EUNOIA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS 2023
General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME	

CIVICS GROUP	2	2	-			REGISTRATION NUMBER		

PHYSICS **9749/02**

Structured Questions

14th September 2023

2 hours

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and registration number on all the work you hand in.
The use of an approved scientific calculator is expected where appropriate.
Answer **all** questions.

Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use paper clips, highlighters, glue or correction fluid.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Q1	**9**
Q2	**7**
Q3	**11**
Q4	**9**
Q5	**9**
Q6	**9**
Q7	**6**
Q8	**20**
s.f.	
P2 Total	**80**

This document consists of **27** printed pages and **5** blank pages.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	$e = 1.60 \times 10^{-19}$ C
the Planck constant,	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron,	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton,	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant,	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant,	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant,	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant,	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall,	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
hydrostatic pressure,	$p = \rho gh$
gravitational potential,	$\phi = -\frac{Gm}{r}$
temperature,	$T / \mathrm{K} = T / {}^\circ\mathrm{C} + 273.15$
pressure of an ideal gas,	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $= \pm\, \omega \sqrt{\left(x_0^2 - x^2\right)}$
electric current,	$I = Anvq$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 (a) The diameter of a marble is measured using a vernier calliper and three sets of measurements are obtained as shown in Table 1.1. The true value of the diameter of the marble is 1.52 cm.

Table 1.1

	diameter of marble / cm				
Set A	1.52	1.49	1.43	1.52	1.55
Set B	1.42	1.45	1.43	1.51	1.58
Set C	1.45	1.56	1.47	1.53	1.46

(i) State and explain which set of measurements is the most precise. [2]

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

(ii) State and explain which set of measurements is the most accurate. [2]

…………………………………………………………………………………………………..

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(b) Two cars A and B are travelling on a straight level road. Car A is 500 m ahead of Car B at t = 0 s. The velocity-time graph for cars A and B in the first 15 s are shown in Fig. 1.2 below.

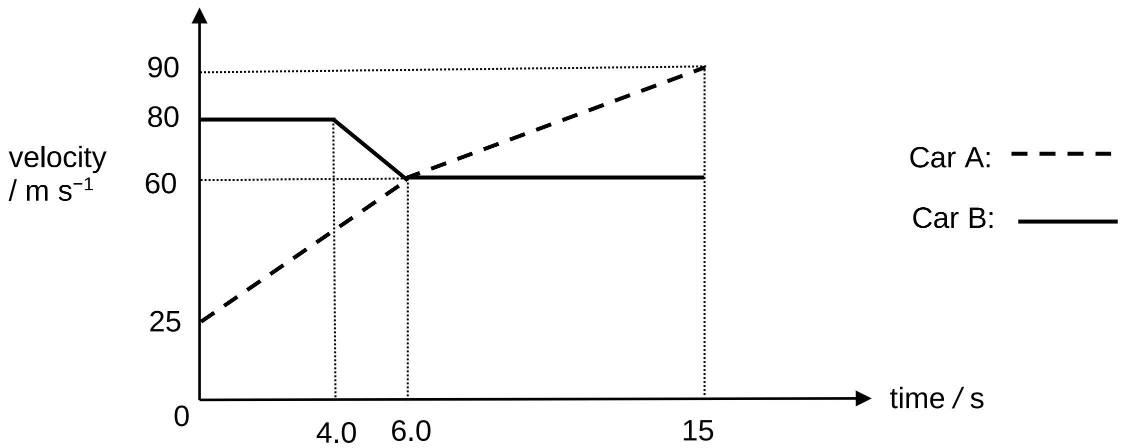

Fig. 1.2

(i) Sketch the corresponding displacement-time graph and acceleration-time graph of **car B** in the graphs provided in Fig. 1.3.

For the displacement-time graph, label the displacement at 15 s on the axis.
For the acceleration-time graph, label all accelerations on the axis.

