CATHOLIC JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS
Higher 1

CANDIDATE NAME			
CLASS	2T	**INDEX NUMBER**	

PHYSICS

8866/02

Paper 2

2014

2 hours

Additional Materials: Answer Paper

READ THESE INSTRUCTIONS FIRST

Write your index number and name on all the work you hand in.
Write in dark blue or black pen on both sides of the paper. **[PILOT FRIXION ERASABLE PENS ARE NOT ALLOWED]**
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. **Circle the 2 questions** that you answered in the table below.

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

FOR EXAMINER'S USE	
SECTION A (40 MARKS)	
1	**/ 7**
2	**/ 6**
3	**/10**
4	**/ 7**
5	**/10**
SECTION B (40 MARKS) *CIRCLE THE 2 QUESTIONS ANSWERED.*	
6	**/ 20**
7	**/ 20**
8	**/ 20**
TOTAL	**/80**

This document consists of **21** printed pages and **1** blank page.

[Turn over]

PHYSICS 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}
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
acceleration of free fall,	g	=	9.81 m s^{-2}

PHYSICS FORMULAE:

uniformly accelerated motion,	s	=	$u t + \frac{1}{2} a t^2$
	v^2	=	$u^2 + 2 a s$
work done on / by a gas,	W	=	$p \Delta V$
hydrostatic pressure	p	=	$\rho g h$
resistors in series,	R	=	$R_1 + R_2 + ...$
resistors in parallel,	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + ...$

Section A

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

1 **(a)** The acceleration of free fall g can be estimated through the period of oscillation T of a simple pendulum of length L. The relationship between these quantities is:

$$T = 2\pi\sqrt{\frac{L}{g}}$$

In an experiment, the time taken for a pendulum of length (0.850 ± 0.001) m to complete 20 oscillations is measured to be (36.9 ± 0.2) s.

Determine the acceleration of free fall g with its associated uncertainty.

g = ………… ± ………. m s^{-2} **[4]**

(b) Estimate the maximum kinetic energy possessed by a secondary school boy playing on a playground swing. State the reasoning and estimates you have made in your working clearly.

maximum kinetic energy = ……………….. J **[3]**

2 A wind turbine generates electrical energy from the kinetic energy of the wind. Fig. 2.1 shows a cylindrical volume of air which will pass the blades of a wind turbine in unit time.

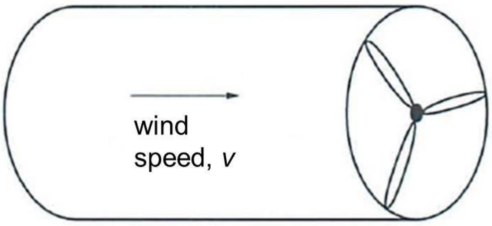

Fig. 2.1

(a) Explain why the input power to the turbine is numerically equal to the kinetic energy of the air contained within this volume.

....

....

.... **[1]**

(b) Show that the power input P to the wind turbine is given by

$$P = 0.5\pi r^2 \rho v^3$$

where r is the radius of the circular area swept, ρ is the density of air and v is the wind speed.

[4]

(c) State one reason why the power output from the wind turbine will always be less than the value predicted by the above equation for a given wind velocity.

....

....

.... **[1]**

3 **(a)** Define *potential difference* between two points on an electric circuit.

....

....

.... **[1]**

(b) A cell of e.m.f. 4.5 V and internal resistance of 0.70 Ω is connected in series with a resistor R, as shown in Fig. 3.1. Resistor R is made of metal wire and the ammeter reads 200 mA.

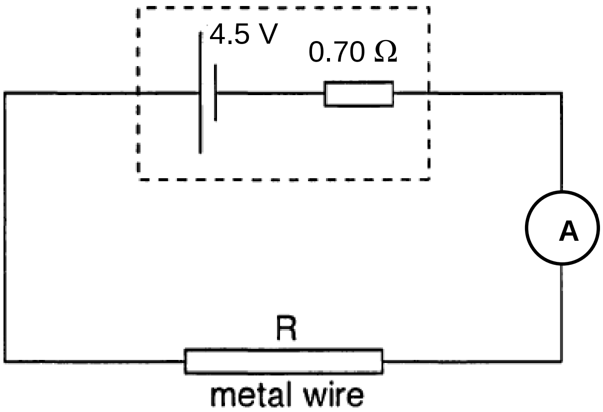

Fig. 3.1

Determine the resistance of R.

resistance of R = ... Ω **[2]**

(c) A second similar cell is now connected in series with the cell in **(b)** and the resistor R. The current in the circuit is 350 mA and the resistance of R changes.

