UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

*5961585709*

**PHYSICS** **9702/22**

Paper 2 AS Structured Questions **May/June 2010**

**1 hour**

Candidates answer on the Question Paper.

No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| Total | |

This document consists of **16** printed pages and **4** blank pages.

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International Examinations

**[Turn over**

**Data**

| | |
|---|---|
| speed of light in free space, | $c = 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$ |
| permeability of free space, | $\mu_0 = 4\pi \times 10^{-7}\ \mathrm{H\,m^{-1}}$ |
| permittivity of free space, | $\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$ |
| elementary charge, | $e = 1.60 \times 10^{-19}\ \mathrm{C}$ |
| the Planck constant, | $h = 6.63 \times 10^{-34}\ \mathrm{J\,s}$ |
| unified atomic mass constant, | $u = 1.66 \times 10^{-27}\ \mathrm{kg}$ |
| rest mass of electron, | $m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$ |
| rest mass of proton, | $m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$ |
| molar gas constant, | $R = 8.31\ \mathrm{J\,K^{-1}\,mol^{-1}}$ |
| the Avogadro constant, | $N_A = 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$ |
| the Boltzmann constant, | $k = 1.38 \times 10^{-23}\ \mathrm{J\,K^{-1}}$ |
| gravitational constant, | $G = 6.67 \times 10^{-11}\ \mathrm{N\,m^{2}\,kg^{-2}}$ |
| acceleration of free fall, | $g = 9.81\ \mathrm{m\,s^{-2}}$ |

**Formulae**

| | |
|---|---|
| uniformly accelerated motion, | $s = ut + \frac{1}{2}at^2$ <br> $v^2 = u^2 + 2as$ |
| work done on/by a gas, | $W = p\Delta V$ |
| gravitational potential, | $\phi = -\dfrac{Gm}{r}$ |
| hydrostatic pressure, | $p = \rho gh$ |
| pressure of an ideal gas, | $p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$ |
| simple harmonic motion, | $a = -\omega^2 x$ |
| velocity of particle in s.h.m., | $v = v_0 \cos \omega t$ <br> $v = \pm\, \omega\sqrt{(x_0^{\,2} - x^2)}$ |
| electric potential, | $V = \dfrac{Q}{4\pi\varepsilon_0 r}$ |
| capacitors in series, | $1/C = 1/C_1 + 1/C_2 + \ldots$ |
| capacitors in parallel, | $C = C_1 + C_2 + \ldots$ |
| energy of charged capacitor, | $W = \frac{1}{2}QV$ |
| resistors in series, | $R = R_1 + R_2 + \ldots$ |
| resistors in parallel, | $1/R = 1/R_1 + 1/R_2 + \ldots$ |
| alternating current/voltage, | $x = x_0 \sin \omega t$ |
| radioactive decay, | $x = x_0 \exp(-\lambda t)$ |
| decay constant, | $\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$ |

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Answer **all** the questions in the spaces provided.

*For Examiner's Use*

**1** A metal wire has a cross-section of diameter approximately 0.8 mm.

**(a)** State what instrument should be used to measure the diameter of the wire.

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

**(b)** State how the instrument in **(a)** is

**(i)** checked so as to avoid a systematic error in the measurements,

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**(ii)** used so as to reduce random errors.

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

**2** **(a)** The distance *s* moved by an object in time *t* may be given by the expression

$$s = \tfrac{1}{2}at^2$$

where *a* is the acceleration of the object.

State two conditions for this expression to apply to the motion of the object.

1. ..........................................................................................................................

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2. ..........................................................................................................................

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

**(b)** A student takes a photograph of a steel ball of radius 5.0 cm as it falls from rest. The image of the ball is blurred, as illustrated in Fig. 2.1.
The image is blurred because the ball is moving while the photograph is being taken.