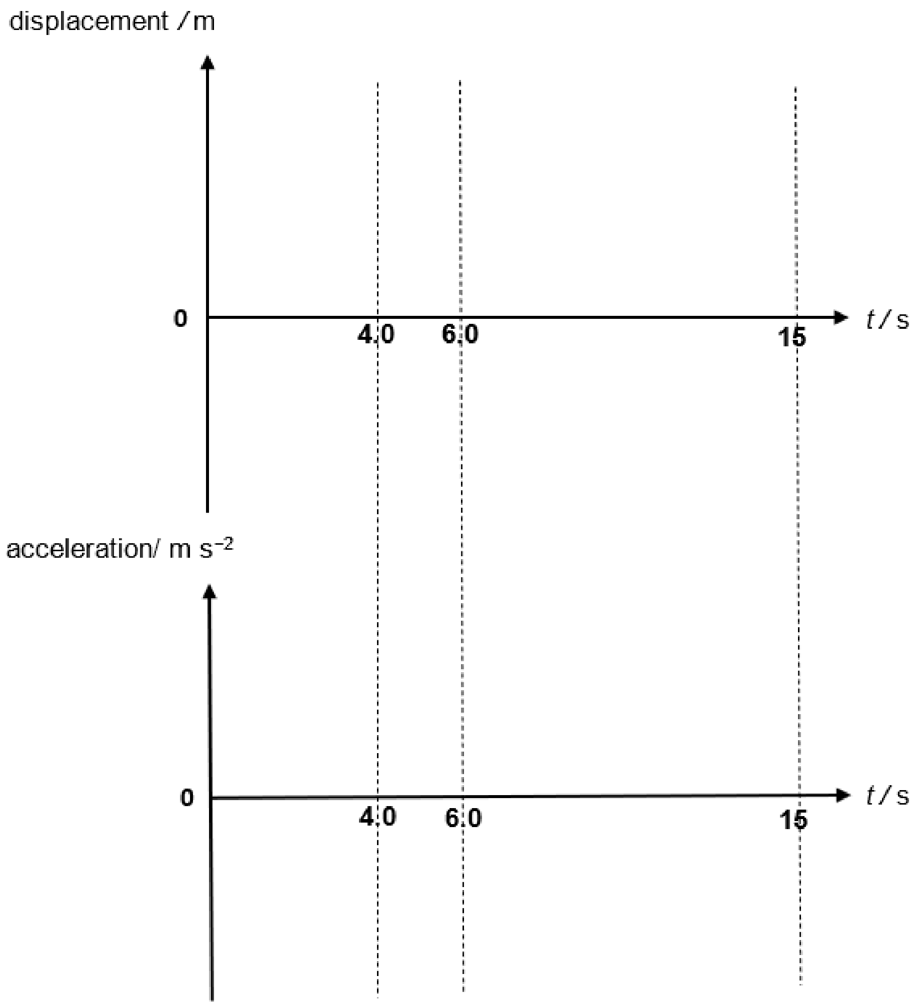

Fig. 1.3

[2]

(ii) Find the minimum distance between the two cars within the first 15 s.

distance = …………………… m [3]

[Total: 9]

2 **(a)** State the two conditions necessary for the equilibrium of a body which is acted upon by a number of forces.

1. ………………………………………………………………………………………………………

………………………………………………………………………………………………………

2. ………………………………………………………………………………………………………

……………………………………………………………………………………………………… [2]

(b) A uniform rod of weight 80 N is supported by a wall hinge at one end and a cable at the other end, as shown in Fig. 2.1. It makes an angle of 60° with the wall and 50° with the cable. Determine the tension in the cable and the force *R* on the rod by the wall hinge**.**

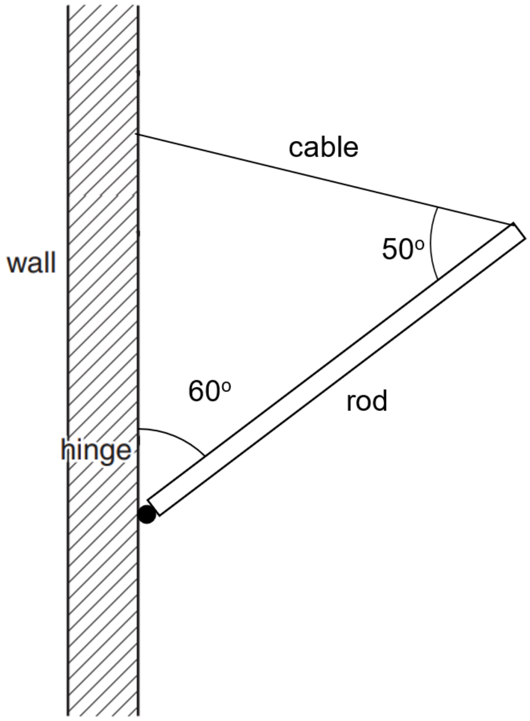

Fig. 2.1

tension = ……………………………………… N

magnitude of force *R* = ………………………………………….. N

direction of force *R* from the wall surface = ………..……………………….………………… [5]

[Total: 7]

3 A small magnet X of mass 30 g is released from rest on the top of a smooth slope of length 1.50 m inclined at 40° as shown in Fig. 3.1. Another small magnet Y was placed at rest on a smooth horizontal surface a long distance away from the slope.

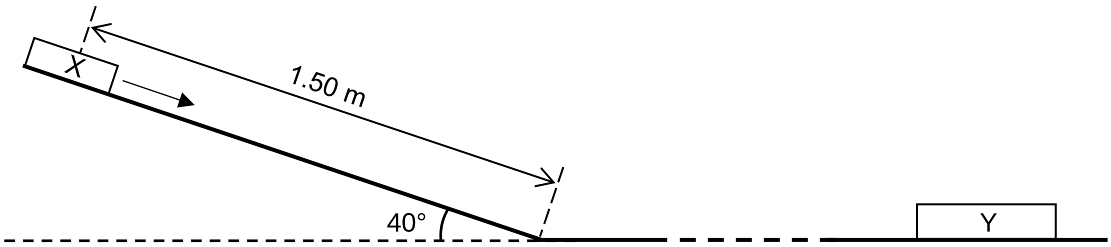

Fig. 3.1

(a) Calculate the speed of magnet X as it reaches the bottom of the slope after being released.

speed of X = ………………………….. m s^{-1} [1]

(b) The two magnets X and Y were positioned with **like** poles facing each other.

Magnet X reaches a point of closest approach with magnet Y before changing direction and going towards the slope. It stopped 0.80 m up the slope. Assume that the collision is elastic.

(i) Calculate the final speed of magnet Y.

speed of Y = ………………………..…… m s^{-1} [3]

(ii) Show that the mass of magnet Y is 190 g. [2]

(c) The two magnets are now aligned with **unlike** poles facing each other. X is released from rest at the top of the frictionless slope. As it touches Y, they stick and move off together.

(i) Explain why such a collision is always inelastic.

……………………………………………………………………………………………......

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

(ii) Show that the speed of X and Y after the collision is 0.59 m s^{-1}. [1]

(iii) After the collision, X and Y travelled up a rough slope inclined at 50° to the horizontal as shown in Fig. 3.2. The slope exerts a constant frictional force of 2.2 N on the magnets.

