MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examinations
Higher 2

H2 Physics 9749/02

Paper 2 Structured Questions **12 September 2018**

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

	Class	Reg No
Candidate Name: ____________________		

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use a 2B pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Answer **all** questions.

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	**/ 6**
2	**/ 8**
3	**/ 11**
4	**/ 10**
5	**/ 10**
6	**/ 8**
7	**/ 7**
8	**/ 20**
Deductions	
Total	**/ 80**

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$\left(1/\left(36\pi\right)\right) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant	G	=	6.67×10^{-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	=	ρgh
gravitational potential	ϕ	=	$-Gm/r$
temperature	T /K	=	T /°C + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translation kinetic energy an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t$
		=	$\pm \omega\sqrt{x_o^2 - x^2}$
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	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

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

1 **(a)** For an oscillating body, state what is meant by

(i) natural frequency of vibration,

....

....

.... [1]

(ii) resonance.

....

....

.... [1]

(b) State and explain one situation where resonance is useful.

....

....

....

.... [2]

(c) In some situations, resonance should be avoided.

State one such situation and how the effects of resonance are reduced.

....

....

....

.... [2]

2 A particle in a medium is oscillating because of the passage of a transverse wave W_1.

The wave has intensity I at this point. The amplitude of the oscillation is A.

Fig. 2.1 shows the variation with time t of the displacement x of the particle.

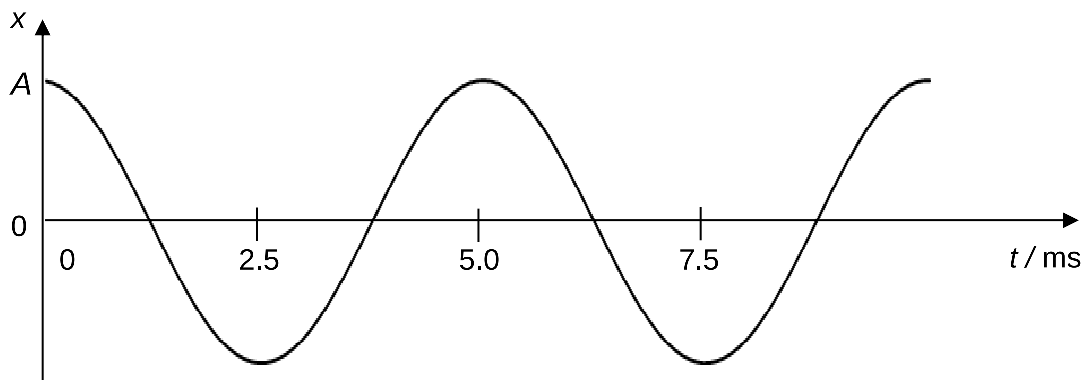


Fig. 2.1

A second, similar transverse wave W_2 has the same frequency and is incident on the same particle. The amplitude of the oscillation due to W_2 alone is $\frac{5}{2}A$ at this point.

(a) Calculate

(i) the frequency of the waves,

frequency = ... Hz [1]

(ii) the intensity, in terms of I, of the wave W_2.

intensity = ... I [2]

(b) **(i)** State two conditions which are necessary for the waves W_1 and W_2 to produce an observable interference pattern.

....

.... [2]

(ii) State the condition that must be satisfied if the waves are to interfere to produce a minimum resultant intensity at a point.

....

.... [1]

(iii) Calculate, in terms of I, this minimum intensity.

minimum intensity = ... I [2]

3 **(a)** State two differences between stationary waves and progressive waves.

1. ....

....

2. ....

.... [2]

(b) **(i)** A laser produces a narrow beam of coherent light of wavelength 632 nm. The beam is incident normally on a diffraction grating as shown in Fig. 3.1.

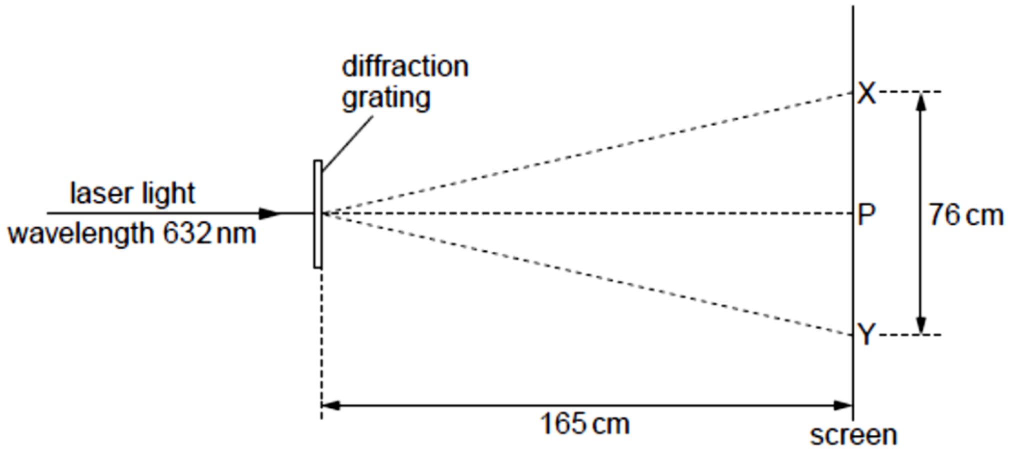


Fig. 3.1 (Top view)

Spots of light are observed on a screen placed parallel to the grating. The distance between the grating and the screen is 165 cm.