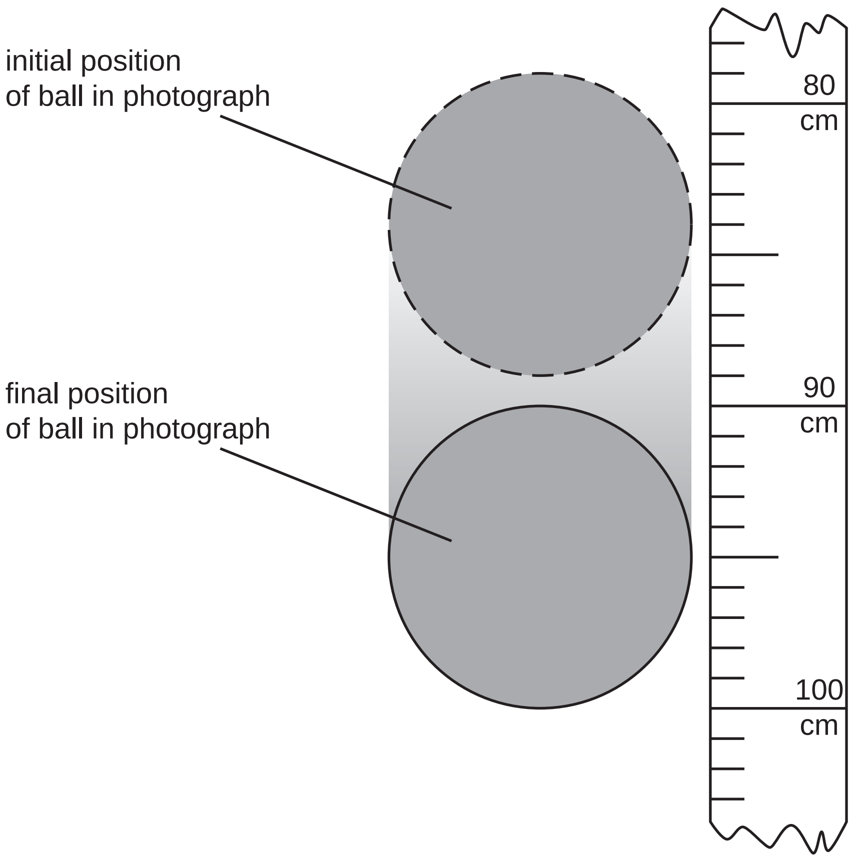


**Fig. 2.1**

The scale shows the distance fallen from rest by the ball. At time $t = 0$, the top of the ball is level with the zero mark on the scale. Air resistance is negligible.

Calculate, to an appropriate number of significant figures,

**(i)** the time the ball falls before the photograph is taken,

time = ............................................ s [3]

**(ii)** the time interval during which the photograph is taken.

time interval = ............................................ s [3]

**(c)** The student in **(b)** takes a second photograph starting at the same position on the scale. The ball has the same radius but is less dense, so that air resistance is not negligible.

State and explain the changes that will occur in the photograph.

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

For Examiner's Use

**3** **(a)** **(i)** Define *force*.

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

**(ii)** State Newton's third law of motion.

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.................................................................................................................... [3]

**(b)** Two spheres approach one another along a line joining their centres, as illustrated in Fig. 3.1.

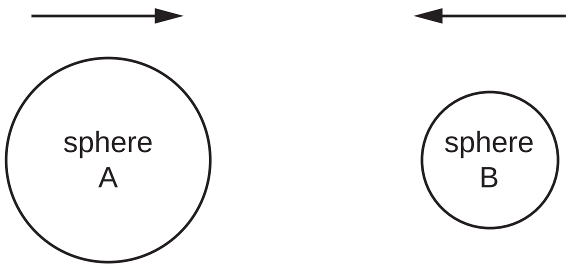


**Fig. 3.1**

When they collide, the average force acting on sphere A is $F_A$ and the average force acting on sphere B is $F_B$.

The forces act for time $t_A$ on sphere A and time $t_B$ on sphere B.

**(i)** State the relationship between

**1.** $F_A$ and $F_B$,

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

**2.** $t_A$ and $t_B$.

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

**(ii)** Use your answers in **(i)** to show that the change in momentum of sphere A is equal in magnitude and opposite in direction to the change in momentum of sphere B.

..........................................................................................................................

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

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**(c)** For the spheres in **(b)**, the variation with time of the momentum of sphere A before, during and after the collision with sphere B is shown in Fig. 3.2.

