CATHOLIC JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS
Higher 1

PHYSICS — 8866/02

Paper 2 — **2014**

Suggested Solutions — **2 hours**

Section A

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.

$$\Delta T = \frac{0.2}{20} = 0.01\text{s}$$

$$T = (1.85 \pm 0.01)\text{s}$$

$$g = \frac{4\pi^2 L}{T^2} = \frac{4\pi^2(0.850)}{1.85^2} = 9.80 \text{ m s}^{-2}$$

$$\frac{\Delta g}{g} = 2\frac{\Delta T}{T} + \frac{\Delta L}{L}$$

$$= 2\left(\frac{0.01}{1.85}\right) + \left(\frac{0.001}{0.850}\right) = 0.01$$

$$g = (9.80 \pm 0.01) \text{ m s}^{-2}$$

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.

Using the conservation of energy, *mgh* = maximum KE of boy

Mass of a boy = 50 kg (accept 40 - 70kg)
h of a boy on a swing = 1 – 2 metres

KE = *mgh* = (40)(9.81)(1.5) = **600 J (Accept a range of 300 to 900 J)**

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.

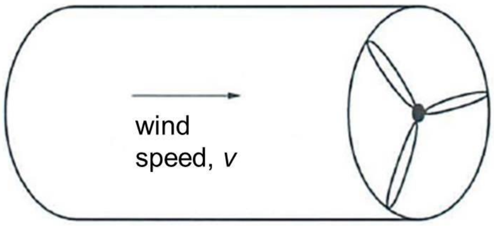


Fig. 2.1

(a) Explain why the input power to the turbine is numerically equal to the kinetic energy of the air contained within this volume. **[1]**

Since the volume of the air column corresponds to the volume of air passing through the blade per unit time, kinetic energy of the air in the column per unit time would be equal to the work done per unit time on the turbine.

(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]**

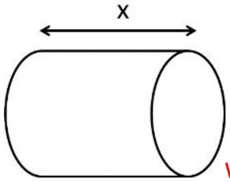
Power Input = Rate of change of KE of air

$$P = \frac{dE}{dt}$$

$$= \frac{1}{2} v^2 \frac{dm}{dt}$$

Mass flow rate = $\frac{dm}{dt}$

where mass = volume of a cylinder "of air" x density of air = $(Ax).\rho$



where x is the displacement of the wind over time t and $v = \frac{dx}{dt}$

Therefore, mass flow rate = $\frac{dm}{dt} = \rho A \frac{dx}{dt} = \rho A v$

A is the circular area swept = πr^2

$$P = \frac{dE}{dt} = \frac{1}{2} v^2 \frac{dm}{dt}$$

$$= 0.5 v^2 \rho (\pi r^2) v$$

$$= 0.5 \pi r^2 \rho v^3 \text{ (shown)}$$

(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]**

If all the kinetic energy of the air is converted into electrical energy, the air will **lose all its KE and become stationary**. This means that **no further flow of air** occurs.

3 **(a)** Define *potential difference* between two points on an electric circuit. **[1]**

Potential difference between two points on a circuit is the amount of **energy** converted **per unit charge** from **electrical** to **non electrical** between the two points.

(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.

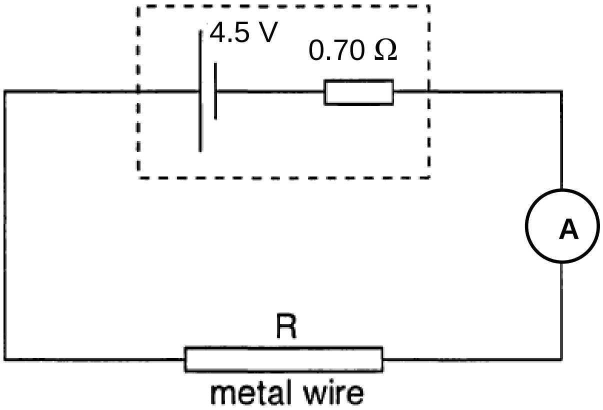


Fig. 3.1

Determine the resistance of R.

resistance of R = ………………… Ω **[2]**

$\varepsilon = IR + Ir$

$IR = \varepsilon - Ir$

$(0.20)R = 4.5 - (0.70 \times 0.20)$

$R = 21.8\ \Omega$

(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]**

note that the total internal resistance is sum of the individual internal resistance (1.40 Ω).

$\varepsilon = IR + Ir$

$IR = \varepsilon - Ir$

$(0.35)R = 9.0 - (1.40 \times 0.35)$

$R = 24.3\ \Omega$

(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.