The brightest spot is P. The spots formed closest to P and on each side of P are X and Y.

X and Y are separated by a distance of 76 cm.

Calculate the number of lines per metre on the grating.

number per metre = ... m^{-1} [2]

(ii) The grating in **(b)(i)** is now rotated about an axis parallel to the incident laser beam, as shown in Fig. 3.2.

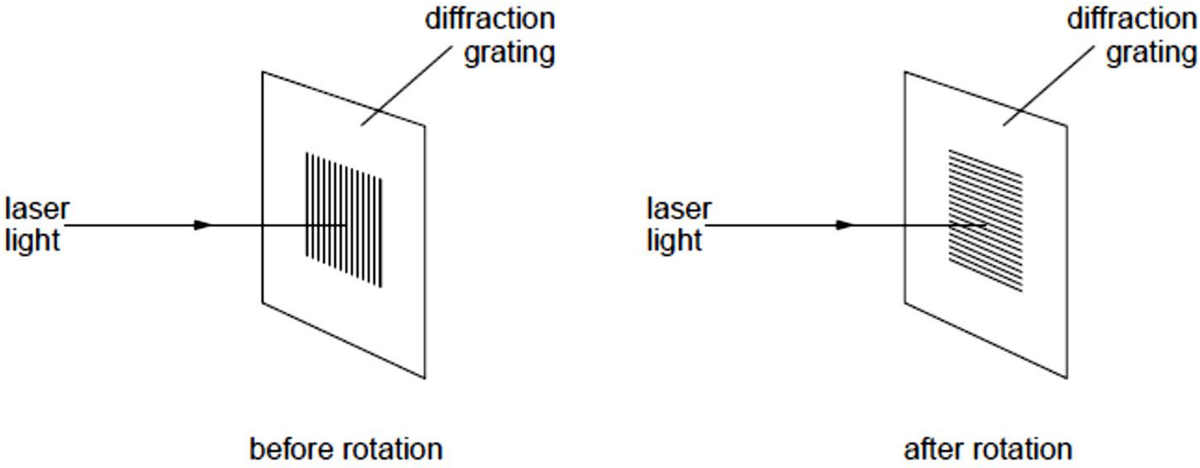


Fig. 3.2

State what effect, if any, this rotation will have on the positions of the spots P, X and Y.

....

.... [2]

(iii) In another experiment using the apparatus in **(b)(i)**, a student notices that the distances XP and PY, as shown in Fig. 3.1 are not equal.

Suggest a reason for this difference.

....

....

.... [1]

(c) A cord is held under tension between two fixed points A and B, as shown in Fig. 3.3. The distance AB is 0.40 m.

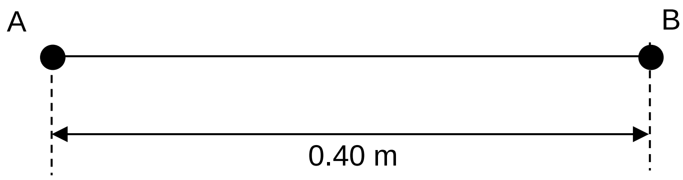


Fig. 3.3

(i) Explain why only stationary waves of certain frequencies are able to form between A and B.

....

....

.... [1]

(ii) The string is made to resonate in a mode with the third lowest possible frequency. Calculate the wavelength of this wave.

wavelength = ... m [1]

(iii) By reference to the formation of the stationary wave, explain the significance of the product of frequency and wavelength for a stationary wave.

....

....

....

.... [2]

4 **(a)** Fig. 4.1 shows a piece of metal, of mass 50 g, held in the flame of a Bunsen burner for several minutes. The metal is then quickly transferred and immersed in 130 g of water contained in a calorimeter.

