

<b>Name</b>	<b>Class</b>	<b>Index Number</b>
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**PIONEER JUNIOR COLLEGE  
JC2 Preliminary Examination**

**PHYSICS  
Higher 1**

**8866/02**

Paper 2 Structured Questions

16 September 2016

**2 hours**

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

**READ THESE INSTRUCTIONS FIRST**

Write your name, class and index number 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.

**Section A**

Answer **all** questions.

**Section B**

Answer any **two** 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.

<b>For Examiner's Use</b>			
<b>Section A</b>			
<b>1</b>		/	<b>5</b>
<b>2</b>		/	<b>12</b>
<b>3</b>		/	<b>7</b>
<b>4</b>		/	<b>6</b>
<b>5</b>		/	<b>10</b>
<b>Section B</b>			
<b>6</b>		/	<b>20</b>
<b>7</b>		/	<b>20</b>
<b>8</b>		/	<b>20</b>
<b>Total</b>		/	<b>80</b>

This document consists of **24** printed pages.

**Data**

speed of light in free space,	$c = 3.00 \times 10^8 \text{ ms}^{-1}$
elementary charge,	$e = 1.60 \times 10^{-19} \text{ C}$
the Planck constant,	$h = 6.63 \times 10^{-34} \text{ Js}$
unified atomic mass constant,	$u = 1.66 \times 10^{-27} \text{ kg}$
rest mass of electron,	$m_e = 9.11 \times 10^{-31} \text{ kg}$
rest mass of proton,	$m_p = 1.67 \times 10^{-27} \text{ kg}$
acceleration of free fall,	$g = 9.81 \text{ ms}^{-2}$

**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,	$p = \rho gh$
resistors in series,	$R = R_1 + R_2 + \dots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \dots$

## Section A

Answer **all** the questions in this section.

- 1 (a) Explain the difference between a *random error* and a *systematic error*.

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

- (b) The work done  $W$  on a system of ideal gas contained in a vessel is defined by the equation

$$W = \frac{qr^4(p_1 - p_2)}{h},$$

where radius of cross-section area of vessel,  $r = (2.03 \pm 0.03)$  mm

pressure,  $p_1 = (125 \pm 2)$  kPa

pressure,  $p_2 = (105 \pm 2)$  kPa

height of vessel,  $h = (160 \pm 8)$  mm

and  $q$  is a dimensionless constant of value  $1 \times 10^6$ .

Express the result of  $W$ , together with its associated uncertainty to the appropriate number of significant figures.

$W =$  ..... Pa m<sup>3</sup> [3]

2 (a) Define *work done*.

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

(b) Fig. 2.1 shows a tank filled with water. An object of mass 40 g is released from rest at the bottom of the tank. A force  $U$ , of constant magnitude 0.50 N, acts on the object upwards, causing it to move upwards. When the object is at a height of 10 cm from the bottom of the tank, it has an instantaneous velocity  $v$ . It is assumed that there are no drag forces acting on the object by the water.

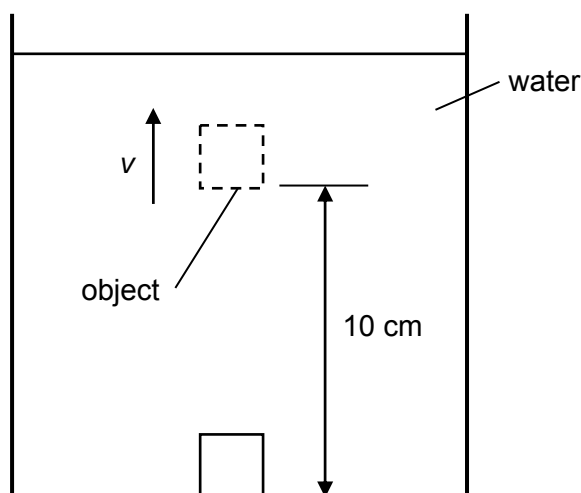


Fig. 2.1

(i) Determine the work done on the object due to the force  $U$ .

work done = ..... J [1]

(ii) Hence, determine the value of  $v$  using the principle of conservation of energy.

$v =$  .....  $\text{m s}^{-1}$  [2]

- (iii) In practice, there are drag forces acting by the water against the object as it moves upwards.

Discuss how the value of  $v$  in (b)(ii) will be affected in this situation.

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

- (c) The object in the tank of water continues to move upwards at constant velocity  $v'$ , as shown in Fig. 2.2. The force  $U$  remains constant, while there is a drag force  $D$  that resists the motion of the object due the viscosity of the water.

