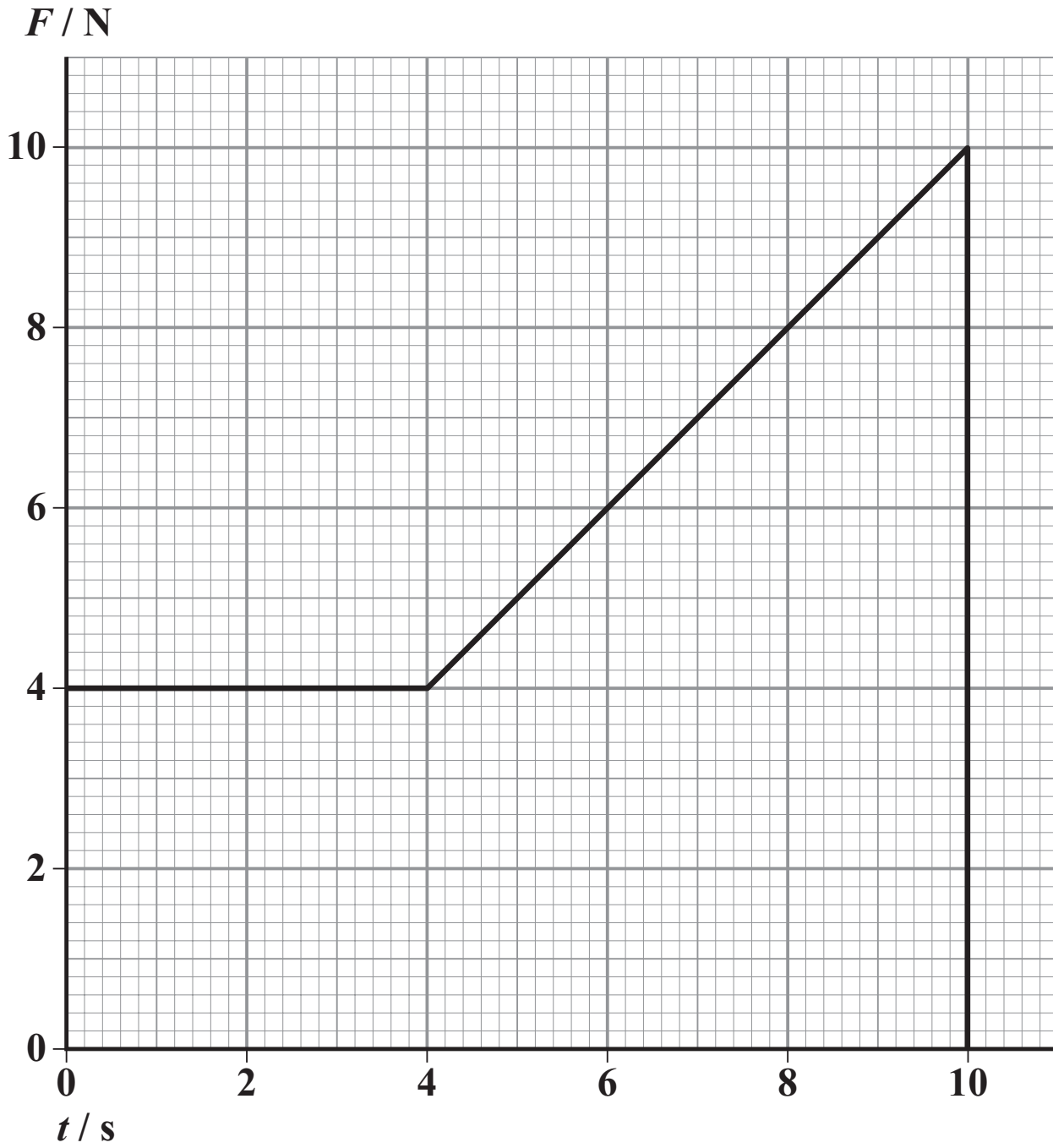
D 23400 J

[Turn over]



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The graph shows how the force F applied to an object varies with time t .