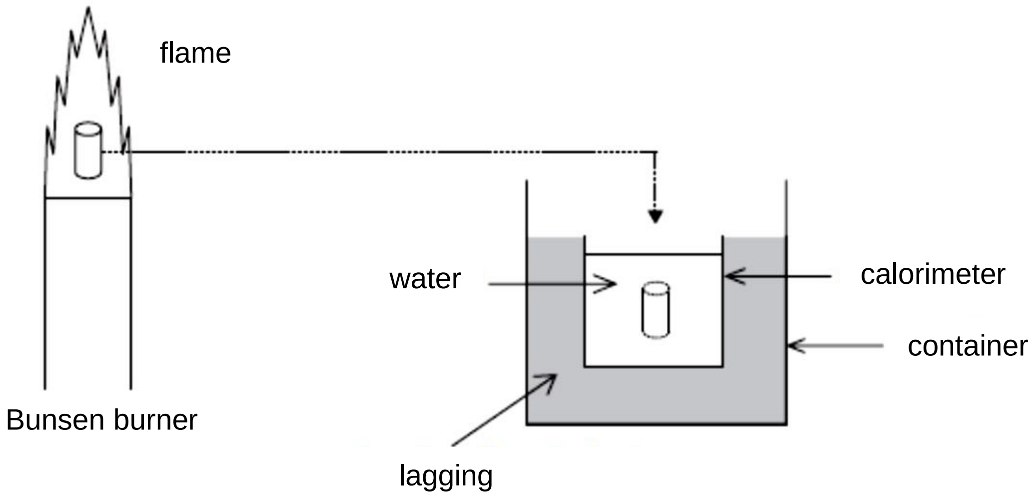


Fig. 4.1

The water into which the metal has been placed is stirred until it reaches a steady temperature. The following data are available:

heat capacity of metal	82.7 J K^{-1}
specific heat capacity of the water	4.2×10^3 J kg^{-1} K^{-1}
heat capacity of the calorimeter	54.6 J K^{-1}
initial temperature of the water	25 °C
final temperature of the water	90 °C

Use the data to calculate the temperature of the Bunsen flame and state an assumption made for your calculation.

temperature = ... °C

Assumption: ....

.... [3]

(b) The gas in the cylinder of a diesel engine can be considered to undergo a cycle of changes of pressure, volume and temperature. One such cycle, for an ideal gas, is shown in Fig. 4.2. Processes A to B and C to D take place without heat exchange with the surroundings.

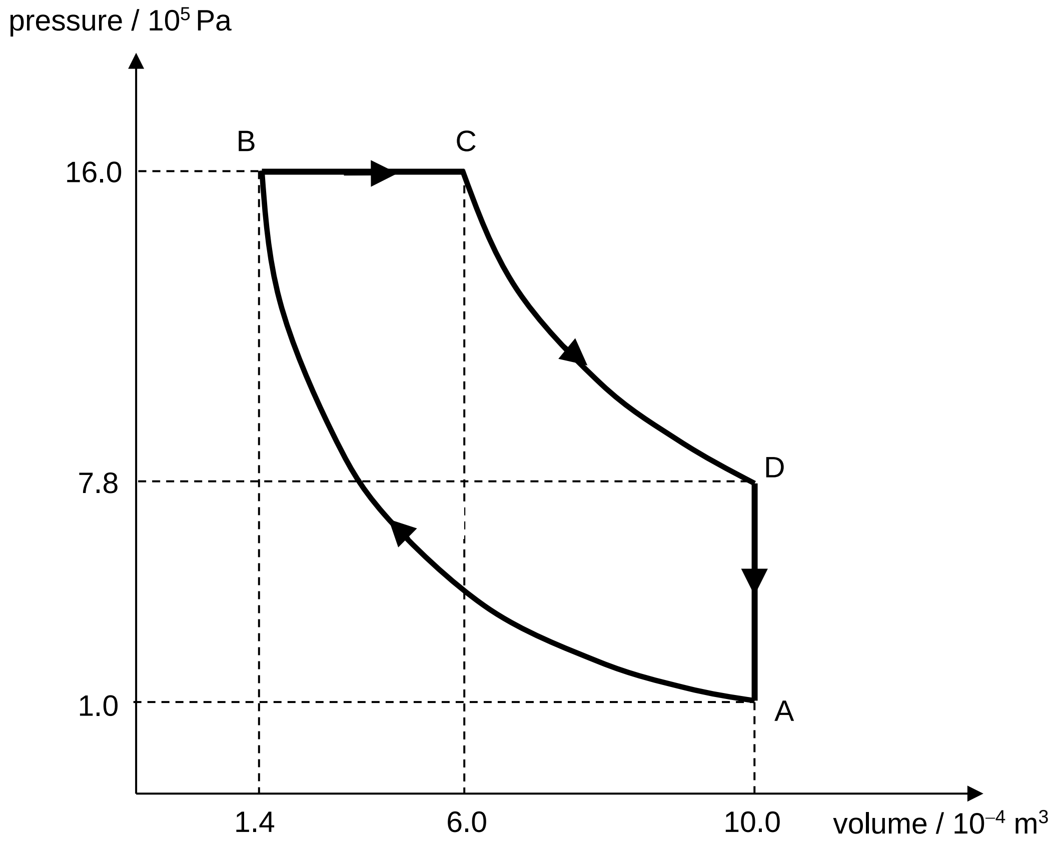


Fig. 4.2

Complete the table below.

Process	**Heat supplied to gas / J**	**Work done on gas / J**	**Increase in internal energy of gas / J**
A to B		300	
B to C	2580		
C to D		–440	
D to A	–1700		

[4]

(c) A fixed mass of ideal gas is heated from temperature T_1 to T_2 at constant volume. Explain why a greater amount of heat is required to heat the same mass of ideal gas from T_1 to T_2 at constant pressure.