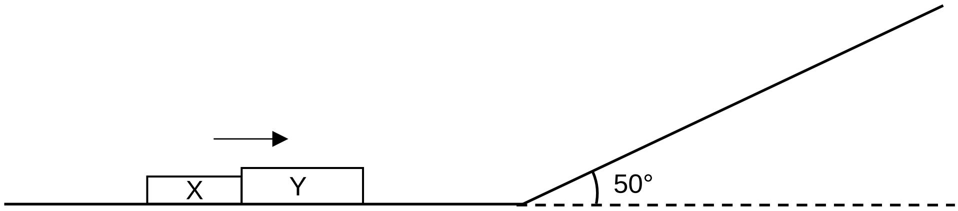

Fig. 3.2

The magnets travelled a distance *d* up the rough slope before coming to a stop.

Calculate the distance *d*.

d = ... m [3]

[Total: 11]

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4 (a) Define *electric field strength*.

………......

………......[1]

(b) Fig. 4.1 is a **full scale** diagram that shows a series of equipotential lines around a few point charges.

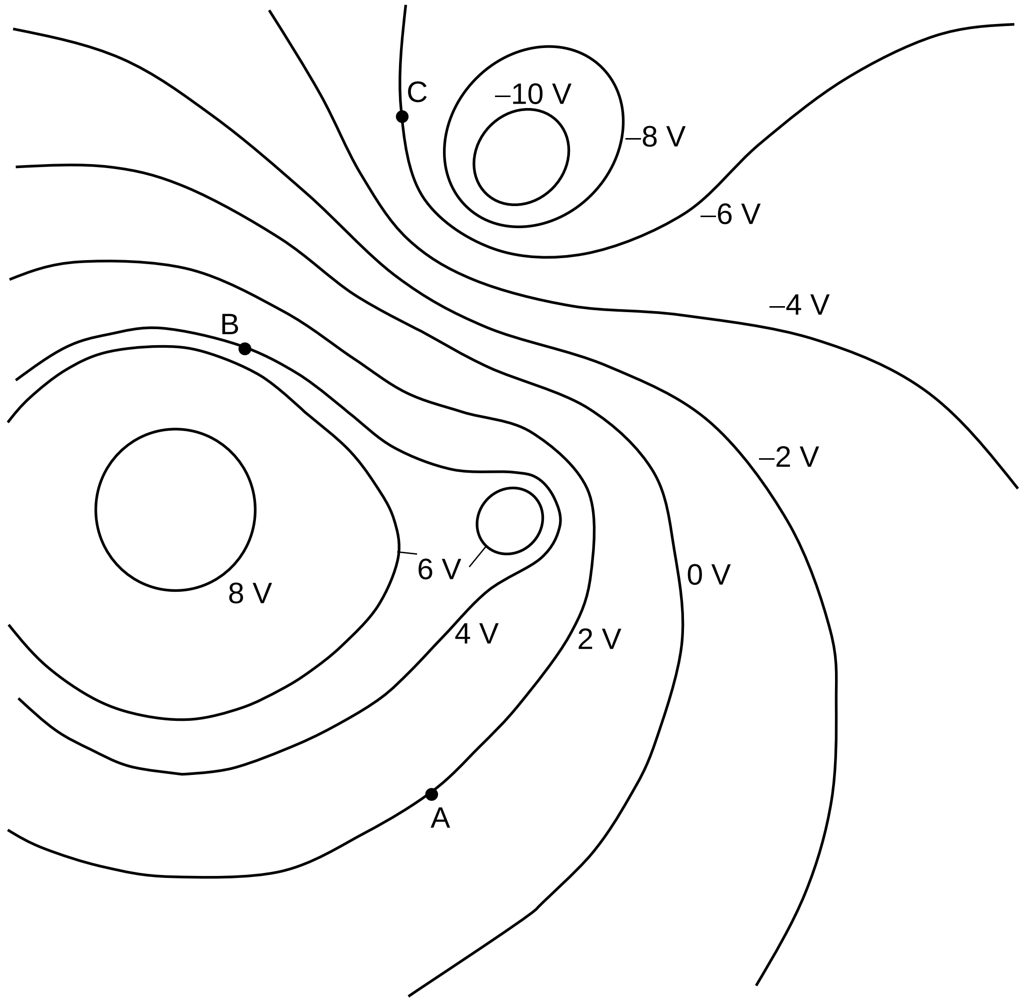

Fig. 4.1

(i) Determine the magnitude of the electric force experienced by an electron placed at point A.

electric force = ………………………. N [2]

(ii) Another electron is projected from point B to point C with an initial speed of 5.3×10^{6} m s^{-1}.

Calculate the final speed of the electron at point C.

final speed = ……………………….. m s^{-1} [3]

(c) Electrons are emitted from a cathode P and accelerated towards an anode Q. The distance PQ is 8.0 cm.

The variation with distance *d* from P along PQ of the magnitude of the electric field strength *E* is shown in Fig. 4.2.