Calculate the new resistance of R.

new resistance of R = ... Ω **[2]**

[Turn over]

(d) The cells in **(c)** are now connected in series with a fixed resistor of resistance 2500 Ω and a thermistor, as shown in Fig. 3.2.

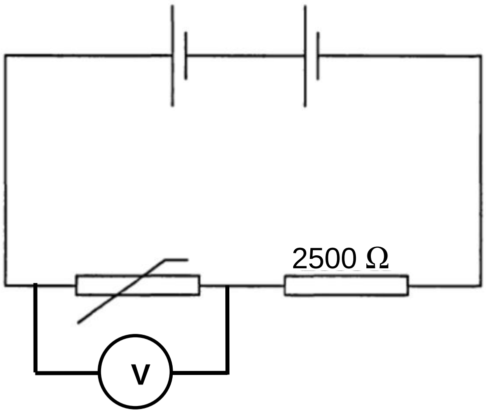

Fig. 3.2

The thermistor has resistance 5000 Ω at 0 °C and 2250 Ω at 20 °C.

(i) Determine the maximum and the minimum values of the readings of the voltmeter as the temperature of the thermistor is varied from 0 °C to 20 °C.
The internal resistance of the cells can be assumed to be negligible and the voltmeter has a very high resistance.

maximum reading = ………… V

minimum reading = ………… V **[2]**

(ii) In one particular application of the circuit shown in Fig. 3.2, it is desired that the potential difference across the **fixed** resistor should range from 3.6 V at 0 °C to 7.2 V at 20 °C.
Determine whether, by substituting a different fixed resistor in the circuit of Fig. 3.2, it is possible to achieve this range of potential.

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.... **[3]**

4 **(a)** Define *magnetic flux density*.

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.... **[2]**

(b) Fig. 4.1 shows a cross-section of a solenoid.

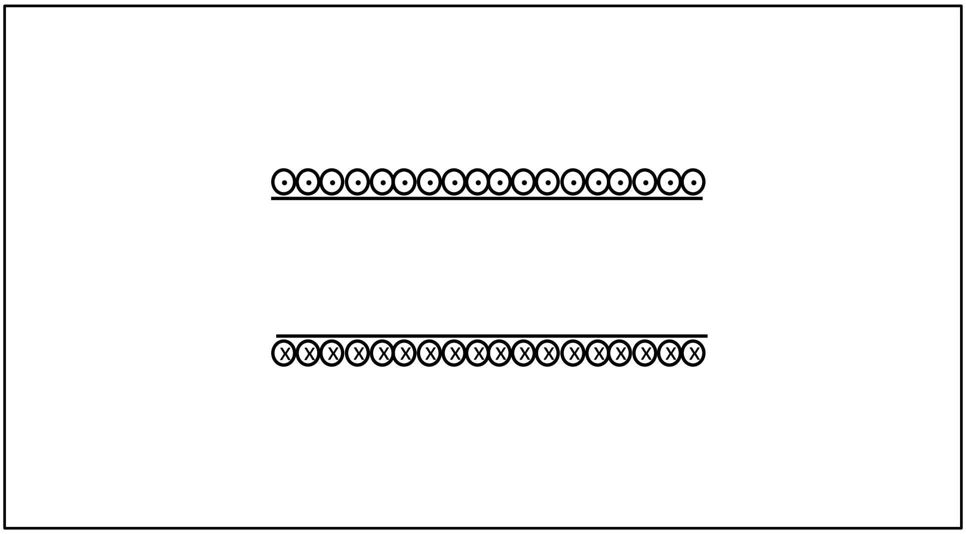

Fig. 4.1

(i) Sketch on Fig. 4.1 the pattern of magnetic field lines which would be obtained when a direct current passes around the solenoid. **[2]**

(ii) A long thin wire is placed at the centre of the solenoid. The wire carries 5.8 A and is oriented at an angle of 12° to the axis of the solenoid.

Calculate the magnetic flux density *B*, given that the magnetic force exerted per unit length on the wire is 0.045 N m^{-1}.

B = ... T **[3]**

5 Ultraviolet-Visible (UV-Vis) Absorption technology can be used to determine the concentration of substance. The components of a UV-Vis absorption spectrometer are shown in Fig. 5.1.