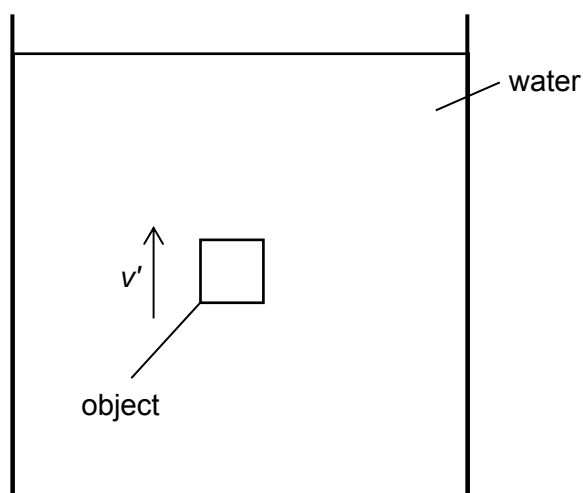


Fig. 2.2

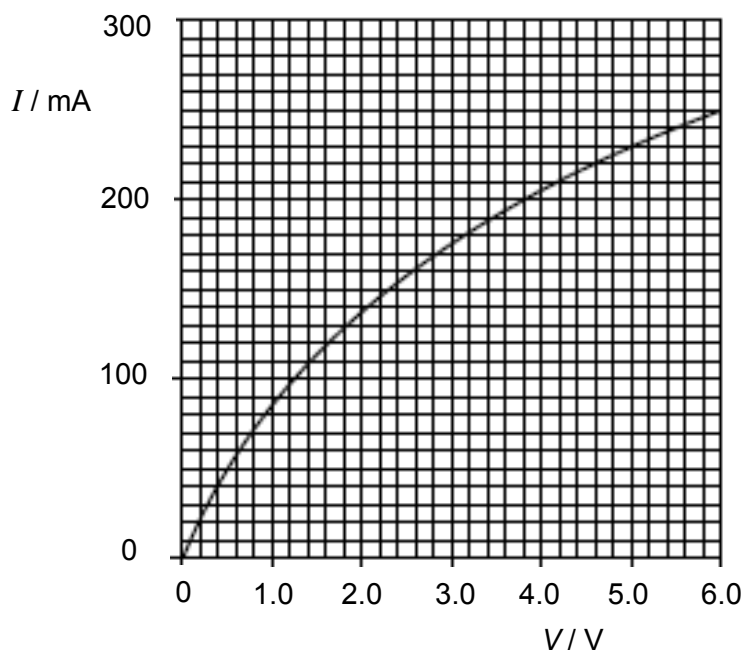
- (i) On Fig. 2.2, draw and label the forces acting on the object. [2]
- (ii) Determine the magnitude of  $D$ .

$$D = \dots\dots\dots \text{ N } [1]$$

- (iii) Discuss whether the object is in translational equilibrium.

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

- 3 (a) Fig. 3.1 shows the  $I$ - $V$  characteristics of a 6.0 V, 1.5 W filament lamp.



**Fig. 3.1**

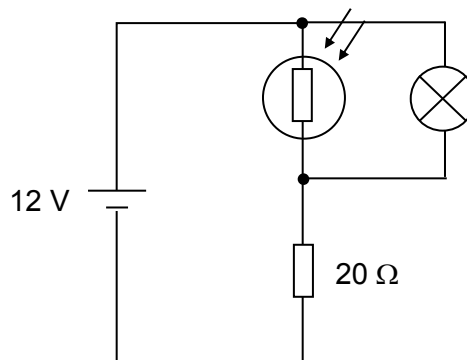
- (i) Explain how Fig. 3.1 shows that the resistance of the lamp increases as the potential difference across the lamp increases.

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

- (ii) Using microscopic terms, explain why resistance of filament lamp increases when the potential difference across the lamp increases.

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

- (b) A student designs a circuit for a night light using a 6.0 V, 1.5 W filament lamp with a constant resistance of  $24\ \Omega$ , and a light dependent resistor (LDR), as shown in Fig. 3.2.



**Fig. 3.2**

The LDR has a resistance of  $10\ \Omega$  in daylight and increases to  $1000\ \Omega$  in the dark.

- (i) Using Fig. 3.2, explain why the lamp will not be able to attain normal working conditions in daylight.

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

- (ii) Show that the resistance of the LDR is  $120\ \Omega$  in order for the lamp to be under normal working conditions.

[2]

- 4 (a) On Fig. 4.1, sketch the magnetic flux pattern due to two long parallel wires carrying currents in opposite directions.