....

....

....

.... [3]

5 **(a)** Define *magnetic flux*.

....

.... [1]

(b) Fig. 5.1 shows a 1.6 m long solenoid with 400 turns and a cross-sectional diameter of 4.0 cm. A coil Y, with 80 turns, is wounded tightly around the centre region of the solenoid.

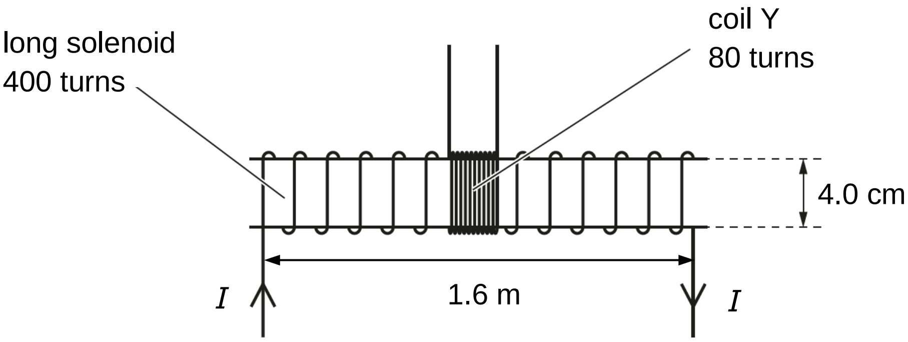


Fig. 5.1

(i) Show that, for a current I of 3.8 A in the solenoid, the magnetic flux linkage of coil Y is 1.2×10^{-4} Wb.

[2]

(ii) The current I in the solenoid in **(b)(i)** is reversed in 0.30 s.

Calculate the mean e.m.f. induced in coil Y.

mean e.m.f. = ... V [2]

[Turn over

(iii) The current I in the solenoid in **(b)(ii)** varies with time t as shown in Fig. 5.2.

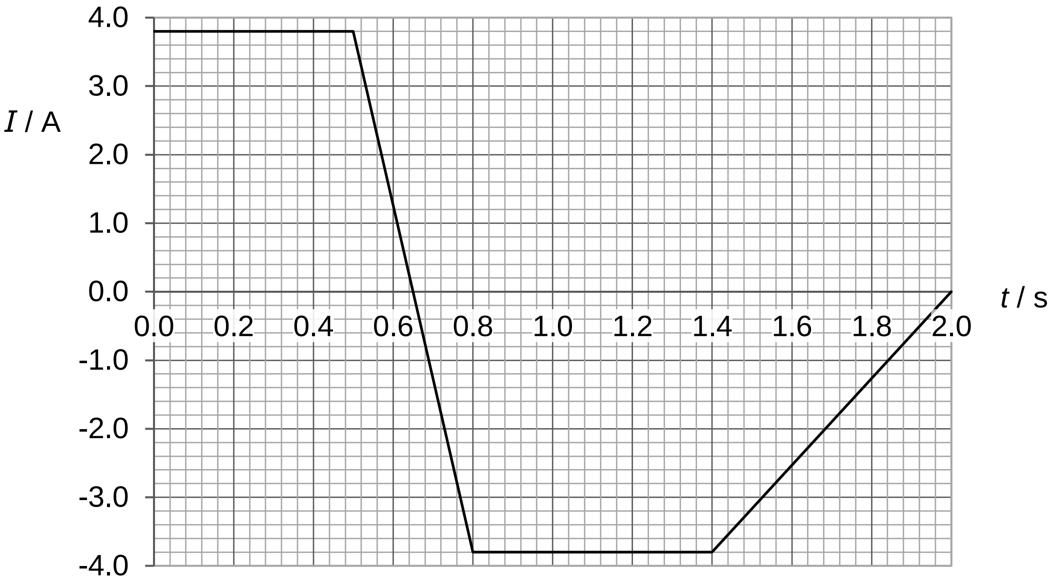
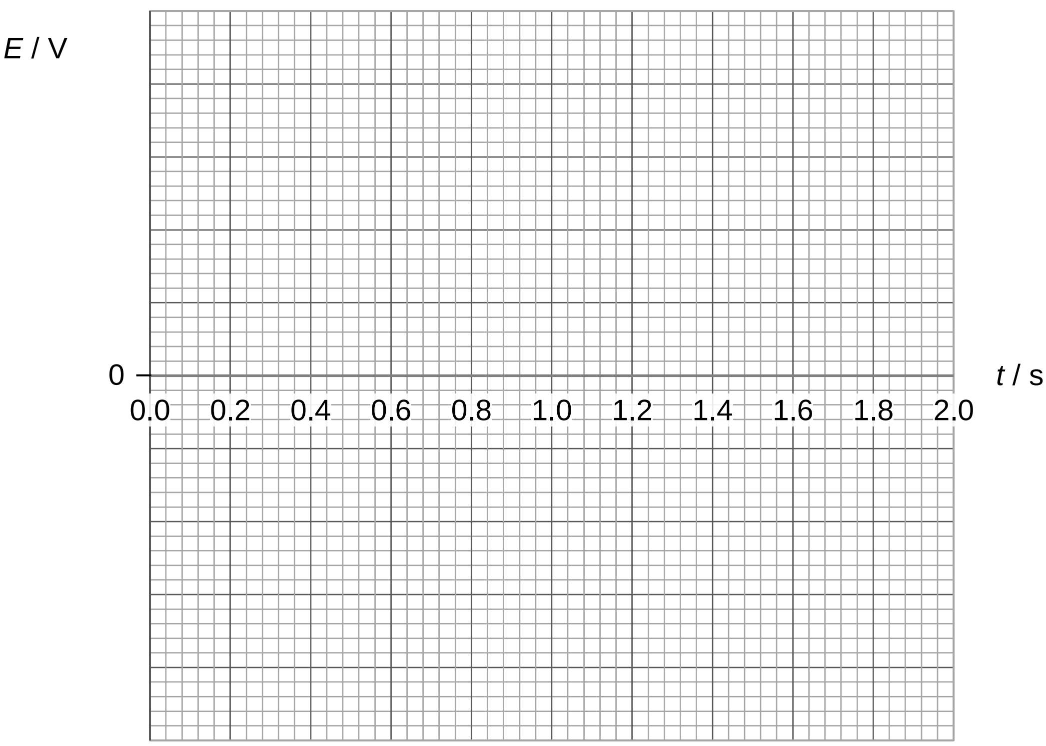