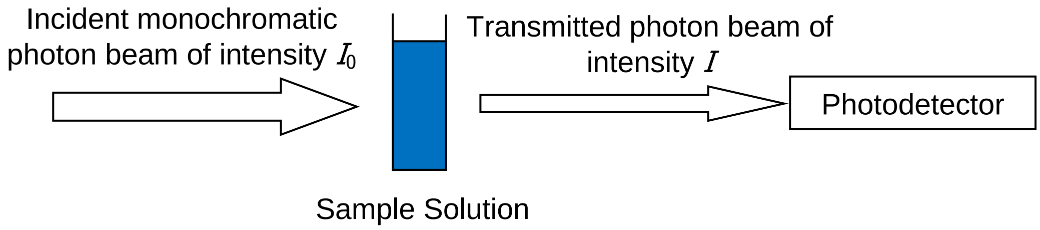

Fig. 5.1

An incident monochromatic photon beam shines through a sample solution. After which, a photodetector measures the intensity of the light after passing through the sample. The intensity of the incident photon beam is I_0 and the intensity of the transmitted photon beam is I.

The extent of how much light of a given wavelength is absorbed is known as the absorbance, *A*. The higher the amount of light absorbed, the higher the absorbance. For an incident photon beam at a fixed wavelength, the absorbance, *A*, is given by

$$A = \ln \frac{I_0}{I}$$

An experiment is conducted to analyse nitrite concentration in water. Generally, an increase in nitrite concentration brings about an increase in absorbance as there are more molecules involved in the absorption of light.

A calibration graph of absorbance *A* against nitrite concentration *c* is plotted and drawn in Fig. 5.2.

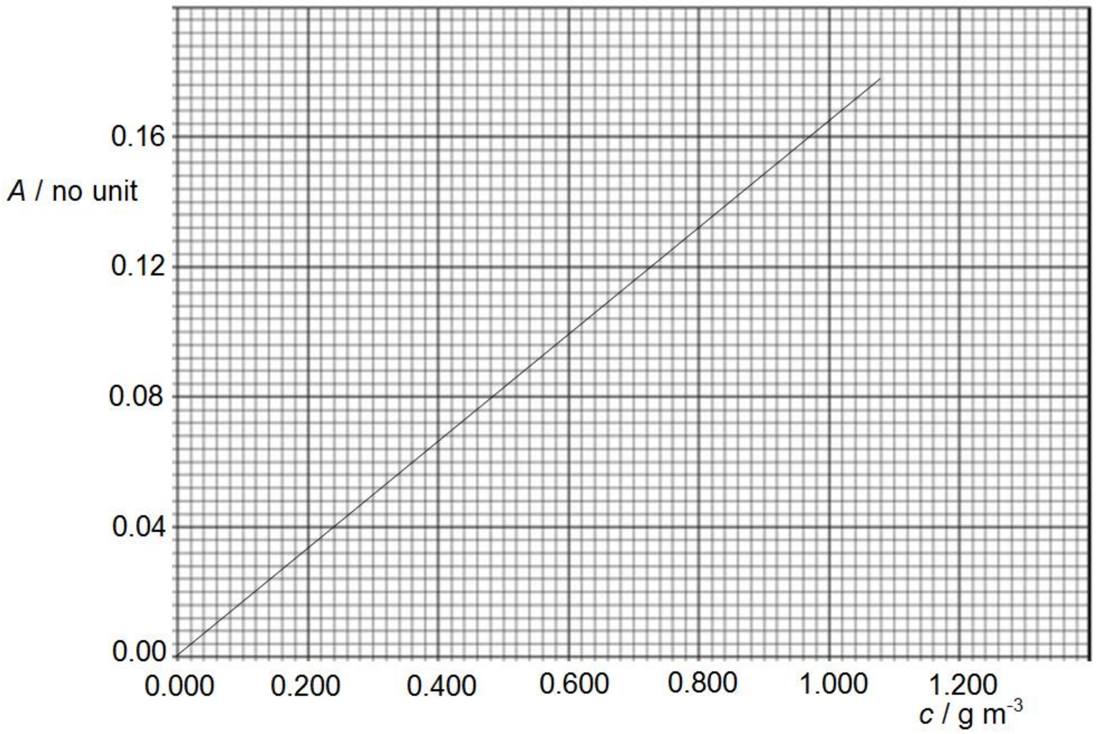

Fig. 5.2

(a) (i) Show that the calibration graph drawn in Fig. 5.2 indicates the relation

$$I = I_0 e^{-kc}$$

where *c* is the nitrite concentration in the sample and *k* is a positive constant.