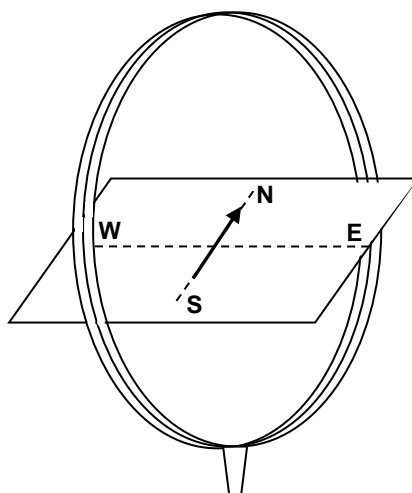


**Fig. 4.1**

[2]

- (b) Fig. 4.2 shows a flat circular coil arranged in a vertical plane at the Equator. The axis of the coil points in the East-West direction, and the coil has 60 turns and a diameter of 14.0 cm. A compass, which is in a horizontal plane, has its pivot coincide with the centre of the coil. Initially no current flows through the coil and the compass points towards the North.

The Earth's magnetic field is  $50.0 \mu\text{T}$  at the Equator.



**Fig. 4.2**

The magnetic flux density at the centre of a flat circular coil follows the expression

$$B = \frac{\mu_0 NI}{2R},$$

where  $N$  is the number of turns of the coil;

$I$  is the current through the coil;

$R$  is the radius of the coil;

and  $\mu_0$  is the permeability of free space of value  $4\pi \times 10^{-7} \text{ H m}^{-1}$ .



A current of 100 mA flows in a clockwise direction in the coil as viewed from the West.

Determine

- (i)  $B_c$ , the magnetic flux density at the centre of the coil, due to the current in the coil only,

$$B_c = \dots\dots\dots \text{ T } [1]$$

$$\text{direction} = \dots\dots\dots [1]$$

- (ii)  $B_R$ , the resultant magnetic flux density at the centre of the coil.

$$B_R = \dots\dots\dots \text{ T } [1]$$

$$\text{direction} = \dots\dots\dots [1]$$

- 5 The period  $T$  of a satellite in a circular orbit of radius  $r$  around a body of mass  $M$  is given by the expression

$$T^2 = \frac{4\pi^2}{GM} r^3,$$

where  $G$  is the gravitational constant, and has a value of  $6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$ .

(a) Fig. 5.1 contains some of the data for the major moons of Saturn.

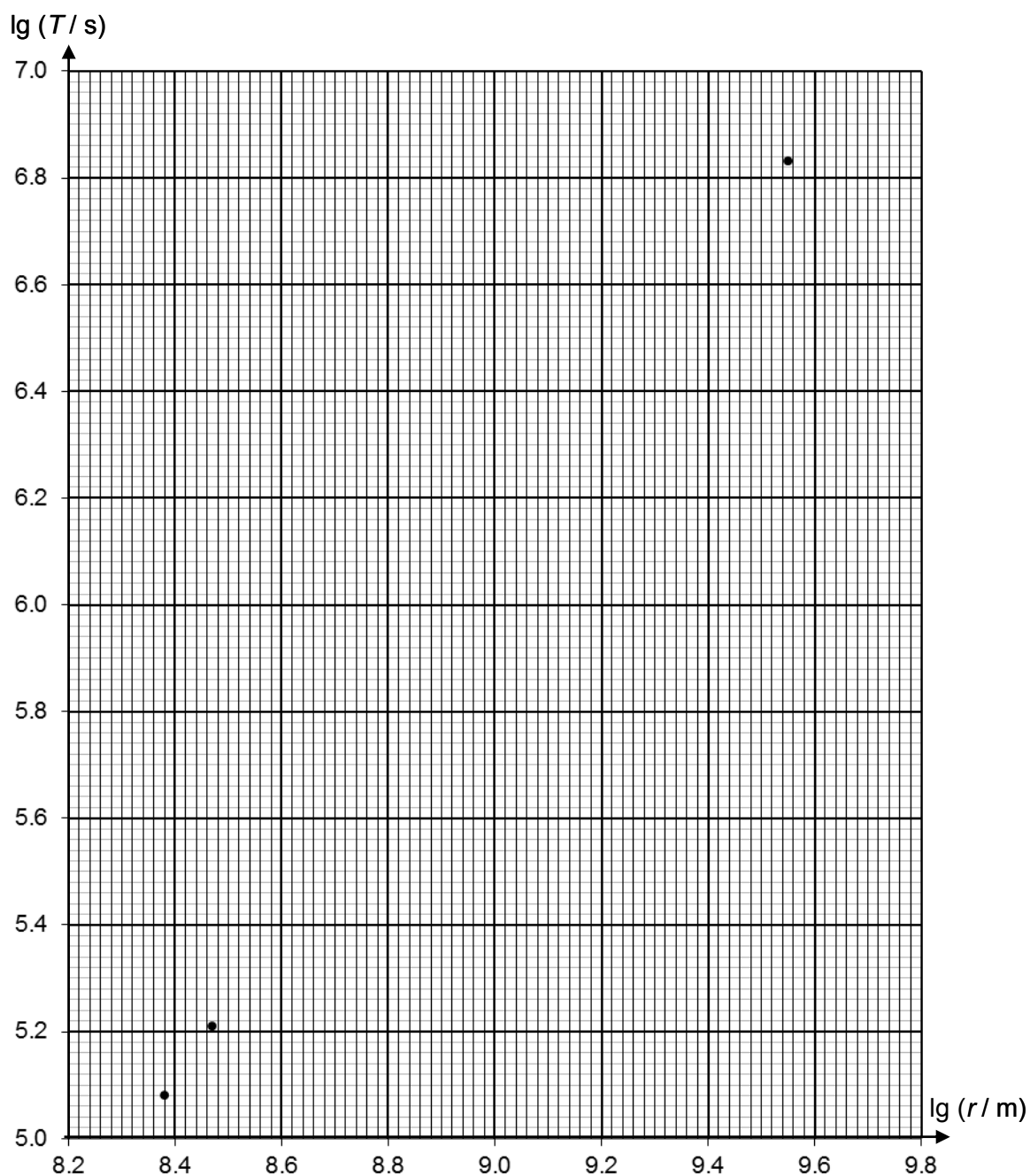
moon	period $T / 10^6 \text{ s}$	mean distance from centre of Saturn $r / 10^9 \text{ m}$	$\lg (T / \text{s})$	$\lg (r / \text{m})$
Enceladus	0.121	0.238	5.08	8.38
Tethys	0.164	0.295	5.21	8.47
Rhea	0.389	0.527		
Titan	1.38	1.22		
Lapetus	6.83	3.56	6.83	9.55