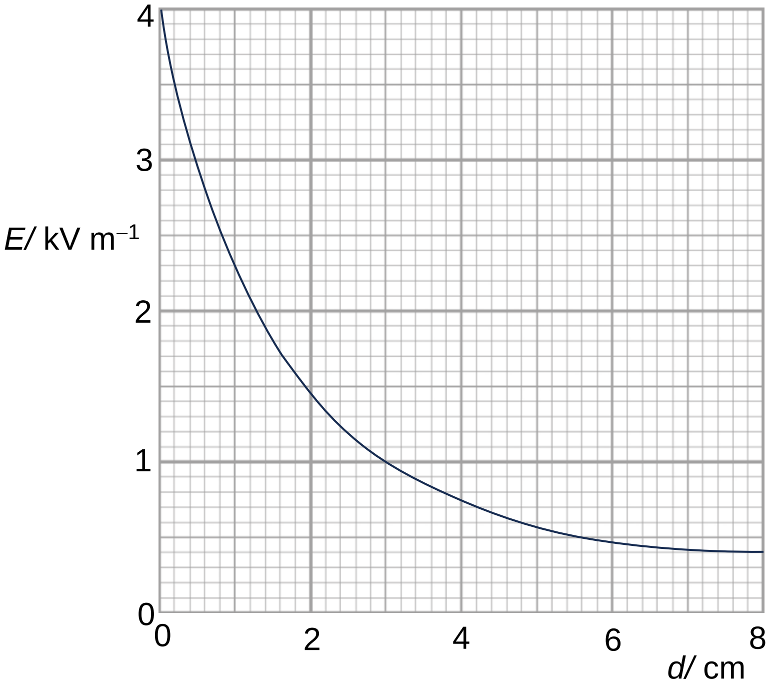

Fig. 4.2

Estimate the change in electric potential energy experienced by an electron as it accelerates from P to Q.

change in potential energy = ……………………… J [3]

[Total: 9]

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5 A cell of e.m.f. 1.2 V and negligible internal resistance is connected to three resistors and a semiconductor diode, as shown in Fig. 5.1.

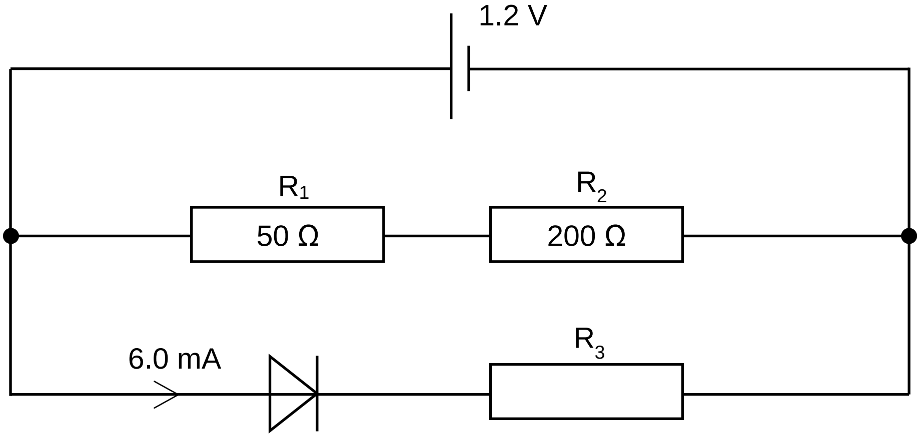

Fig. 5.1

The I-V characteristic of the semiconductor diode is shown in Fig. 5.2.

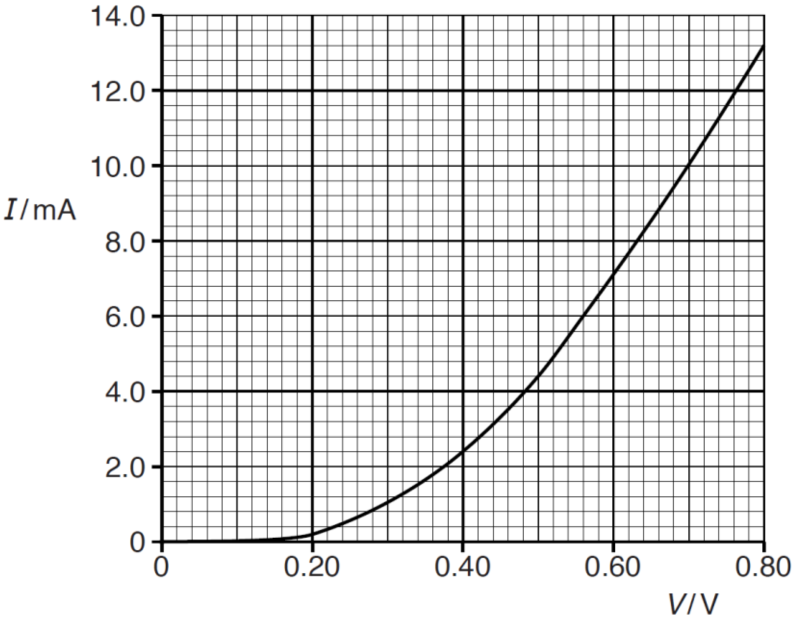

Fig. 5.2

The current in the diode is 6.0 mA.

(a) Use Fig. 5.2 to determine the resistance of the diode for a current of 6.0 mA.

resistance = ... Ω [1]

(b) Determine the resistance of R_3.

resistance = ... Ω [2]

(c) Determine the current in R_1.

current = ... A [2]

(d) Determine the total power dissipated in the circuit.

total power = ... W [2]

(e) A 1.0 m metal wire is added to the circuit as shown in Fig. 5.3.