[2]

(ii) Determine the gradient of the graph drawn in Fig. 5.2.

gradient =………………...... **[2]**

(iii) Hence, state the value and a suitable unit of *k*.

value of *k* =………………......

unit of *k* =………………...... **[1]**

[Turn over]

(b) Following from the equation

$$A = \ln \frac{I_0}{I}$$

We can deduce that $A = \ln I_0 - \ln I.$

The following table in Fig. 5.3 gives some of the numerical details for different values of concentration based on the graph in Fig. 5.2.

c / g m^{-3}	A / no unit	ln (I / mW)	I / mW
0.000	0.000	1.61	5.00
0.040	0.008	1.60	4.95
0.140	0.024	1.59	4.90
0.260	0.044	1.57	4.81
0.400			
0.580	0.096	1.51	
0.800	0.132	1.48	4.39
1.000	0.164	1.45	4.26

Fig. 5.3

(i) Insert values in the spaces to complete the table above. **[2]**

(ii) Complete the graph in Fig. 5.4 using Fig.5.3.

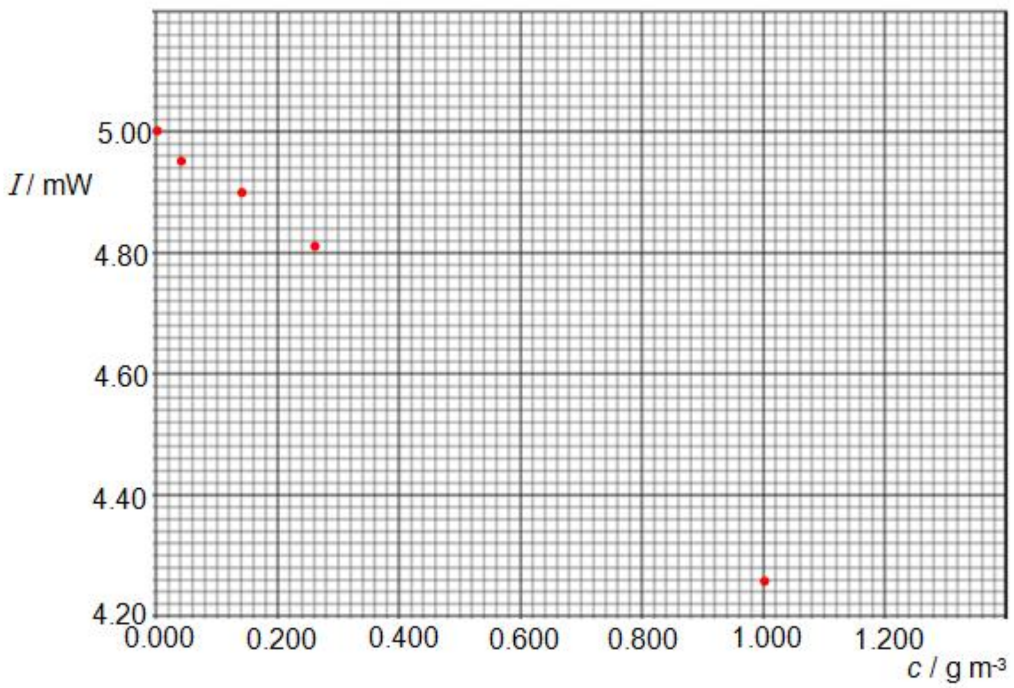

Fig. 5.4 **[3]**

Section B

Answer any **two** questions from this Section in the spaces provided.

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

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.... **[1]**

(b) A squash ball of mass 24 g hits the wall when it reaches its maximum height of 3.2 m. It leaves a racket which is 1.7 m above the ground as seen in Fig. 6.1. The ball is incident with a horizontal velocity of 15 m s^{-1} and rebounds in a horizontal direction with a velocity of 12 m s^{-1}. The ball is in contact with the wall for 0.15 s.

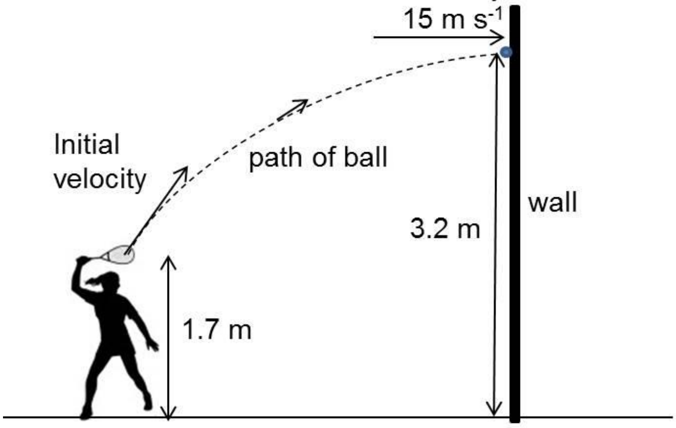

Fig. 6.1

(i) Calculate the initial vertical component of the ball's velocity.

vertical velocity = ……………………. m s^{-1} **[2]**

(ii) Determine the average force exerted on the wall during the ball's collision with the wall.

magnitude of the force = ……………………….. N

direction of force on the wall = ……………………...... **[4]**

[Turn over]

(iii) State and explain whether the collision of the ball with the wall is elastic.