What is the momentum gained by the object from $t = 0$ to $t = 10$ s? [1 mark]

A 18 kg m s⁻¹

B 32 kg m s⁻¹

C 40 kg m s⁻¹

D 58 kg m s⁻¹

[Turn over]



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When light of a certain frequency greater than the threshold frequency of a metal is directed at the metal, photoelectrons are emitted from the surface.

The power of the light incident on the metal surface is doubled.

Which row shows the effect on the maximum kinetic energy and the number of photoelectrons emitted per second? [1 mark]

| | Maximum kinetic energy | Number of photoelectrons emitted per second |
|---|------------------------|---|
| A | remains unchanged | remains unchanged |
| B | doubles | remains unchanged |
| C | remains unchanged | doubles |
| D | doubles | doubles |



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[Turn over]



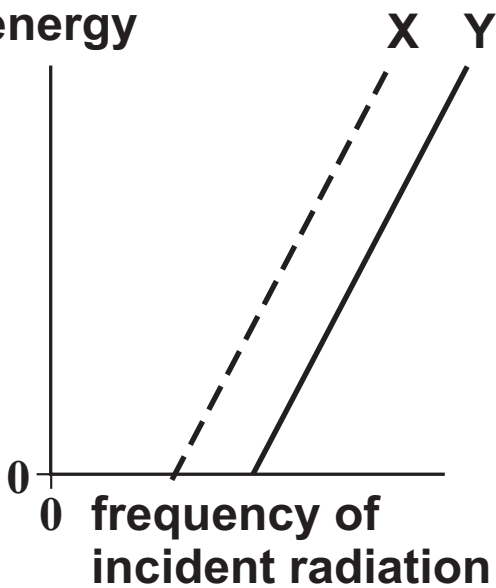
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Line X on the graphs below shows how the maximum kinetic energy of emitted photoelectrons varies with the frequency of incident radiation for a particular metal.

Which graph shows the results for a metal Y that has a higher work function than X? [1 mark]