**Fig. 5.1**

Complete Fig. 5.1 for the moons Rhea and Titan.

[2]

- (b) Fig. 5.2 shows a graph representing the variation of  $\lg (T / \text{s})$  with  $\lg (r / \text{m})$  for the moons of Saturn, with some of the data from Fig. 5.1 plotted.



**Fig. 5.2**

On Fig. 5.2,

- (i) plot the points corresponding to the moons Rhea and Titan,
- (ii) draw the line of best fit for all the points.

[2]

(c) Determine the gradient of the graph in Fig. 5.2.

gradient = ..... [2]

(d) Scientists were able to determine the mass of planets in the Solar System through studying the orbits of their moons.

(i) Using Fig. 5.2, determine the mass of Saturn.

mass = ..... kg [2]

(ii) A student studying the orbits of the moons of Saturn decides to determine the mass of Saturn with the orbital radius and period of Titan only.

Discuss one disadvantage of using this method as compared to (d)(i).

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

## Section B

Answer **two** of the questions in this section.

- 6 (a) State *Newton's second law of motion*.

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

- (b) Fig. 6.1 shows a car connected to a trailer using a tow bar. The car and trailer weigh 2000 kg and 1000 kg respectively, and the tow bar can withstand a maximum load of 20 kN. The magnitude of the resistive force on the car is 2.6 kN and on the trailer is 1.3 kN.

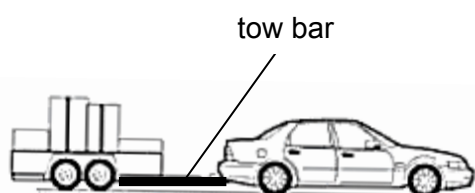


Fig. 6.1

Determine the maximum forward thrust that can be delivered by the engine without breaking the tow bar.

maximum thrust = ..... N [3]

- (c) The car now pulls the trailer from rest up a slope of  $20^\circ$  with an acceleration of  $3.0 \text{ m s}^{-2}$  as shown in Fig. 6.2. The resistive force on the car and trailer remains constant.

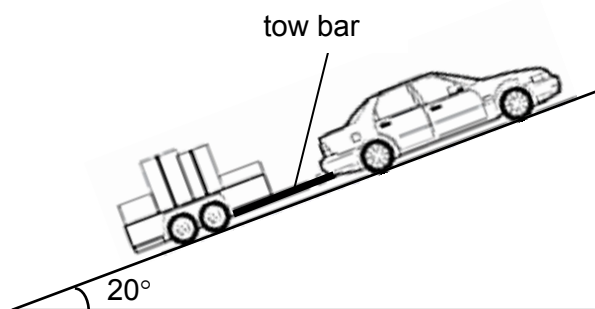


Fig. 6.2

- (i) On Fig. 6.3, draw a free body diagram of the forces acting on the trailer, labelling the forces clearly.