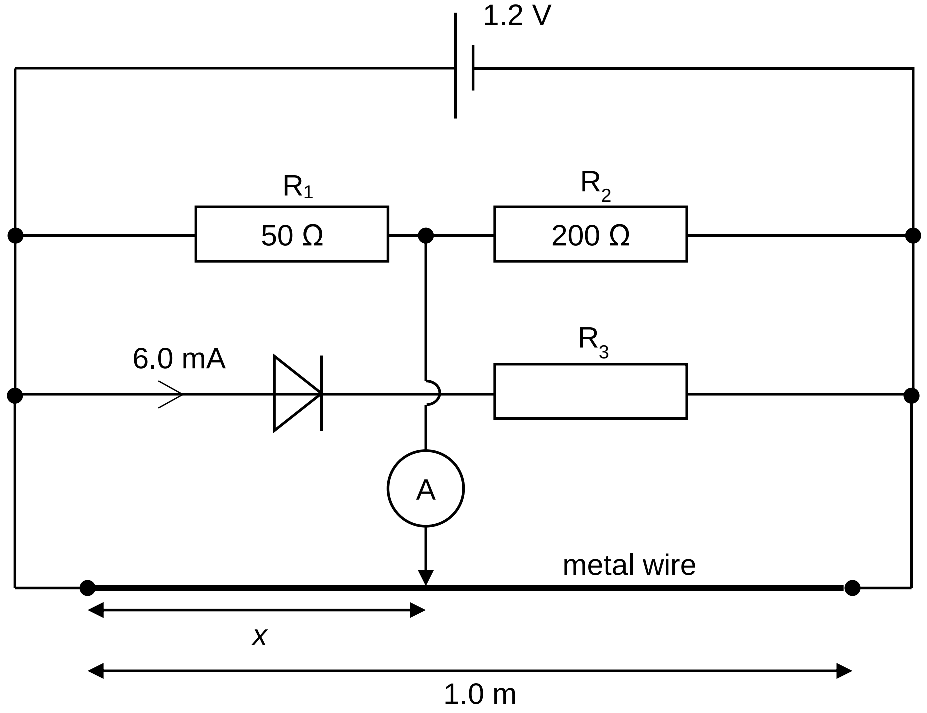

Fig. 5.3

Determine length *x* such that there is no current flowing through the ammeter.

x = ... m [2]

[Total: 9]

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6 Two oppositely charged parallel metal plates P and Q are placed in vacuum. The electric field strength E is uniform in the region between the plates, and is zero outside this region. Uniform magnetic flux density B into the plane of the paper also exists in the region between the plates, as well as in the adjacent area, as shown in Fig. 6.1.

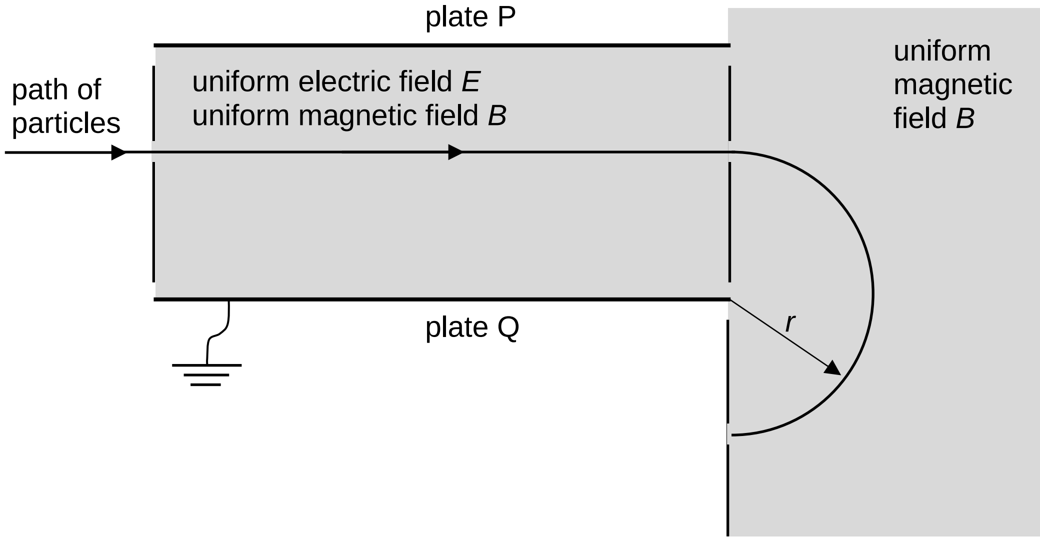

Fig. 6.1

A beam of negatively charged particles moving in the direction perpendicular to the electric field enters the region between the plates.

(a) **(i)** Some of the particles move in a straight line undeflected in the region between the plates.

State and explain the polarity, positive or negative, of plate P.

....

....

....

.... [2]

(ii) Show that the speed v of these particles satisfies

$$v = \frac{E}{B}$$

[1]

(iii) Some of the particles move with an initial speed $v > \dfrac{E}{B}$.

On Fig. 6.1, sketch the path between the plates of these particles.

Explain your answer.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(b) After leaving the parallel plates, the undeflected particles enter a region with only the uniform magnetic flux density *B*, in which they follow a circular trajectory of radius *r*.

(i) Explain why the speed of the particles remains constant along the circular trajectory.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(ii) Show that, for the particles that follow the circular path of radius *r*, the charge-to-mass ratio is given by

$$\frac{q}{m} = \frac{E}{B^2 r}.$$

[2]

[Total: 9]

7 **(a)** A solenoid of diameter 9.0 cm and 560 turns is placed in a uniform magnetic field as shown in Fig. 7.1.

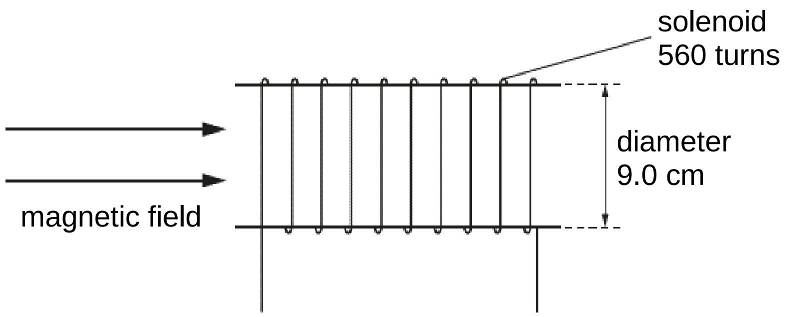

Fig. 7.1

The variation with time *t* of the magnetic flux density is shown in Fig. 7.2.