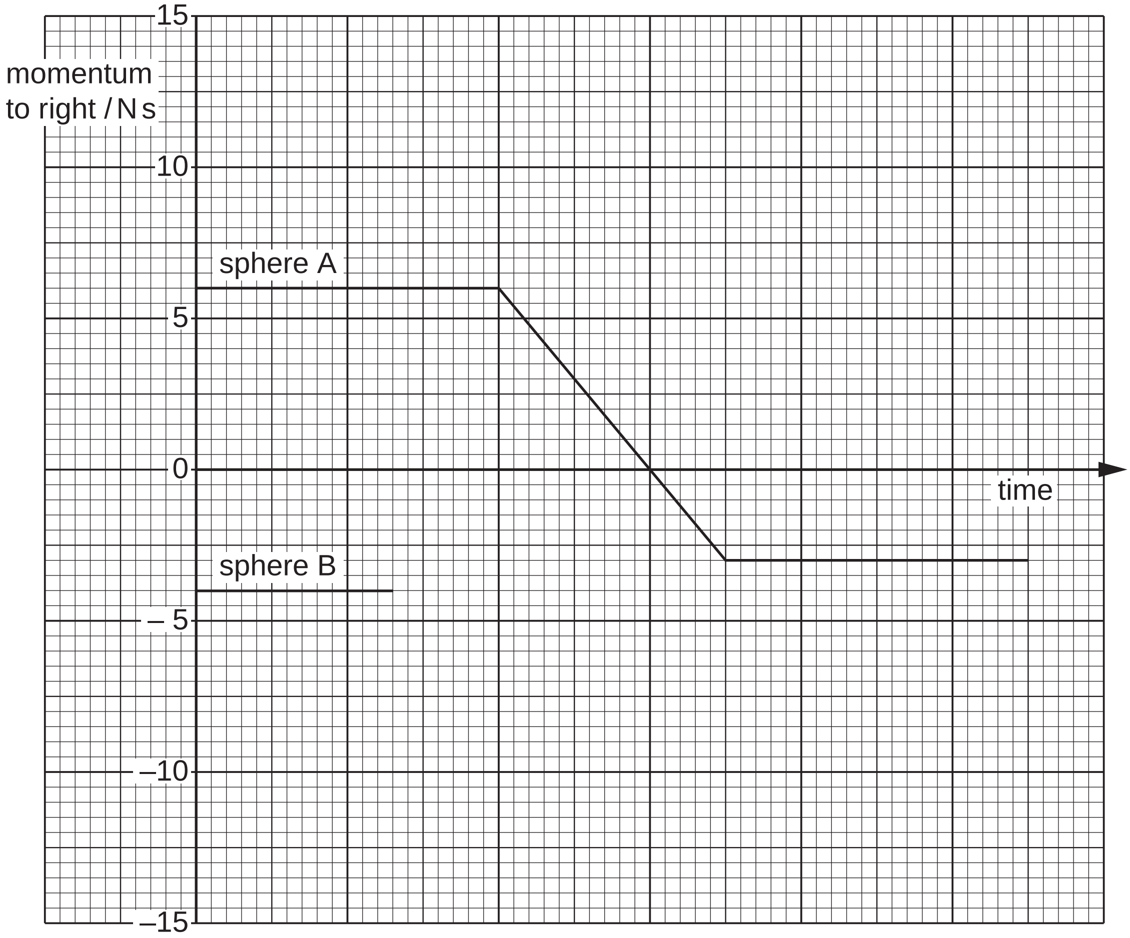


**Fig. 3.2**

The momentum of sphere B before the collision is also shown on Fig. 3.2.

Complete Fig. 3.2 to show the variation with time of the momentum of sphere B during and after the collision with sphere A. [3]

4 **(a)** State two features of a stationary wave that distinguish it from a progressive wave.

*For Examiner's Use*

1. ..........................................................................................................................

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2. ..........................................................................................................................

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

**(b)** A long tube is open at one end. It is closed at the other end by means of a piston that can be moved along the tube, as shown in Fig. 4.1.