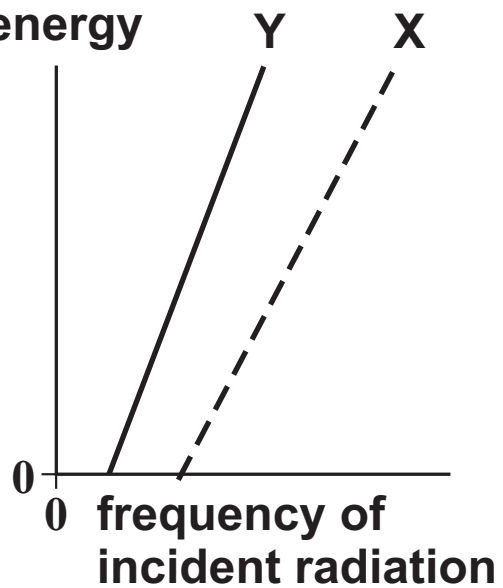
A

maximum
kinetic
energy



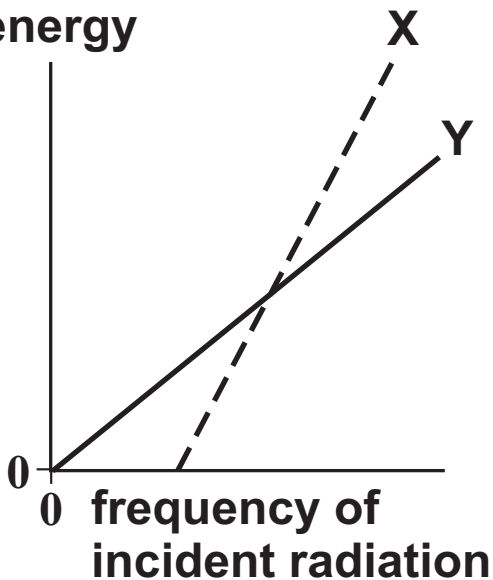
B

maximum
kinetic
energy



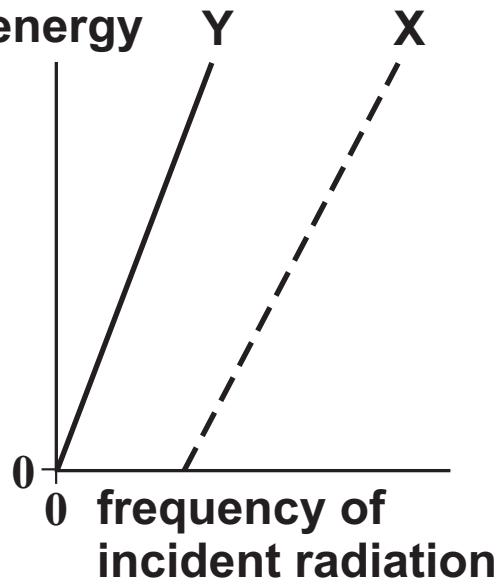
C

maximum
kinetic
energy



D

maximum
kinetic
energy





A



B



C



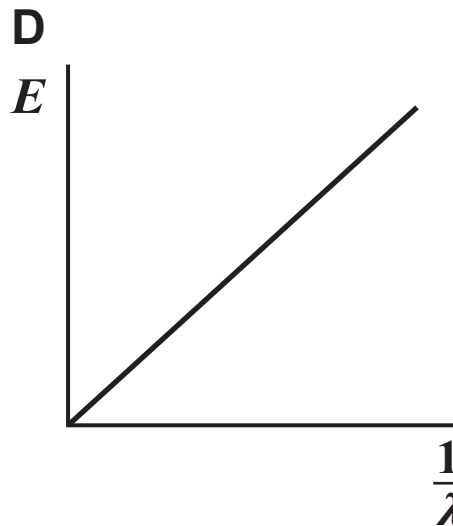
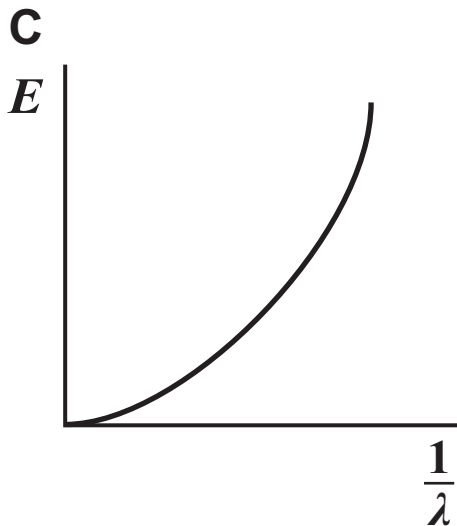
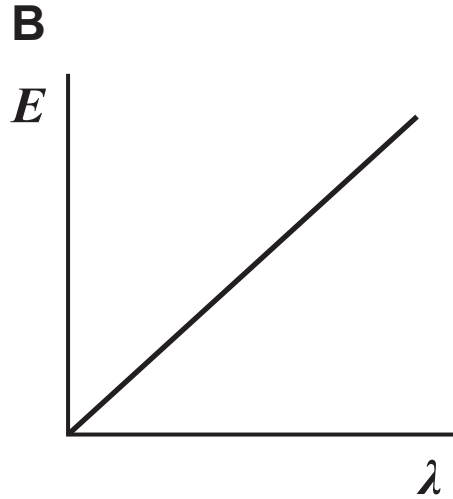
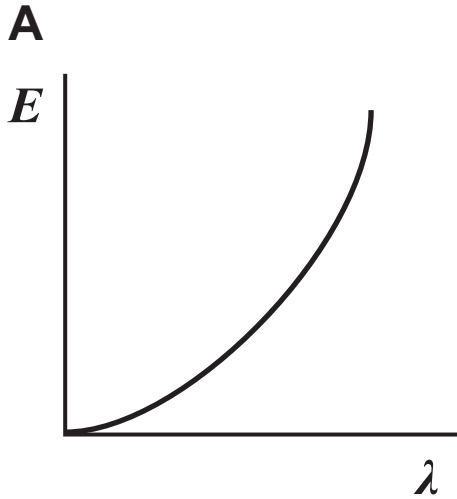
D