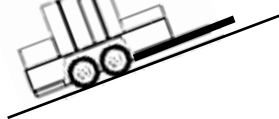


Fig. 6.3

- (ii) Calculate the tension in the tow bar.

[1]

tension = ..... N [2]

(iii) After moving a distance of 150 m up the slope, the tow bar suddenly snaps.

Determine

1. the magnitude of the acceleration of the trailer at this instant,

acceleration = .....  $\text{m s}^{-2}$  [2]

2. the time taken for the trailer to stop momentarily,

time = ..... s [2]

3. the time taken for the trailer to move back to the bottom of the slope from the instant the tow bar snapped.

time = ..... s [3]

- (iv) On Fig. 6.4, sketch the variation with time  $t$  of the velocity,  $v$ , of the trailer from the instant the tow bar snaps to when it reaches the bottom of the slope. Take  $t = 0$  s to be the instant when the tow bar snaps. Label all values on the axes clearly.

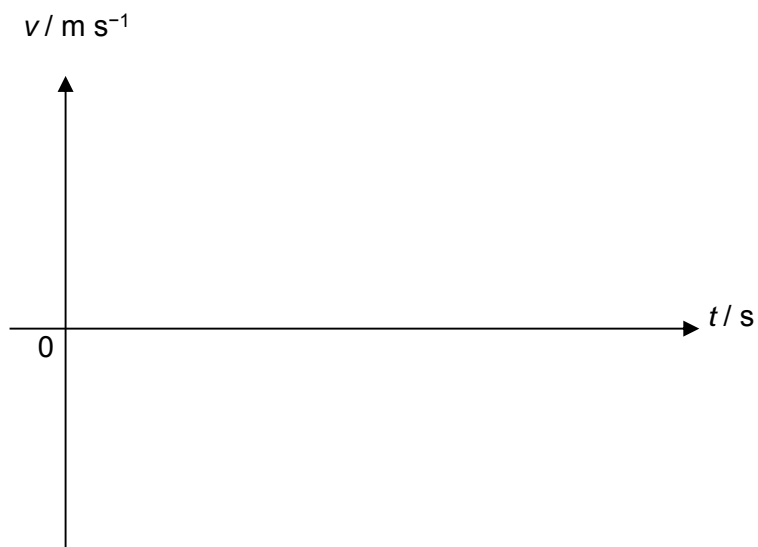


Fig. 6.4

[3]

- (v) The trailer finally hits a wall at a speed of  $15 \text{ m s}^{-1}$  and comes to rest. The impact lasts for  $0.10 \text{ s}$ .

Determine the magnitude of the impact force on the trailer.

force = ..... N [3]



7 (a) State the *principle of superposition*.

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

(b) Fig. 7.1 shows two loudspeakers P and Q connected to a signal generator, emitting sound of a single frequency. A person walks in the direction from O to Y. The line OY is at a distance  $D$  from the loudspeakers and point O is equidistant from loudspeakers P and Q.

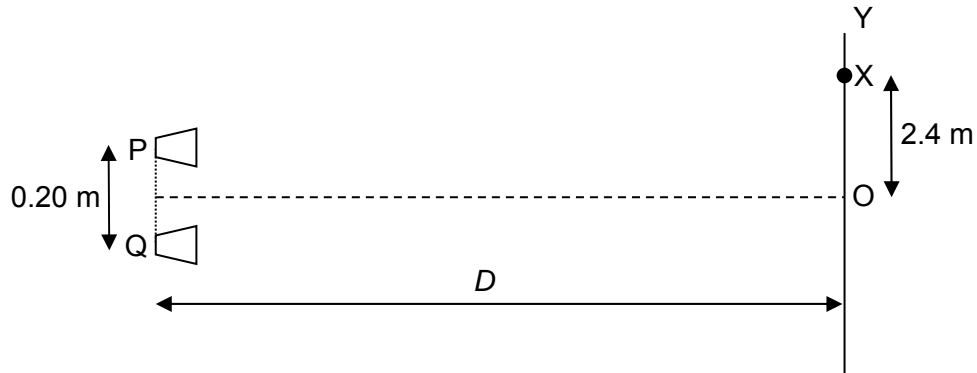


Fig. 7.1

The sound waves emitted by P and Q have displacements  $x_P$  and  $x_Q$  respectively at the point X. Fig. 7.2 shows the variation with time  $t$  of each of these displacements. Point X is the position of the first minimum heard from point O.