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.... **[1]**

(iv) Explain why the ball does not rebound to the point from where it was hit by the racket.

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.... **[2]**

(c) Define the terms *moment of a force* and draw a sketch to illustrate its meaning.

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.... **[2]**

(d) A rigid bar of mass 500 g is held horizontally by two supports X and Y, as shown in Fig. 6.2.

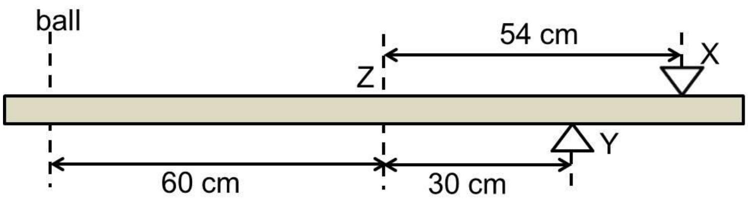

Fig. 6.2

The support X is 54 cm from the centre of gravity Z of the bar and support Y is 30 cm from Z.

A ball of mass 150 g falls vertically onto the bar such that it hits the bar at a distance of 60 cm from Z, as shown in Fig. 6.2. The variation with time *t* of the velocity *v* of the ball before, during and after hitting the bar is shown in Fig. 6.3.

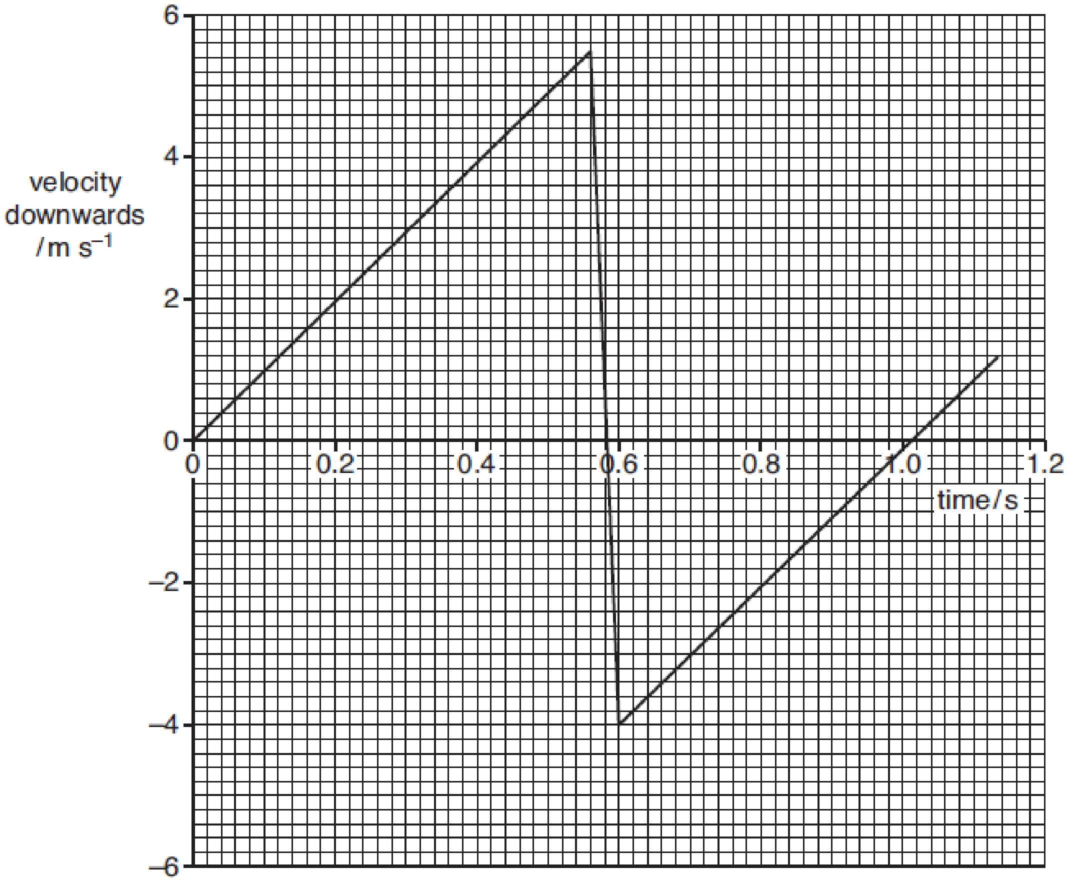

Fig 6.3

For the time the ball is in contact with the bar, use Fig. 6.3

(i) to determine the change in momentum of the ball,

change in momentum = ………………………kg m s^{-1} **[2]**

(ii) to show that the force exerted on the ball by the bar is approximately 36 N.

force = ……………………. N **[1]**

[Turn over]

(e) For the time that the ball is in contact with the bar, use data from Fig. 6.2 and **(d)(ii)** to calculate the force exerted on the bar by

(i) the support X,

force by X = …………………. N **[3]**

(ii) the support Y.

force by Y= …………………… N **[2]**

7 **(a)** Explain, using diagrams, what is meant by the terms below in relation to waves.