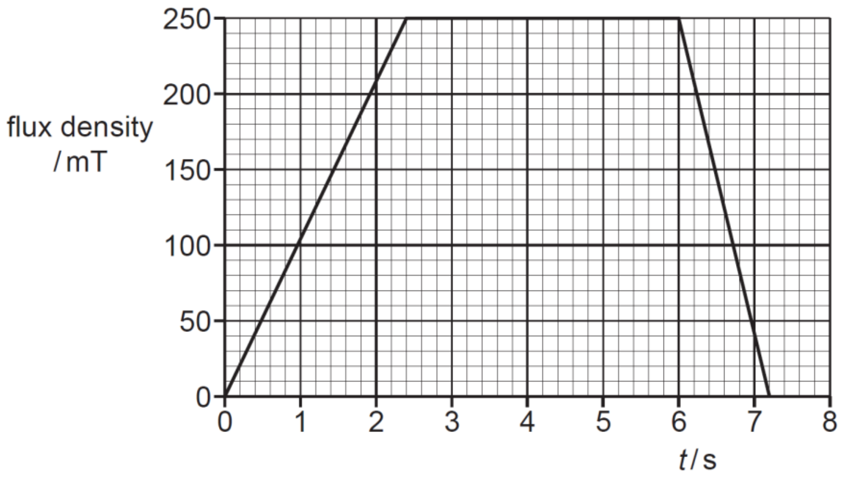

Fig. 7.2

Calculate the maximum magnitude of the induced electromotive force (e.m.f.) in the solenoid.

e.m.f. = …………………………… V [2]

(b) A thin copper sheet X is supported on a rigid rod so that it hangs between the poles of a magnet as shown in Fig. 7.3.

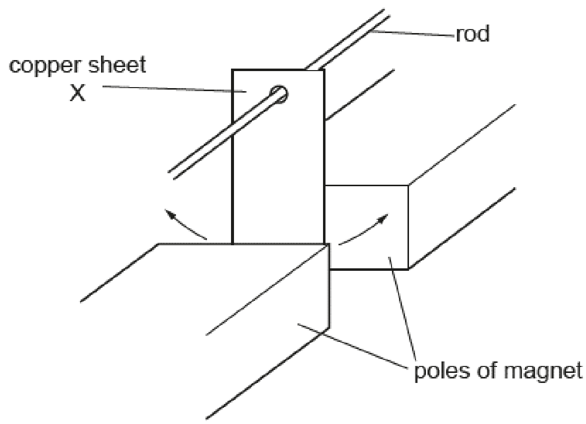

Fig. 7.3

Sheet X is displaced to one side and then released so that it oscillates. A motion sensor is used to record the displacement of X.

A second thin copper sheet Y replaces sheet X. Sheet Y has the same overall dimensions as X but is cut into the shape shown in Fig 7.4.

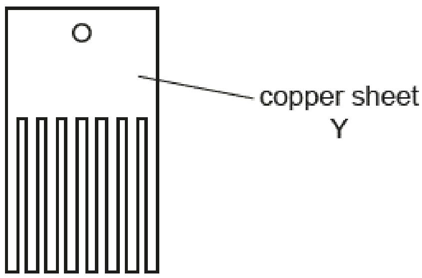

Fig. 7.4

The motion sensor is again used to record the displacement.

The graph in Fig. 7.5 shows the variation with time *t* of the displacement *s* of each copper sheet.

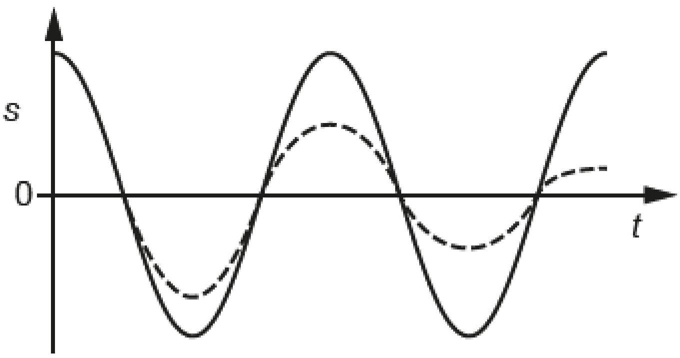

Fig. 7.5

(ii) Deduce which copper sheet is represented by the dashed line. Explain your answer using the principles of electromagnetic induction.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

………………………………………………………………………………………………...[4]

[Total: 6]

8 An object that is at a higher temperature than its surroundings loses thermal energy by emitting electromagnetic radiation.

For loss of thermal energy as electromagnetic radiation, the intensity I_λ of the emitted radiation of wavelength λ varies with wavelength λ as shown in Fig. 8.1.