[Turn over]



| | |
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| 2 | 2 |
|---|---|

Which graph best shows the relationship between photon energy E and wavelength λ of a photon of electromagnetic radiation? [1 mark]



A



B



C



D



2 3

Which row shows the change in velocity, frequency and wavelength of an electromagnetic wave as it travels from an optically less dense to an optically more dense medium? [1 mark]

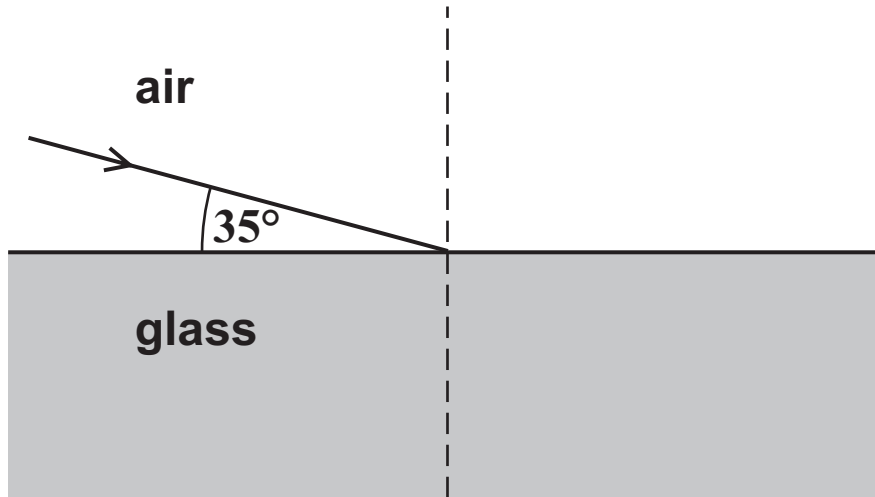
| | Velocity | Frequency | Wavelength | |
|-----------------------|----------|-----------|------------|-----------|
| <input type="radio"/> | A | decreases | decreases | unchanged |
| <input type="radio"/> | B | increases | unchanged | increases |
| <input type="radio"/> | C | decreases | unchanged | decreases |
| <input type="radio"/> | D | increases | increases | unchanged |

[Turn over]



| | |
|---|---|
| 2 | 4 |
|---|---|

The diagram shows a ray of light travelling in air and incident on a glass block of refractive index 1.5



What is the angle of refraction in the glass?
[1 mark]



A 22.5°



B 23.3°



C 33.1°



D 59.4°



2 5

Intensity maxima are produced on a screen when a parallel beam of monochromatic light is incident on a diffraction grating. Light of a longer wavelength can be used or the distance from the diffraction grating to the screen can be increased.

Which row gives the change in appearance of the maxima when these changes are made independently? [1 mark]

| | Longer wavelength | Distance from grating to screen increased |
|-----------------------|-------------------------|---|
| <input type="radio"/> | A closer together | more widely spaced |
| <input type="radio"/> | B more widely spaced | more widely spaced |
| <input type="radio"/> | C more widely spaced | closer together |
| <input type="radio"/> | D closer together | closer together |

[Turn over]



| | |
|---|---|
| 2 | 6 |
|---|---|

What **CANNOT** be used as a unit for the Young modulus? [1 mark]

A N m^{-2}

B Pa

C $\text{kg m}^{-2} \text{s}^{-2}$

D $\text{kg m}^{-1} \text{s}^{-2}$

| | |
|---|---|
| 2 | 7 |
|---|---|

Light of wavelength 500 nm is passed through a diffraction grating which has 400 lines per mm.