(i) progressive wave

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.... **[2]**

(ii) diffraction

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.... **[2]**

(iii) coherence

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[2]

(b) Sound is propagated in air as a longitudinal progressive wave, in which there is a repeated sequence of displacements of the air particles. Fig. 8.1a illustrates nine particles, equally spaced along the line **AB**, in still air.

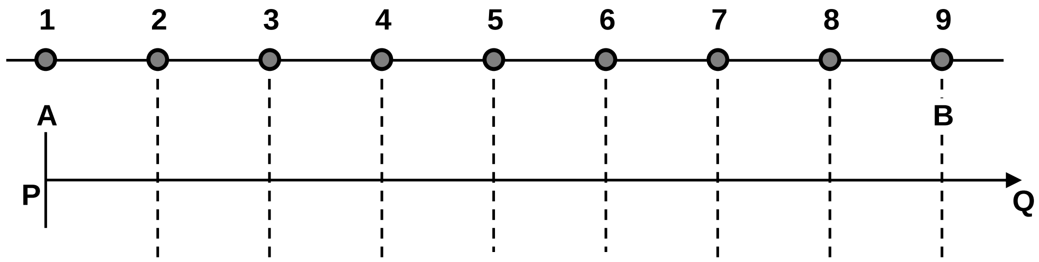

Fig. 7.1a

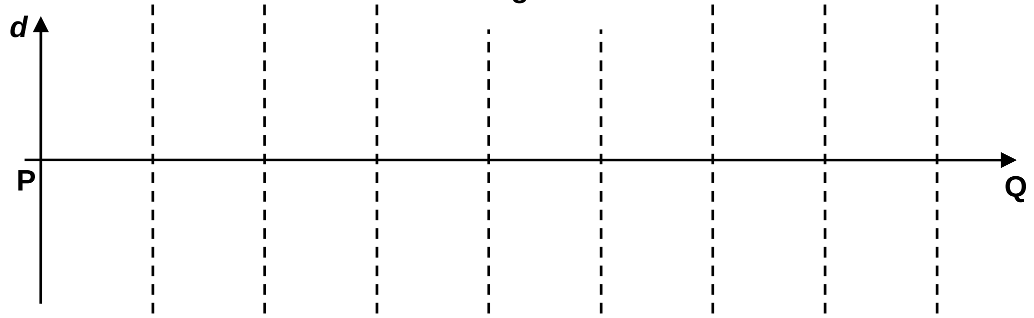

Fig. 7.1b

(i) A sound wave of wavelength equal to the distance between **A** and **B** is sent through the air in the direction of **PQ**. On line **PQ** on Fig. 7.1a, draw the possible positions of the nine particles in the wave relative to their undisturbed positions which they occupy in still air, when the sound wave propagates through the particles. **[1]**

(ii) Using **(b)(i)**, sketch a graph showing how the displacement *d* of the particles from their undisturbed positions vary along **PQ** on Fig. 7.1b. Take direction to the right as positive. **[1]**

(iii) A sound wave can also be described in terms of a repeated sequence of changes in pressure. On Fig. 7.1b, identify, and label with **H,** a point where the pressure is the highest. Justify your answer.

....

....

.... **[2]**

(iv) A loudspeaker, generating a sound wave with a wavelength magnitude equal to AB, and a screen are placed at **A** and **B** respectively. Describe and explain the changes, if any, to Fig. 7.1b over time as compared to the current scenario.

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....

.... **[2]**

(c) A stereo system in a large hall has two identical speakers, S_1 and S_2, 1.2 m apart. The amplitude of the output of each speaker is proportional to the voltage across its terminals. The voltage input to each speaker is adjusted by means of a balance control. The arrangement is shown in Fig. 7.2.