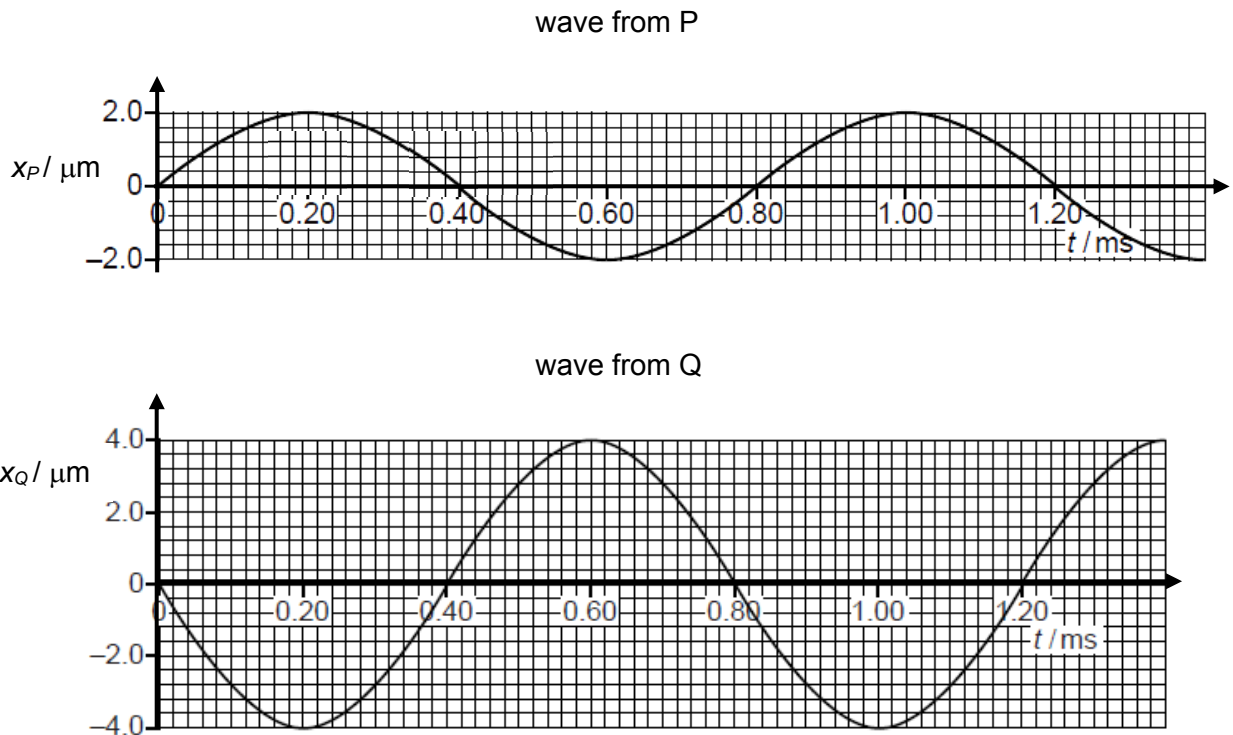


Fig. 7.2

- (i) State and explain whether the two waves are coherent.

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

- (ii) Explain why the sound heard at X is a minimum and is of non-zero intensity.

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

- (iii) Using values from Fig. 7.2, calculate the wavelength of the sound waves emitted from the loudspeakers. The speed of sound is  $330 \text{ m s}^{-1}$ .

wavelength = ..... m [2]

- (iv) Maximum intensity of sound is heard at point O. The loudspeakers are 0.20 m apart and the distance OX is 2.4 m.

1. Calculate the distance  $D$  from the loudspeakers to the line OY.

$D =$  ..... m [3]

2. State an assumption made in (b)(iv)1.

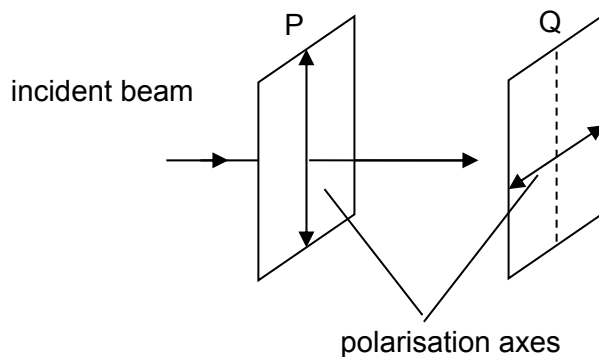
..... [1]

- (v) The sound reaching point O from source P alone has intensity  $I$ . The amplitudes of the sound waves from the two loudspeakers P and Q are assumed to remain constant along the line OY.