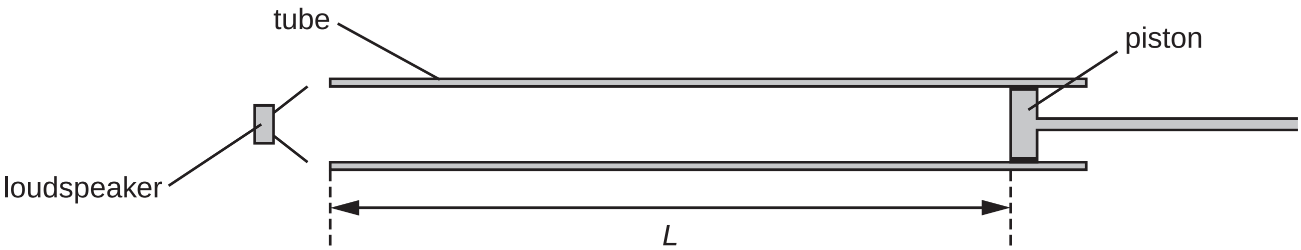


**Fig. 4.1**

A loudspeaker producing sound of frequency 550 Hz is held near the open end of the tube.
The piston is moved along the tube and a loud sound is heard when the distance *L* between the piston and the open end of the tube is 45 cm.
The speed of sound in the tube is 330 m s$^{-1}$.

**(i)** Show that the wavelength of the sound in the tube is 60 cm.

[1]

**(ii)** On Fig. 4.1, mark all the positions along the tube of

**1.** the displacement nodes (label these with the letter N),

**2.** the displacement antinodes (label these with the letter A).

[3]

**(c)** The frequency of the sound produced by the loudspeaker in **(b)** is gradually reduced.

Determine the lowest frequency at which a loud sound will be produced in the tube of length $L$ = 45 cm.

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frequency = ........................................... Hz [3]

**5** **(a)** Tensile forces are applied to opposite ends of a copper rod so that the rod is stretched. The variation with stress of the strain of the rod is shown in Fig. 5.1.

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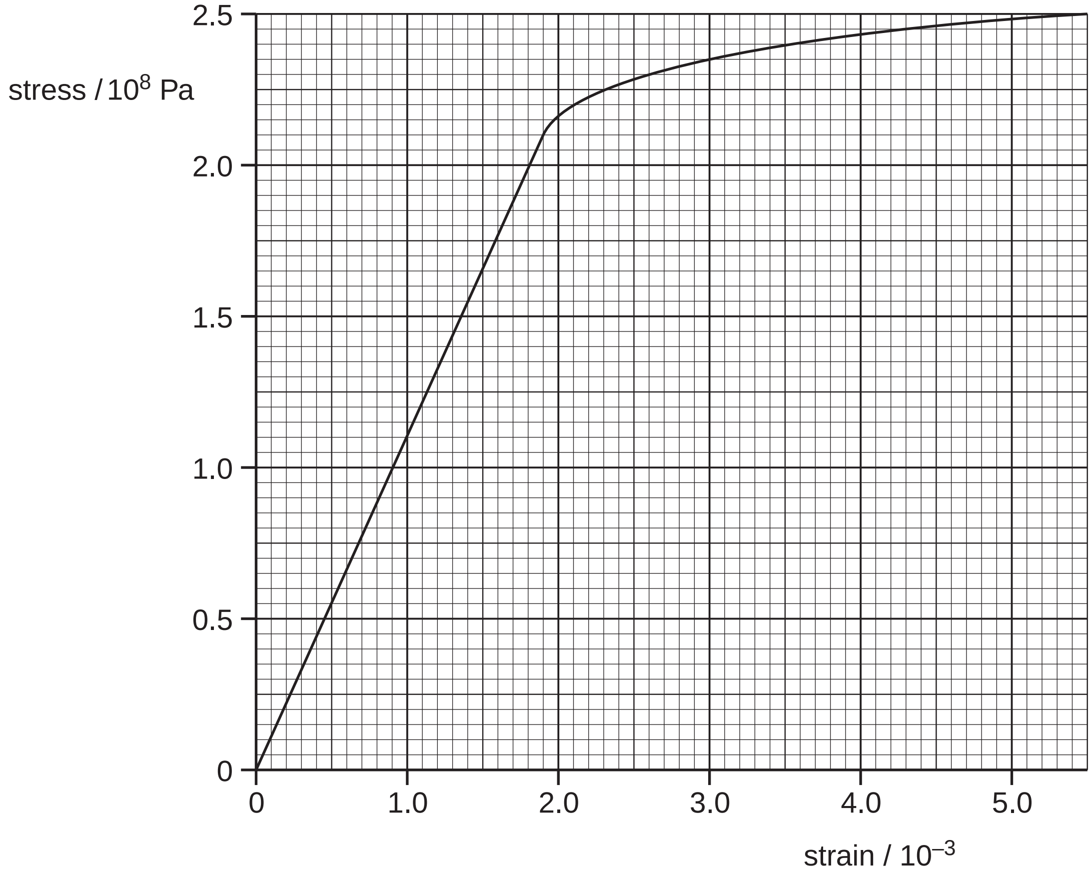