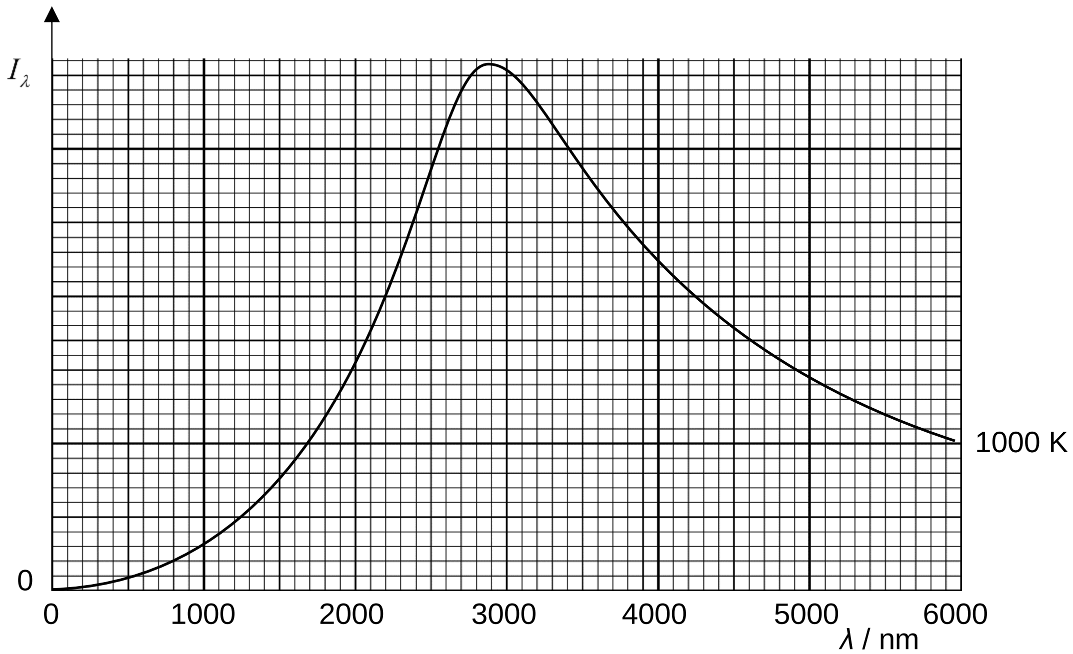

Fig. 8.1

Fig. 8.1 shows the variation of I_λ with λ for the body when it is at 1000 K.

The distribution of intensity is different at different temperatures. This is illustrated in Fig. 8.2.

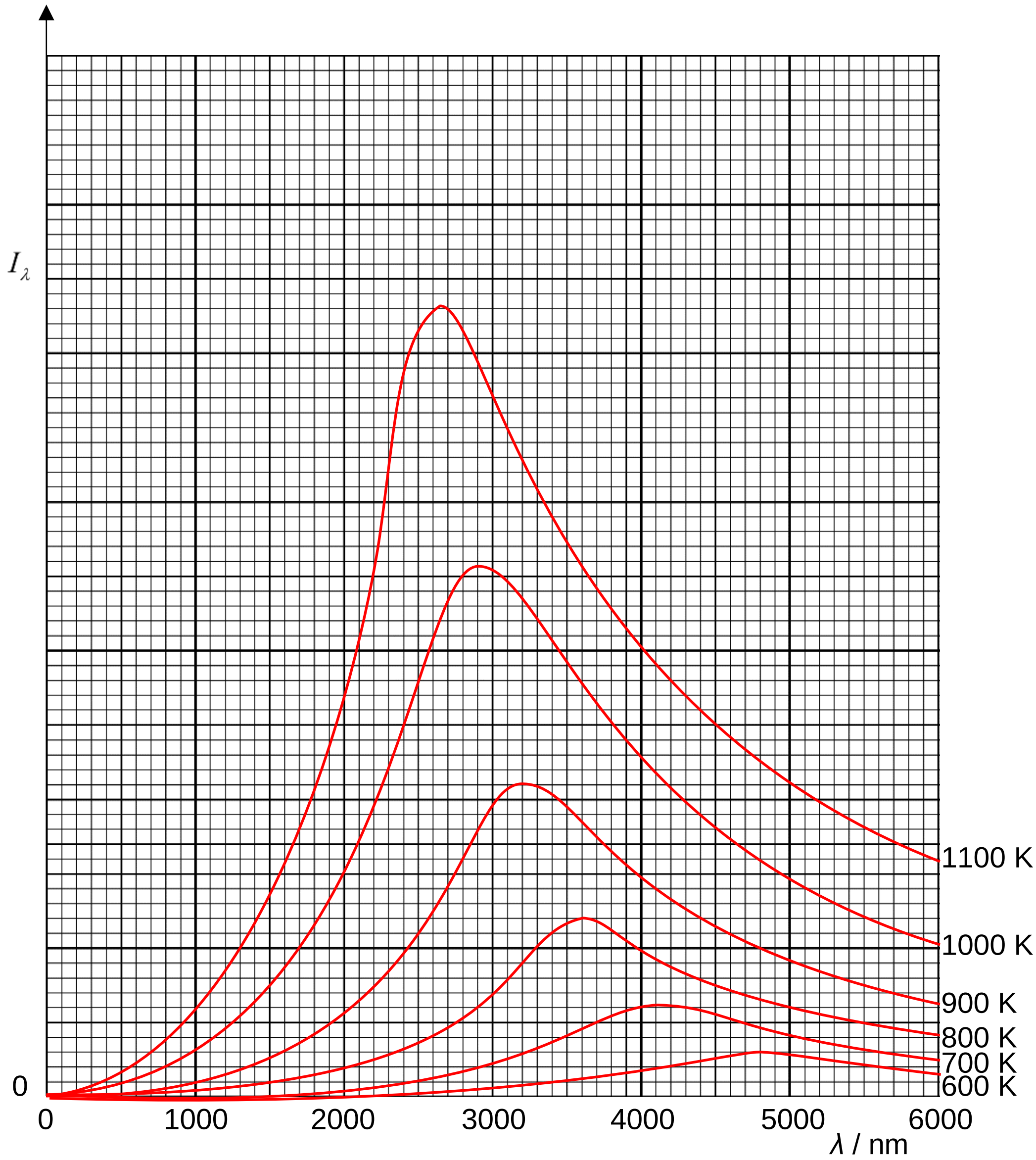

Fig. 8.2

(a) **(i)** On the horizontal axis of Fig. 8.2, indicate with the letter V a wavelength that is in the visible region of the electromagnetic spectrum. [1]

(ii) Hence suggest why, at a temperature of 1100K, the object would glow with a red colour.

....