Fig. 5.2

Use your answer to **(b)(ii)** to sketch, on Fig. 5.3, the variation with time t of the e.m.f. E induced in coil Y.



[3]

(iv) An iron core is inserted into the solenoid and then held stationary within the solenoid. Explain the effect on the e.m.f. induced in coil Y.

....

....

.... [2]

6 **(a)** The photoelectric effect provides evidence for the particulate nature of electromagnetic radiation. State two experimental observations that could not be fully explained using the classical wave theory.

1. ....

....

....

2. ....

....

.... [2]

(b) In an experiment to investigate the photo-electric effect, the wavelength of the radiation incident on the metal surface was varied. For two values of wavelength λ , the stopping potential V_s was measured. The results are shown in Fig. 6.1.

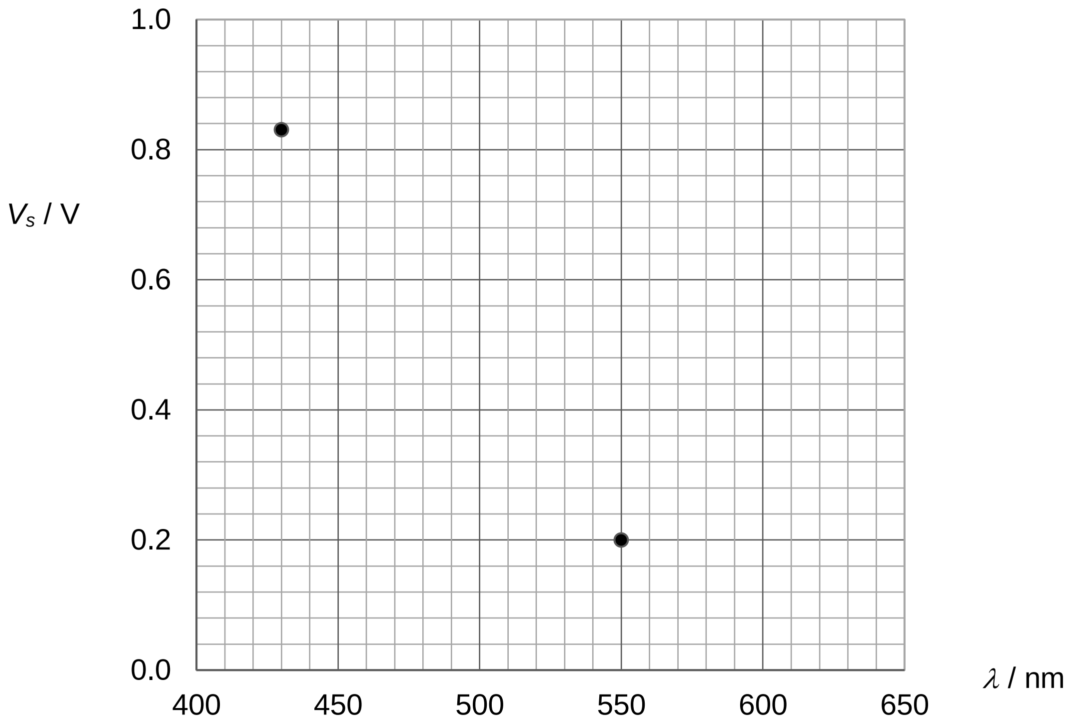


Fig. 6.1

(i) Determine the maximum kinetic energy of a photo-electron emitted from the metal surface by radiation of wavelength 550 nm.

maximum kinetic energy = ...J [1]

(ii) Hence, calculate the threshold wavelength of the metal.

threshold wavelength = ... m [2]

(iii) Suggest why it is not possible to deduce the threshold wavelength of the metal surface directly from Fig. 6.1.