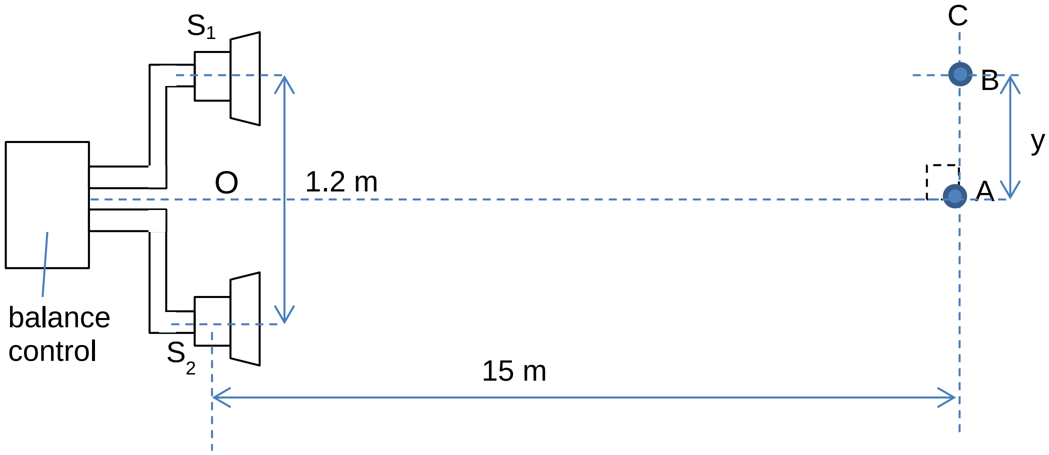

Fig. 7.2 (not to scale)

Initially, the speakers are emitting signals of frequency 1000 Hz which are in phase. The balance control is set such that there is a voltage of 6 V r.m.s. across each speaker. An observer hears a loud sound of intensity I_{max} at A. As he moves along the line AC, 15 m away from the speakers, he observes that the intensity first falls to zero at point B, a distance *y* from A. The speed of sound in air is 330 m s^{-1}.

(i) Determine the distance *y*.

y = ……………. m **[2]**

(ii) Determine the next higher frequency of the speaker such that point B would also be a point of zero intensity.

frequency = ……………. Hz **[3]**

[Turn over]

(iii) With the speakers emitting the original signal frequency of 1000 Hz, the balance control is now adjusted such that the voltages across S_1 and S_2 are 3.0 V r.m.s. and 9.0 V r.m.s. respectively. In terms of I_{max}, determine the new intensity at point B.

intensity = ……………. **[3]**

8 **(a)** Distinguish between *line emission spectrum* and *line absorption spectrum* in terms of
1. how the spectrum appears, and

[1]

2. how the spectrum is formed.

[3]

(b) In a particular experiment, light containing a continuous spectrum of wavelengths from 400 nm to 700 nm is incident on some cool hydrogen gas atoms, as seen in Fig. 8.1.

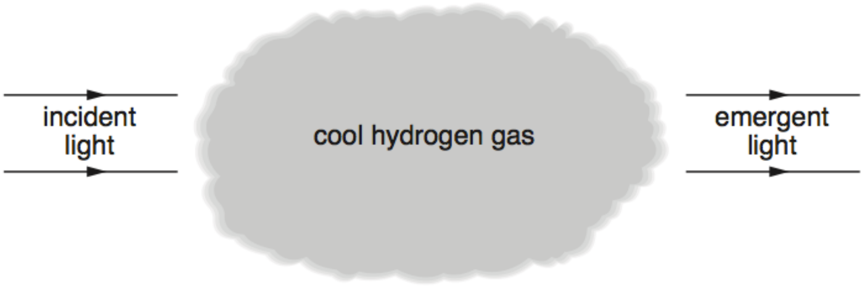

Fig. 8.1

Information regarding the lowest energy levels for the hydrogen atom is illustrated in Fig. 8.2.