.... [1]

(b) At any temperature T, the graph of Fig. 8.2 shows a peak corresponding to a wavelength λ_{max} and an intensity I_{max}. Data for T and λ_{max} are shown in Table 8.3.

Table 8.3

T / K	λ_{max} / nm
600	4830
700	4140
800	3610
900	3210
1000	2900
1100	2630

(i) Without drawing a graph, show that

$$T \times \lambda_{max} = \text{constant},$$

and determine the constant.

constant = ……………………………. [3]

(ii) Hence, determine the wavelength for the maximum intensity at a temperature T of 1200 K.

wavelength = ………………………….. m [2]

(c) The total intensity of emitted radiation from a particular body at temperature T is I_{tot}. Fig. 8.4 shows the values of lg(T/K) plotted against the corresponding values of lg(I_{tot}/W m^{-2}).

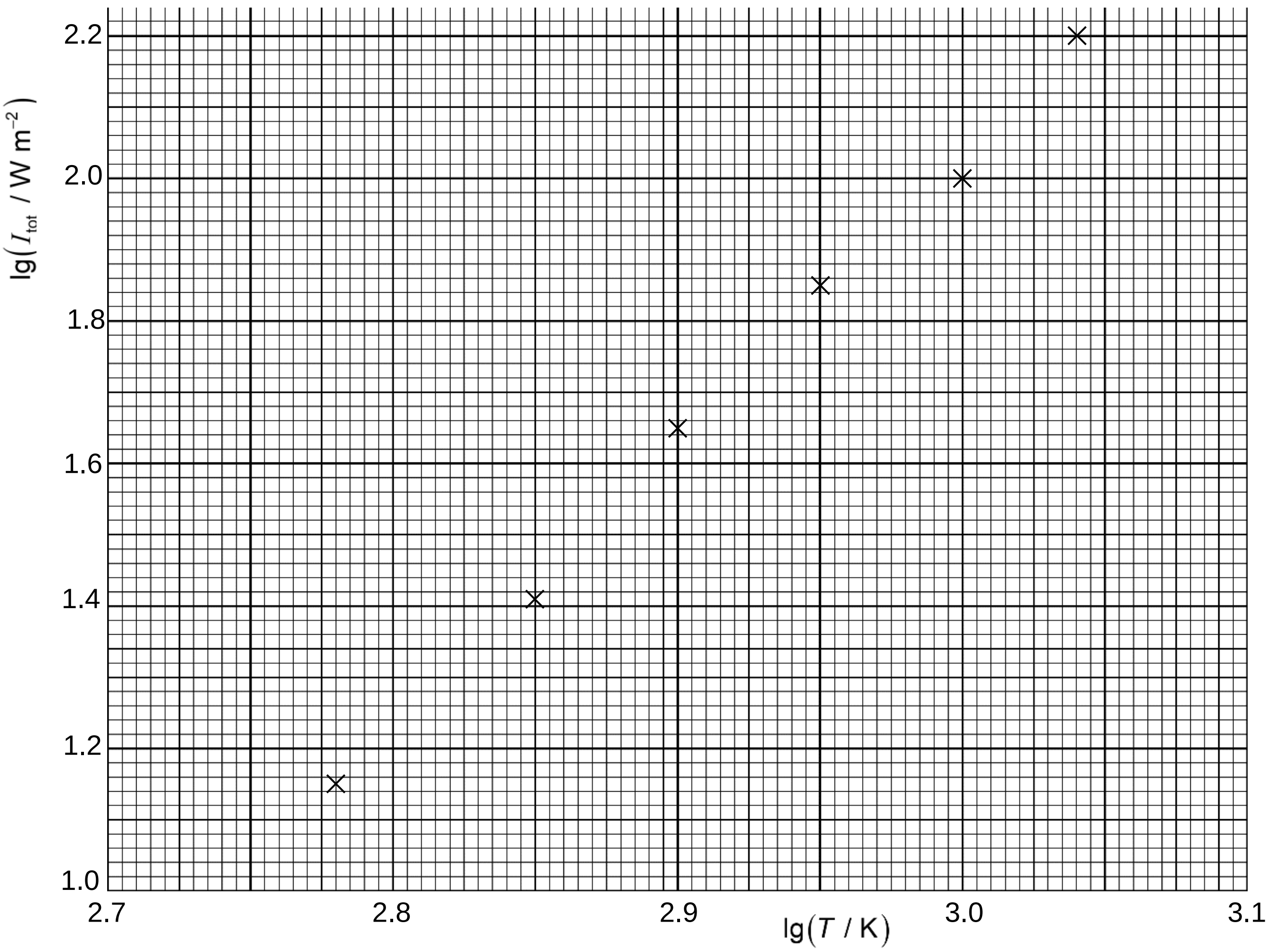

Fig. 8.4

It is known that I_{tot} varies with T according to the relation

$$I_{tot} = cT^n,$$

where c and n are constants.

(i) Use Fig. 8.4 to determine a value for n.

n = ... [3]

(ii) For this body at $T = 900$ K, I_{tot} is found to be 71 W m^{-2}.

Use these data and your answer to (c)(i) to determine I_{tot} for the body at a temperature of 1200 K.

$I_{tot} =$ .... W m^{-2} [3]

(d) Using your answer to **(b)(ii),** sketch on Fig. 8.2, the variation with wavelength λ of intensity I_{λ} for a temperature of 1200 K. [3]

(e) The radiation emitted by a hot body may be used as a means of determining the temperature of the body.

(i) Suggest and explain a property of the radiation that could be used for this purpose.

....

....

.... [2]

(ii) Suggest one advantage and one disadvantage of this method for measuring temperature.

advantage: ....

....

disadvantage: ....

.... [2]

[Total: 20]

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