....

.... [1]

(iv) The intensity of the radiation incident on the metal surface was kept constant as the wavelength was decreased from 550 nm to 430 nm.

State and explain the effect, if any, on the photocurrent.

....

....

.... [2]

7 X-ray photons are produced when electrons are accelerated through a potential difference towards a metal target. An X-ray spectrum is shown in Fig. 7.1.

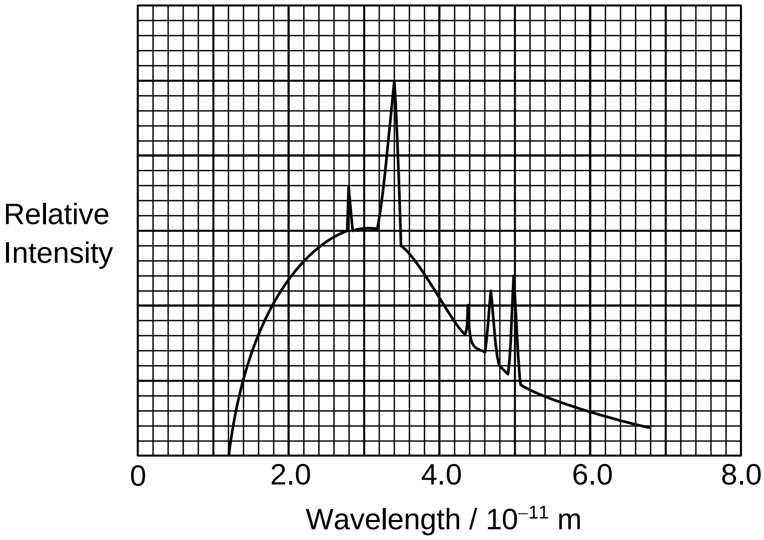


Fig. 7.1

(a) Explain how the most energetic X-ray photons are produced.

....

....

.... [2]

(b) **(i)** Explain how the characteristic X-ray K_α photons are produced.

....

....

.... [2]

(ii) Determine the momentum of the K_α X-ray photon.

momentum = ... N s [2]

(c) The potential difference used to accelerate the electrons is increased. On Fig. 7.1, sketch the new spectrum obtained. [1]

8 This question is about the movement of water from the roots of a tree to its leaves.

Water moves up a tree through its vast network of conduits. These conduits are similar to capillary tubes. It is suspected that water moves up the conduits due to low pressure in the conduits which "sucks" the water upwards, or by capillary action, or a combination of both. Capillary action is a phenomenon whereby water rises up a small tube due to upward forces caused by the adhesion of water to the walls of the tube.

To investigate capillary action, a capillary tube, open at both ends, is supported vertically with one end immersed in water, as shown in Fig. 8.1. The water in the narrow bore of the tube forms a column of height *h*.

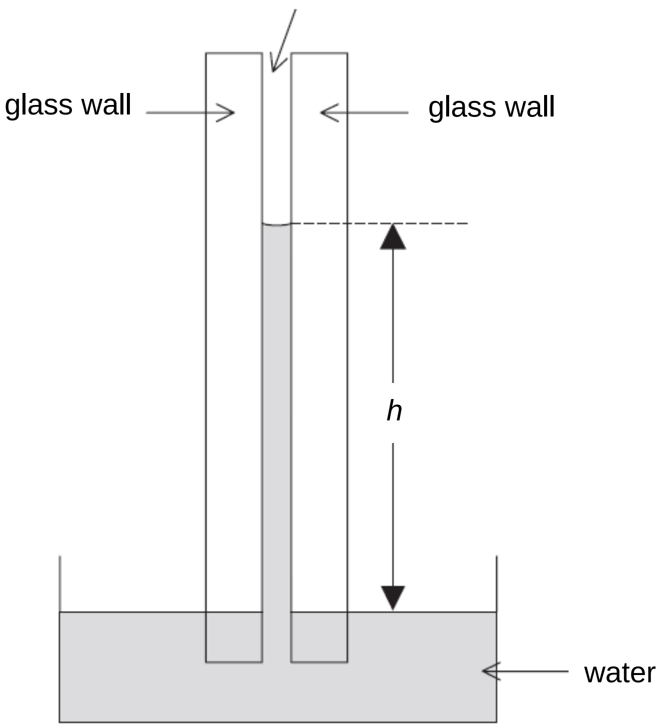


Fig. 8.1
(not to scale)

(a) The height *h* of the water column for a particular capillary tube was measured as the temperature of water θ was varied. Fig. 8.2 shows the data collected.