**Fig. 5.1**

**(i)** Use Fig. 5.1 to determine the Young modulus of copper.

Young modulus = .......................................... Pa [3]

**(ii)** On Fig. 5.1, sketch a line to show the variation with stress of the strain of the rod as the stress is reduced from $2.5 \times 10^6$ Pa to zero. No further calculations are expected. [1]

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**(b)** The walls of the tyres on a car are made of a rubber compound.
The variation with stress of the strain of a specimen of this rubber compound is shown in Fig. 5.2.

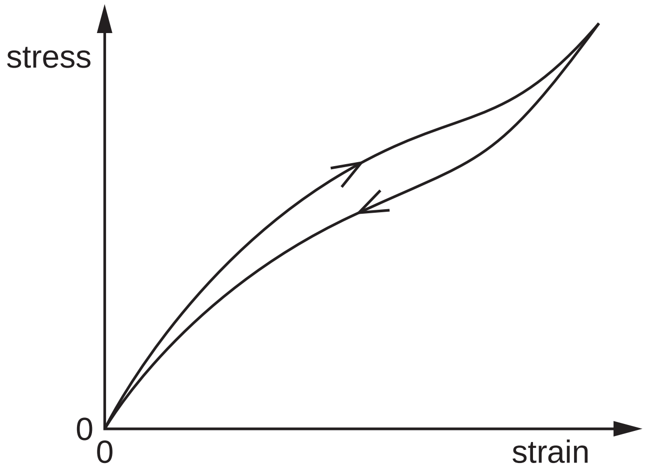


**Fig. 5.2**

As the car moves, the walls of the tyres bend and straighten continuously.

Use Fig. 5.2 to explain why the walls of the tyres become warm.

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....................................................................................................................................[3]

*For Examiner's Use*

**6** **(a)** A metal wire of constant resistance is used in an electric heater.
In order not to overload the circuit for the heater, the supply voltage to the heater is reduced from 230 V to 220 V.

Determine the percentage reduction in the power output of the heater.

reduction = ........................................... % [2]

**(b)** A uniform wire AB of length 100 cm is connected between the terminals of a cell of e.m.f. 1.5 V and negligible internal resistance, as shown in Fig. 6.1.

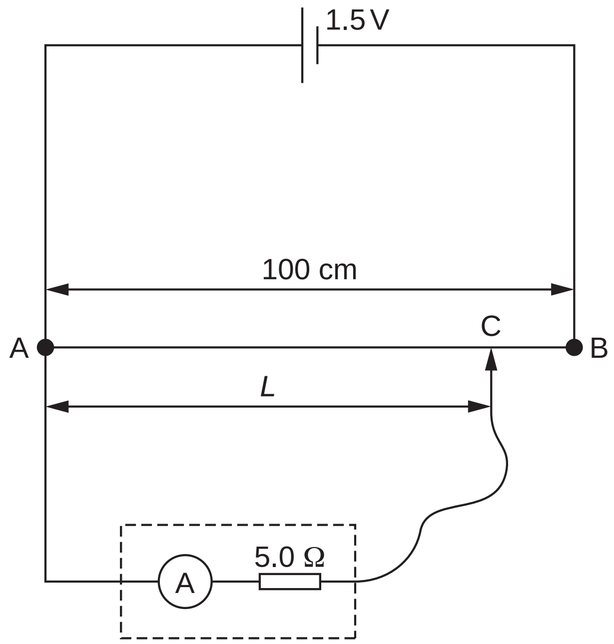


**Fig. 6.1**

An ammeter of internal resistance 5.0 Ω is connected to end A of the wire and to a contact C that can be moved along the wire.