What is the angular separation between the two second-order maxima? [1 mark]

A 11.5°

B 23.1°

C 23.6°

D 47.2°



| | |
|---|---|
| 2 | 8 |
|---|---|

Two identical balls, X and Y, are at the same height and a horizontal distance of 25 cm apart.

X is projected horizontally with a velocity of 0.10 m s^{-1} towards Y at the same time that Y is released from rest. Both X and Y move freely in the absence of air resistance.

What is the distance between the balls 1.0 s later? [1 mark]



A 0.15 m



B 0.25 m



C 2.4 m



D 4.9 m

[Turn over]



| | |
|---|---|
| 2 | 9 |
|---|---|

Two bodies of different masses undergo an elastic collision in the absence of any external force.

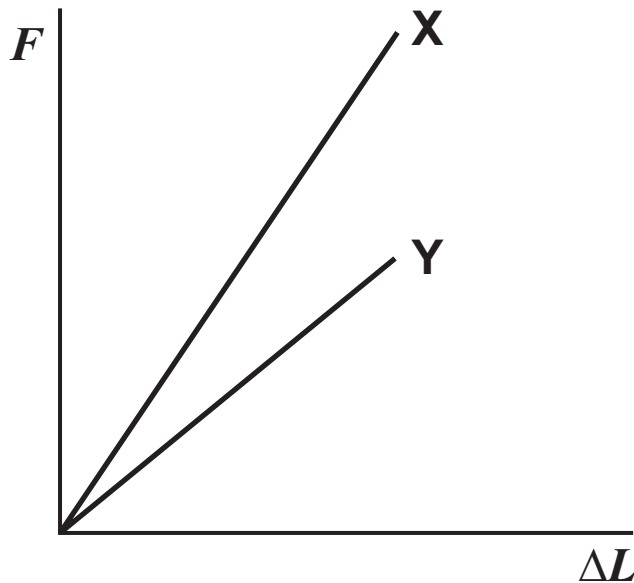
Which row gives the effect on the total kinetic energy of the masses and the magnitudes of the forces exerted on the masses during the collision? [1 mark]

| | Total kinetic energy | Magnitudes of forces |
|-----------------------|------------------------|-----------------------------|
| <input type="radio"/> | A remains unchanged | same on both masses |
| <input type="radio"/> | B remains unchanged | greater on the smaller mass |
| <input type="radio"/> | C decreases | same on both masses |
| <input type="radio"/> | D decreases | greater on the smaller mass |



3 0

Two separate wires X and Y have the same original length and cross-sectional area. The graph shows the extension ΔL produced in X and Y when the tensile force F applied to the wires is increased up to the point where they break.



Which statement is **INCORRECT**? [1 mark]



A For a given extension more energy is stored in X than in Y.



B The Young modulus of the material of wire Y is greater than that of wire X.



C Both wire X and wire Y obey Hooke's law.



D Wire X has a greater breaking stress than wire Y.

[Turn over]



| | |
|---|---|
| 3 | 1 |
|---|---|

Which statement about superconductors is correct? [1 mark]



A When a material becomes a superconductor, its resistivity is almost zero.



B The temperature at which a material becomes a superconductor is called the critical temperature.



C When current passes through a superconductor the pd across it becomes a maximum.



D Copper is a superconductor at room temperature.



| | |
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| 3 | 2 |
|---|---|

A wire has a resistance R .