θ / °C	*h* / cm
30	14.0
40	13.2
50	12.5
60	11.5
70	10.9
80	10.0

Fig. 8.2

Fig. 8.3 shows the variation with temperature θ of height h.

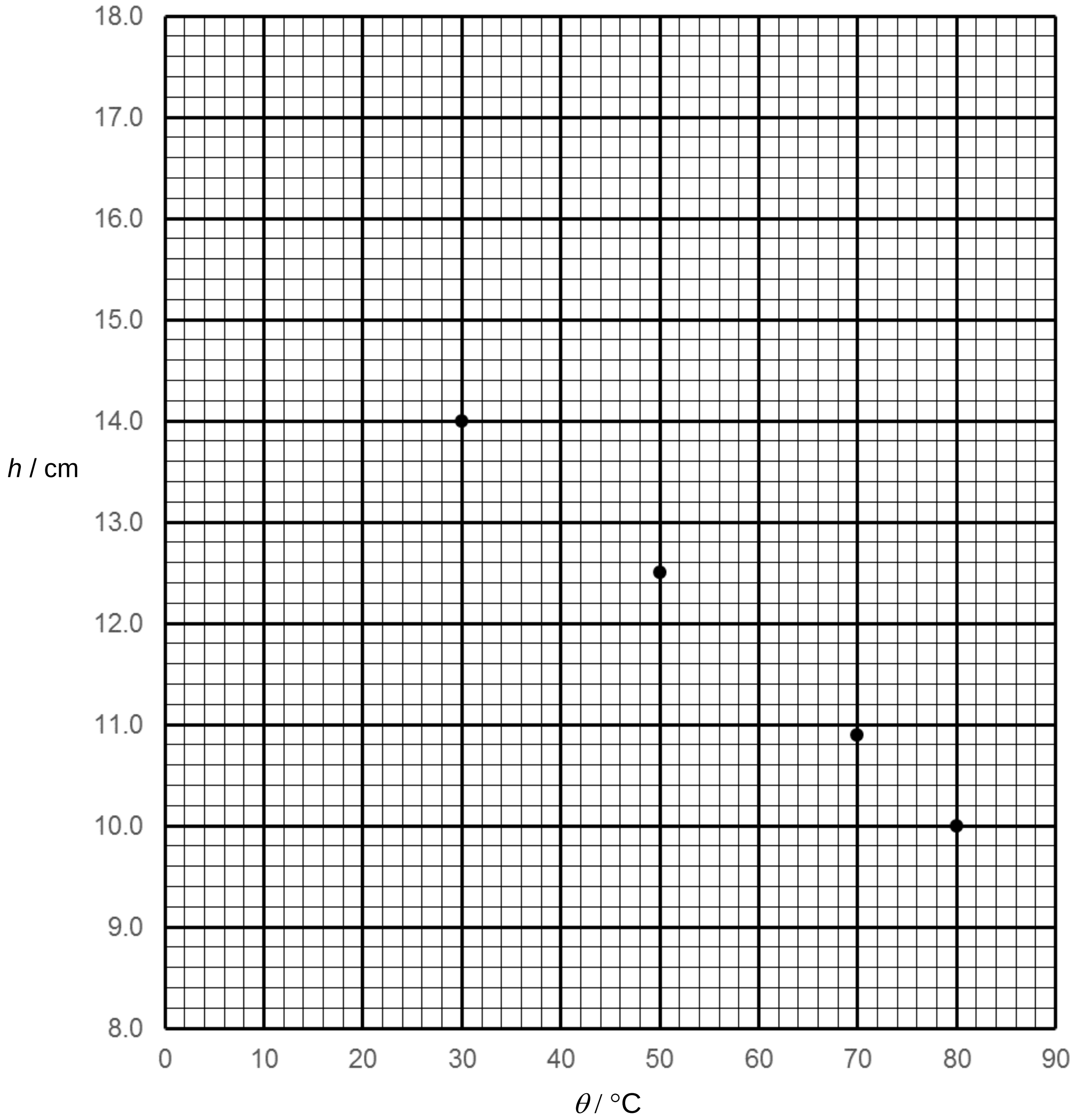


Fig. 8.3

(i) On Fig. 8.3, plot the points for θ = 40 °C and θ = 60 °C. Draw a line of best fit through the data points. [2]

(ii) Using Fig 8.3, determine the height h_0 of the water column when the temperature is 0 °C.

h_0 = ...cm [1]

(iii) It is suggested that the relationship between θ and h is

$$\frac{h}{h_0} = 1 - k\theta$$

where k is a constant.

Explain why the results of this experiment supports the relationship suggested.

....

....

....

.... [3]

(iv) Using the line drawn in **(a)(i)**, determine the value of k, including its units.

k = ... [3]

(b) The experiment is repeated using capillary tubes with bores of different radii *r* but keeping the water temperature constant. Fig. 8.4 shows the variation with $\frac{1}{r}$ of height *h* for a water temperature of 20 °C.