Determine the reading on the ammeter for the contact C placed

**(i)** at A,

reading = ............................................ A [1]

**(ii)** at B.



reading = ........................................... A [1]

**(c)** Using the circuit in **(b)**, the ammeter reading *I* is recorded for different distances *L* of the contact C from end A of the wire. Some data points are shown on Fig. 6.2.

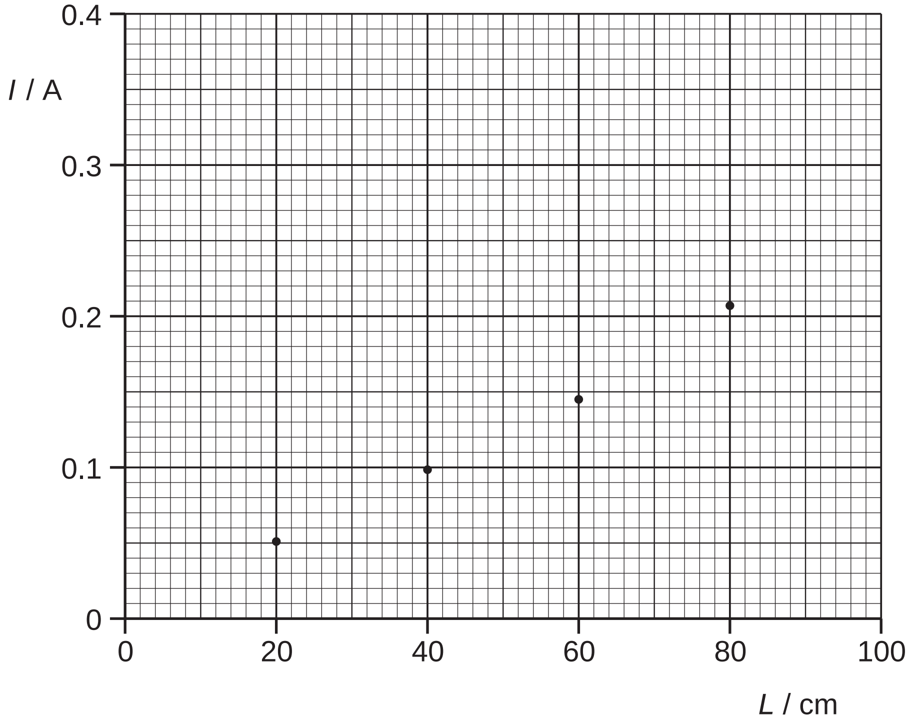


**Fig. 6.2**

**(i)** Use your answers in **(b)** to plot data points on Fig. 6.2 corresponding to the contact C placed at end A and at end B of the wire. [1]

**(ii)** Draw a line of best fit for all of the data points and hence determine the ammeter reading for contact C placed at the midpoint of the wire.

reading = ............................................. A [1]

**(iii)** Use your answer in **(ii)** to calculate the potential difference between A and the contact C for the contact placed at the midpoint of AB.

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potential difference = ............................................. V [2]

**(d)** Explain why, although the contact C is at the midpoint of wire AB, the answer in **(c)(iii)** is **not** numerically equal to one half of the e.m.f. of the cell.

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For Examiner's Use

**7** **(a)** The radioactive decay of some nuclei gives rise to the emission of $\alpha$-particles. State

**(i)** what is meant by an $\alpha$-particle,

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

**(ii)** two properties of $\alpha$-particles.

1. ............................................................................................................................

............................................................................................................................

2. ............................................................................................................................

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

**(b)** One possible nuclear reaction involves the bombardment of a stationary nitrogen-14 nucleus by an $\alpha$-particle to form oxygen-17 and another particle.

**(i)** Complete the nuclear equation for this reaction.

$$^{14}_{7}\text{N} + \,^{\cdots\cdots}_{\cdots\cdots}\alpha \rightarrow \,^{17}_{8}\text{O} + \,\cdots\cdots\cdots\cdots\cdots\cdots$$ [2]

**(ii)** The total mass-energy of the nitrogen-14 nucleus and the $\alpha$-particle is less than that of the particles resulting from the reaction. This mass-energy difference is 1.1 MeV.

**1.** Suggest how it is possible for mass-energy to be conserved in this reaction.

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**2.** Calculate the speed of an $\alpha$-particle having kinetic energy of 1.1 MeV.

speed = ...................................... m $s^{-1}$ [4]

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