What is the resistance when both the length and radius of the wire are doubled? [1 mark]



A

$$\frac{R}{4}$$



B

$$\frac{R}{2}$$



C

$$2R$$



D

$$4R$$

[Turn over]

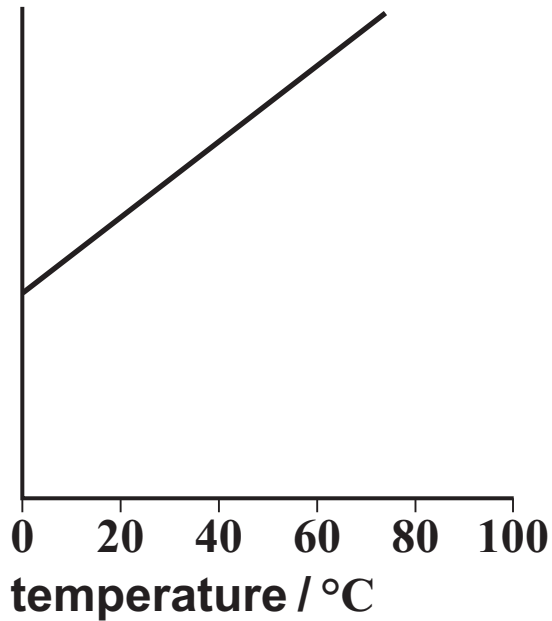


3 3

Which graph shows the variation of the resistance with temperature for an ntc thermistor? [1 mark]