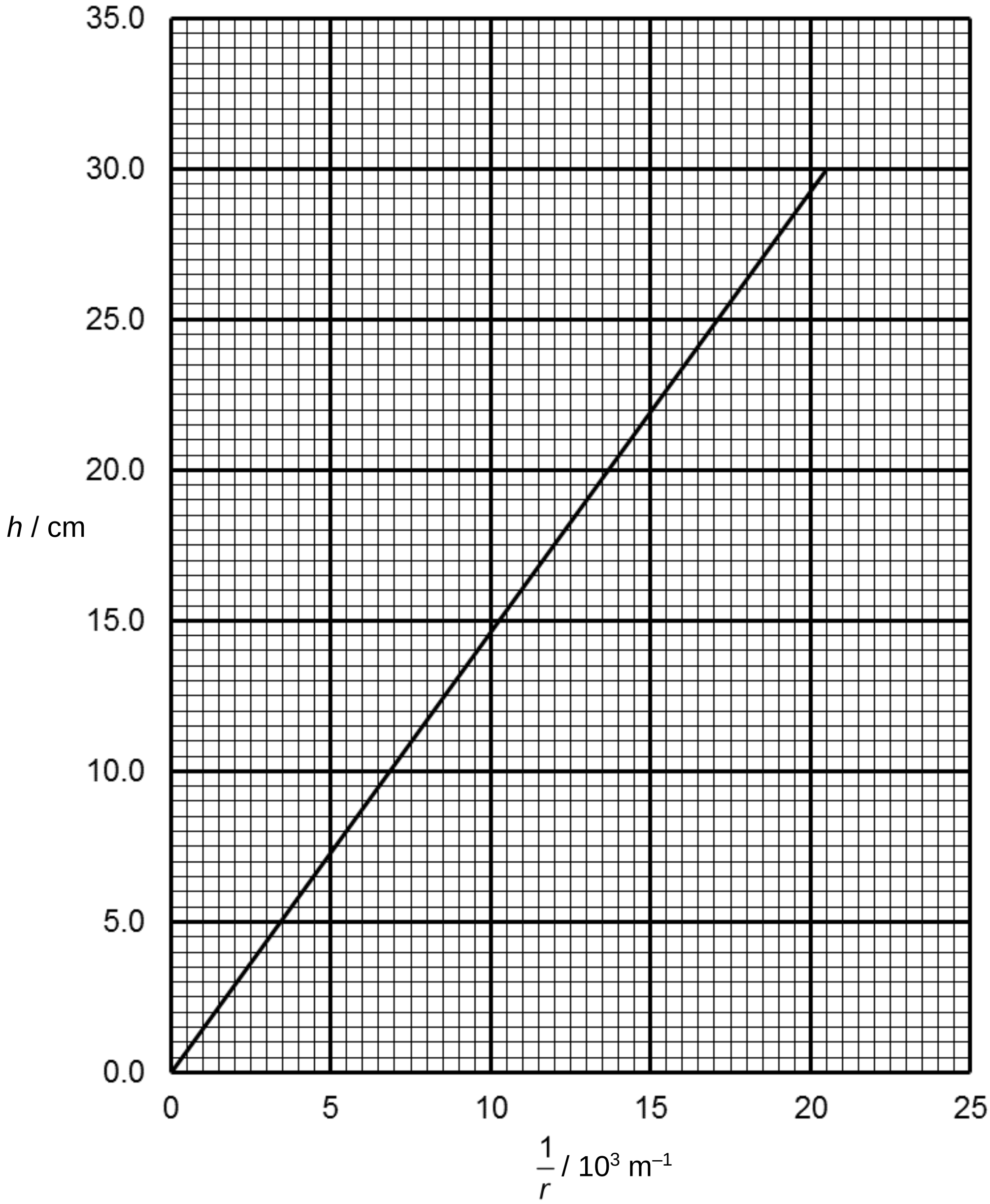


Fig. 8.4

(i) Use Fig. 8.4 to estimate the radius of the bore of the tubes in a 25-metre tall tree, which will enable water to be raised by capillary action from ground level to the top of the tree.

radius = ... m [3]

(ii) State one assumption made in your estimation in **(b)(i)**.

....

.... [1]

(iii) Comment on your answer obtained in **(b)(i)**.

....

....

.... [2]

(c) The other means of moving water up a tree is to create a low pressure in the bore of the tubes in the tree.

(i) Suggest how low pressure can be created in the bore of the tubes in a tree.

....

.... [1]

(ii) Using the following data, calculate the height which water can be moved up a tree via low pressure in the bore of the tubes.

Atmospheric pressure = 101 kPa

Pressure in the bore of the tubes in the tree = 7.8 kPa

Density of water = 1000 kg m^{-3}

height = ... [2]

(iii) Suggest and explain how the height in **(c)(ii)** will change during a hot day.

....

....

.... [2]