Determine the intensity, in terms of  $I$ , of the sound at point O.

intensity = .....  $I$  [3]

- (c) Two sheets of polaroid P and Q are placed closed to each other. Their directions of polarisation are perpendicular to each other, as shown in Fig. 7.3.



**Fig. 7.3**

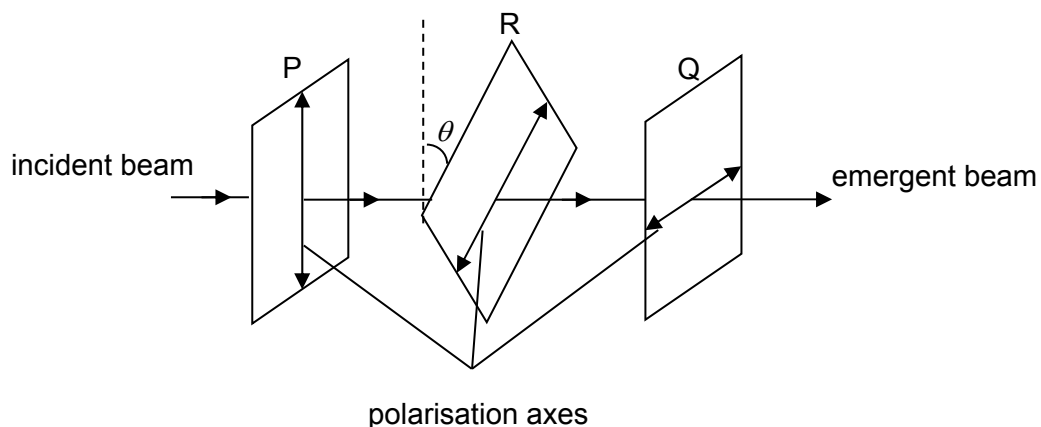
A parallel beam of light passes through polaroid P. The beam, after passing through polaroid P, has amplitude  $A$  and intensity  $I$ .

The beam then passes through polaroid Q.

- (i) State the intensity of the light emerging from polaroid Q.

intensity = .....  $I$  [1]

- (ii) A polaroid R is placed in between polaroid P and Q as shown in Fig. 7.4. Polaroid R has a polarisation axis that is at an angle  $\theta$  with respect to polarisation axis of polaroid P.



**Fig. 7.4**

1. Explain why there is a non-zero intensity of light emerging from polaroid Q.

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

2. Calculate the angle  $\theta$  required for the emergent light beam from polaroid Q to have a resultant amplitude of  $\frac{1}{2}A$ .

angle  $\theta =$  .....  $^{\circ}$  [3]

- 8 (a) Explain what is meant by *photoelectric effect*.

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

- (b) A photoelectric experiment was conducted to determine the variation of stopping potential  $V_s$  with frequency  $f$  of incident electromagnetic radiation on metal A. Five data points were collected and plotted as shown in Fig. 8.1.