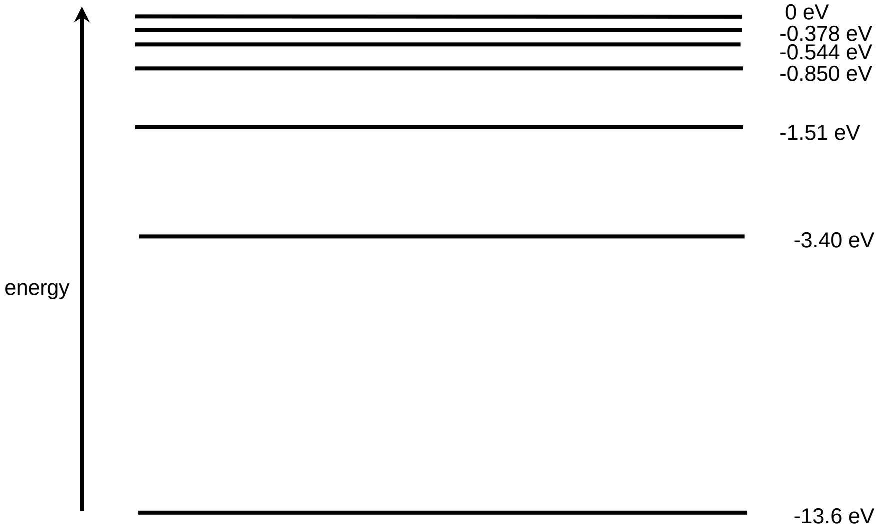

Fig. 8.2

Using suitable calculations, deduce how many dark spectral lines are expected in the emergent light.

number of dark spectral lines = ………………… **[4]**

(c) The emergent light from **(b)** is incident on a light meter, which consists of two electrodes in an evacuated tube. One of the electrodes is photosensitive, emitting electrons when light of a suitable wavelength is incident on it. The other electrode is in a form of a metal gauze, receiving the emitted photoelectrons.

A simple diagram showing the light meter is in Fig 8.3.

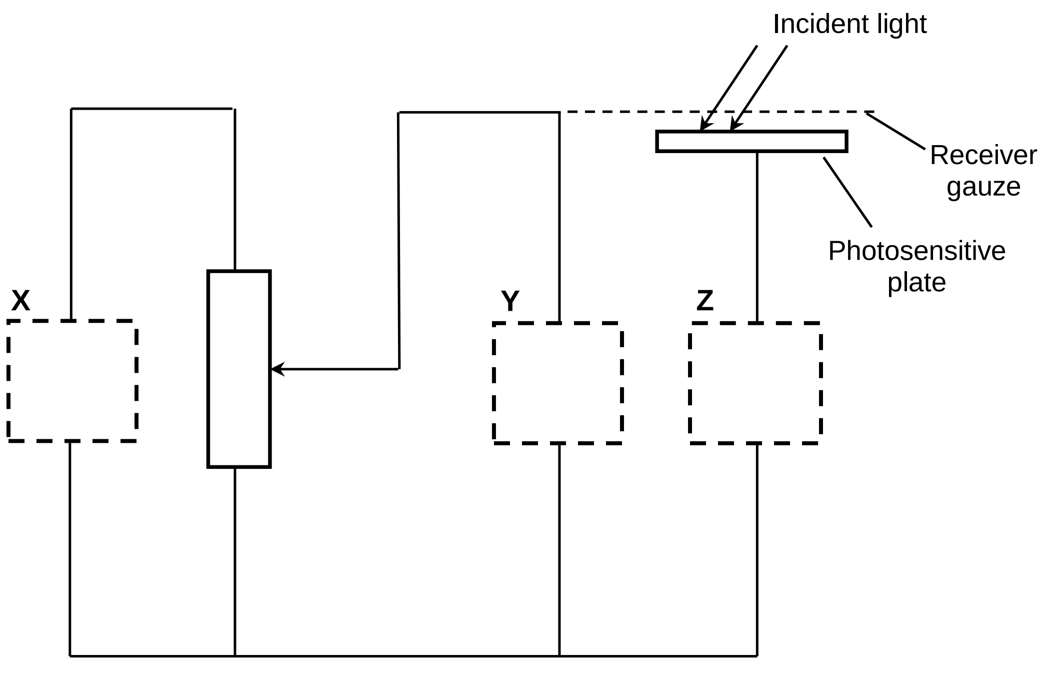

Fig. 8.3

(i) It is known that the dry cell is connected at position X, while the ammeter and voltmeter are connected in two possible positions: Y and Z in Fig 8.3.

Complete the diagram, showing the appropriate connections of the ammeter, voltmeter and a dry cell so as to register a constant ammeter reading no matter how large the emf of the dry cell is. **[4]**

(ii) Students were given a choice of three materials to use as the photosensitive plate. A list of these materials and their respective work functions are summarized in the following table in Fig. 8.4.

Element	Work Function (eV)
P	2.55
Q	4.26
R	5.04

Fig. 8.4

Explain which of the three materials is the best choice for this particular set up. In your reasoning, you should also explain why the other two are not appropriate as well.

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....

.... **[4]**

(iii) The light source is changed to a monochromatic violet laser which delivers a pulse of 10.0 mW for 10.0 ns.

1. Estimate how many photons are present within each pulse.

number of photons = …………………….. **[2]**

2. Assuming that every violet photon from the laser incident on the photosensitive plate is absorbed, calculate the average force exerted on the plate by the violet laser during each pulse.

force = …………………….. N **[2]**

-- End of Paper --

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