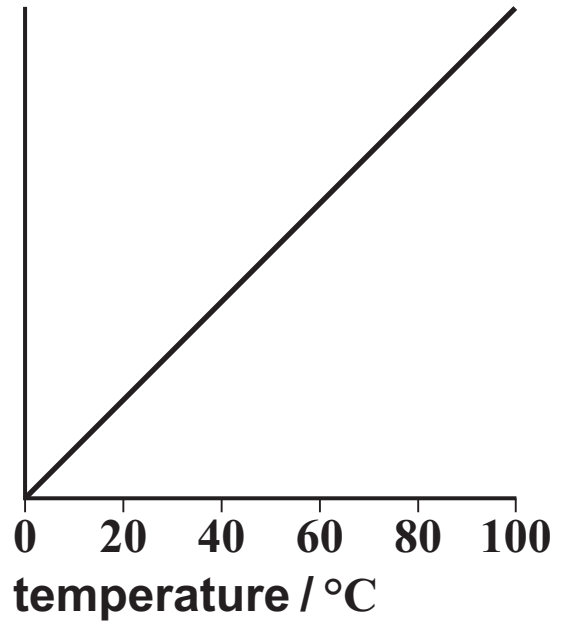
A

resistance



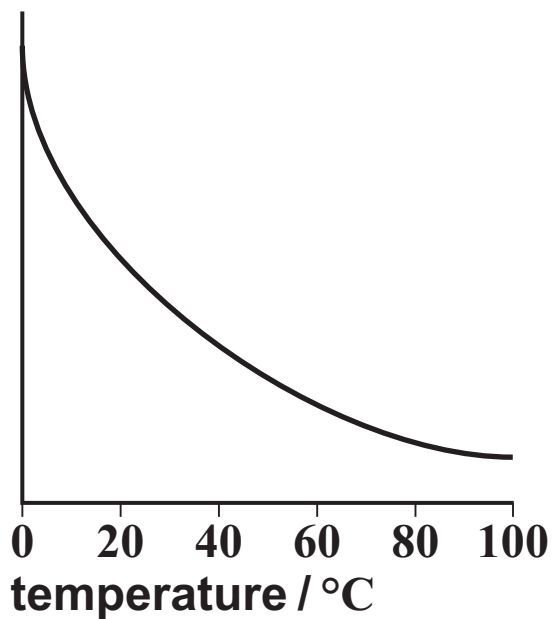
B

resistance



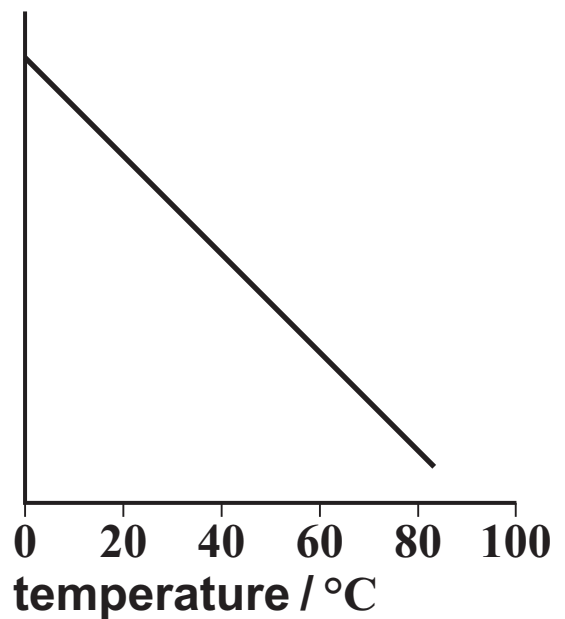
C

resistance



D

resistance





A



B



C



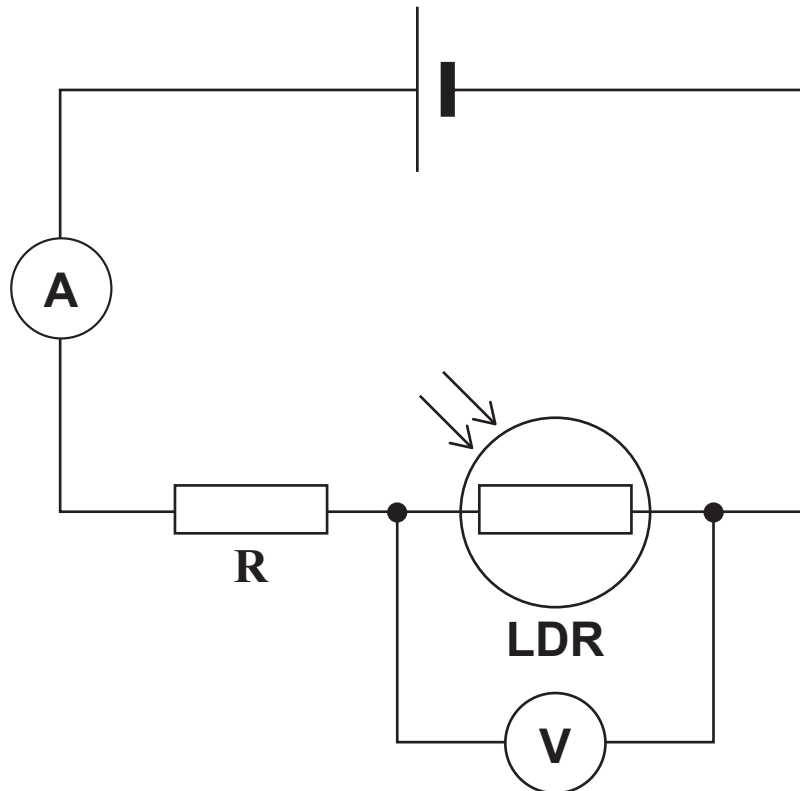
D

[Turn over]



| | |
|---|---|
| 3 | 4 |
|---|---|

The figure shows a light dependent resistor (LDR) and fixed resistor R connected in series across a cell. The internal resistance of the cell is negligible.



Which row shows how the readings on the ammeter and the voltmeter change when the light intensity incident on the LDR is increased? [1 mark]



| | Ammeter reading | Voltmeter reading |
|-----------------------|-----------------|-------------------|
| <input type="radio"/> | A decreases | increases |
| <input type="radio"/> | B decreases | decreases |
| <input type="radio"/> | C increases | increases |
| <input type="radio"/> | D increases | decreases |

END OF QUESTIONS



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| For Examiner's Use | |
|--------------------|------|
| Question | Mark |
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5–34 | |
| TOTAL | |

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