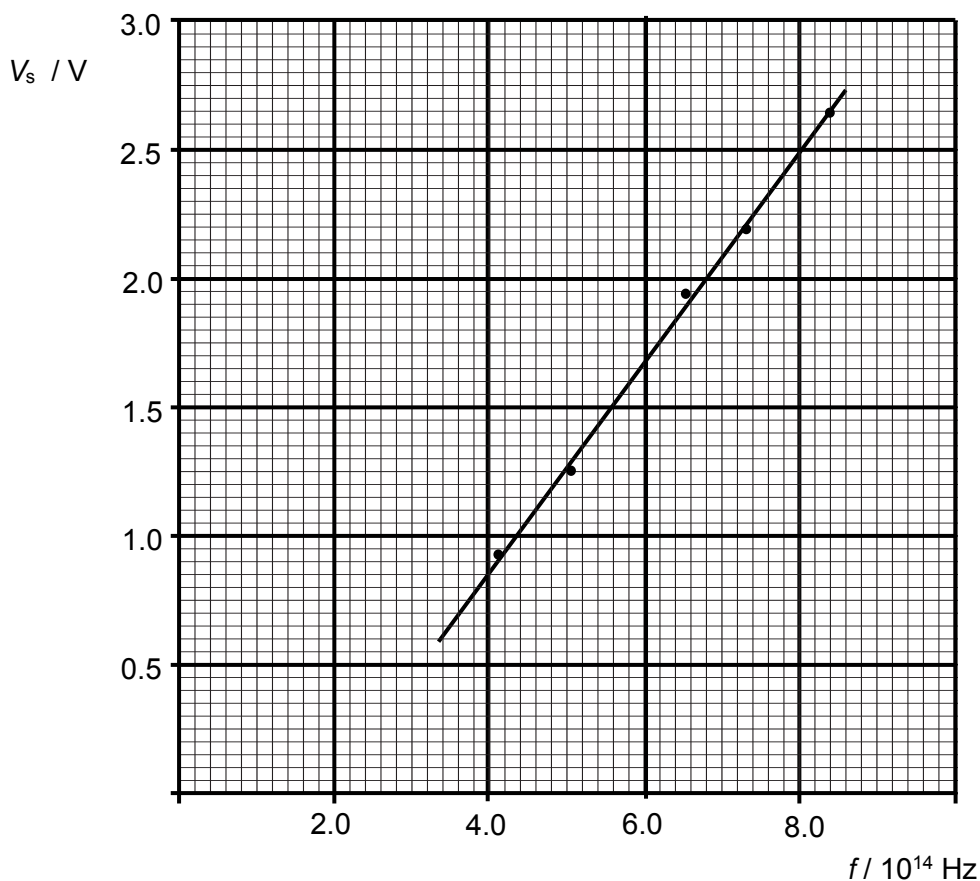


Fig. 8.1

Using Fig. 8.1, calculate

- (i) the Planck constant,

Planck constant = ..... J s [2]

(ii) the work function energy of metal A,

work function energy = ..... J [2]

(iii) the deBroglie wavelength associated with the most energetic electron emitted in this experiment.

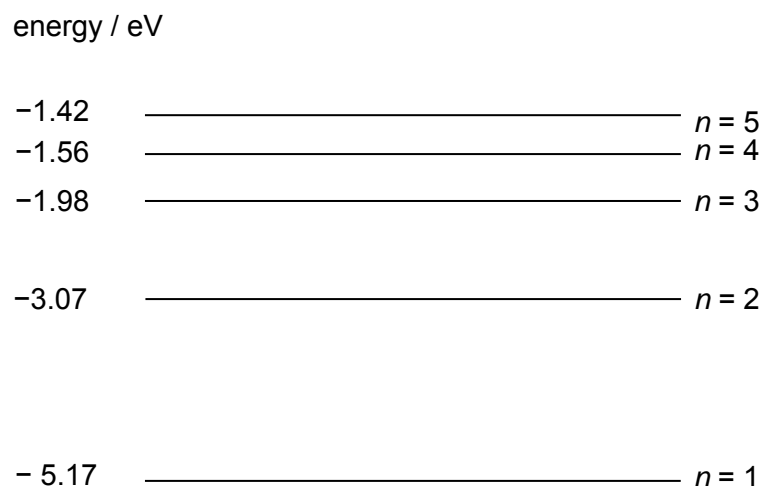
wavelength = ..... m [3]

(c) Explain whether your answer to **b(iii)** is affected by the intensity of electromagnetic radiation incident on the metal surface.

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

(d) On Fig. 8.1, sketch another possible graph for the results obtained if another metal of lower work function energy is used. Label this graph B. [2]

(e) Fig. 8.2 shows the energy levels of sodium gas.



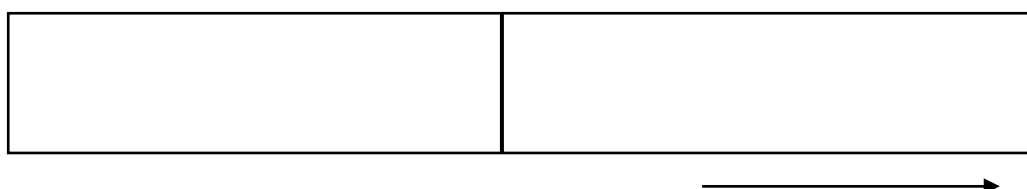
**Fig. 8.2**

The cool sodium gas at low pressure is bombarded by incoming electrons with kinetic energy of 3.70 eV.

- (i) On Fig. 8.2, draw arrows to show all the possible transitions that will be observed if all the sodium atoms are at ground state initially. [2]
- (ii) Determine the range of kinetic energy of the incoming electrons after they have excited the sodium atoms.

range = ..... eV [2]

- (iii) Fig. 8.3 shows the emission line due to the transition from  $n = 2$  to  $n = 1$ . On Fig. 8.3, sketch the positions of all the other possible emission lines observed.



**Fig. 8.3**

[2]

- (f) The cool sodium gas is now bombarded by incoming photons of energy of 3.70 eV instead. State and explain the number of emission lines observed, if any.

.....

.....

..... [1]