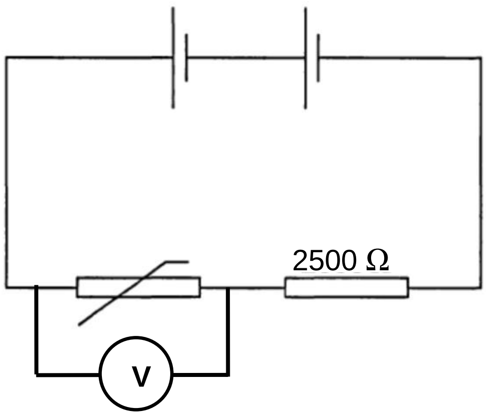


Fig. 3.2

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 negligible and the voltmeter has a very high resistance. **[2]**

By using potential divider,
maximum reading is obtained when the resistance of the thermistor is 5000 Ω.

maximum reading = $\frac{5000}{5000+2500}\times 9.0$ = 6.0 V (2 s.f.)

minimum reading is obtained when the resistance of the thermistor is 2250 Ω.

minimum reading = $\frac{2250}{2250+2500}\times 9.0$ = 4.3 V

(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. **[3]**

at 0 °C, resistance of thermistor is 5000. let R be the resistance of the fixed resistor

3.6 = $\frac{R}{R+5000}\times 9.0$
solving, R = 3330 Ω.

at 20 °C,

7.2 = $\frac{R}{R+2250}\times 9.0$
solving, R = 9000 Ω.

The values of resistance of the fixed resistor for the two conditions are not the same. Hence, it is **not possible** to substitute **a single** fixed resistor to meet the requirements.

4 **(a)** Define *magnetic flux density*. **[2]**

The magnetic flux density at a point is the **force per unit current per unit length** of a curret-carrying conductor lying at **right angles to the magnetic field**.

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

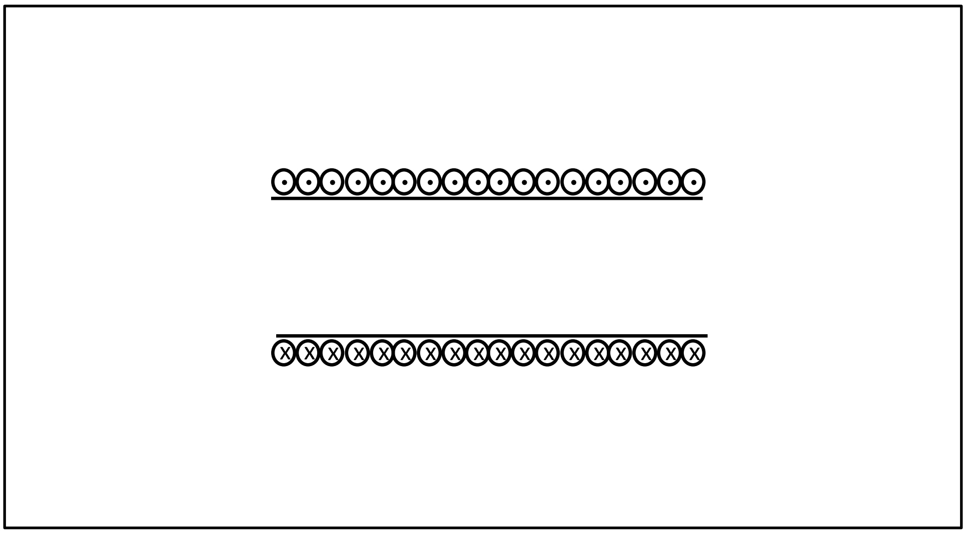
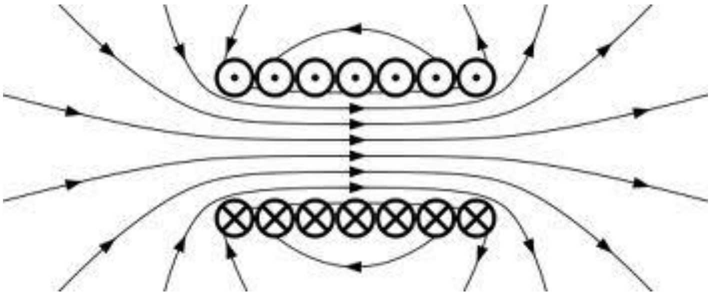


Fig. 4.1

(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}.

$F = B I L \sin \theta$

$\frac{F}{L} = B I \sin \theta$

$0.045 = B (5.8) (\sin 12°)$

$B = 0.037$ T

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.

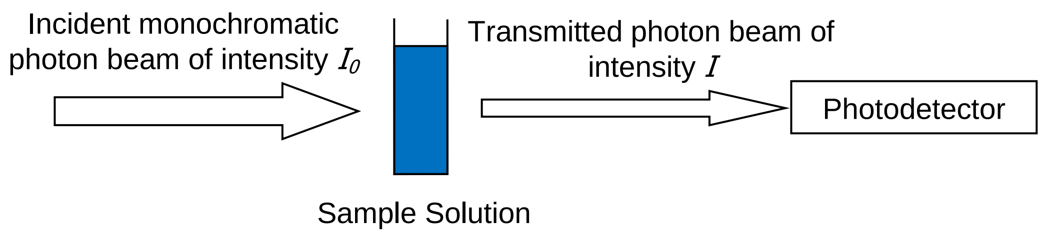


Fig. 5.1

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.

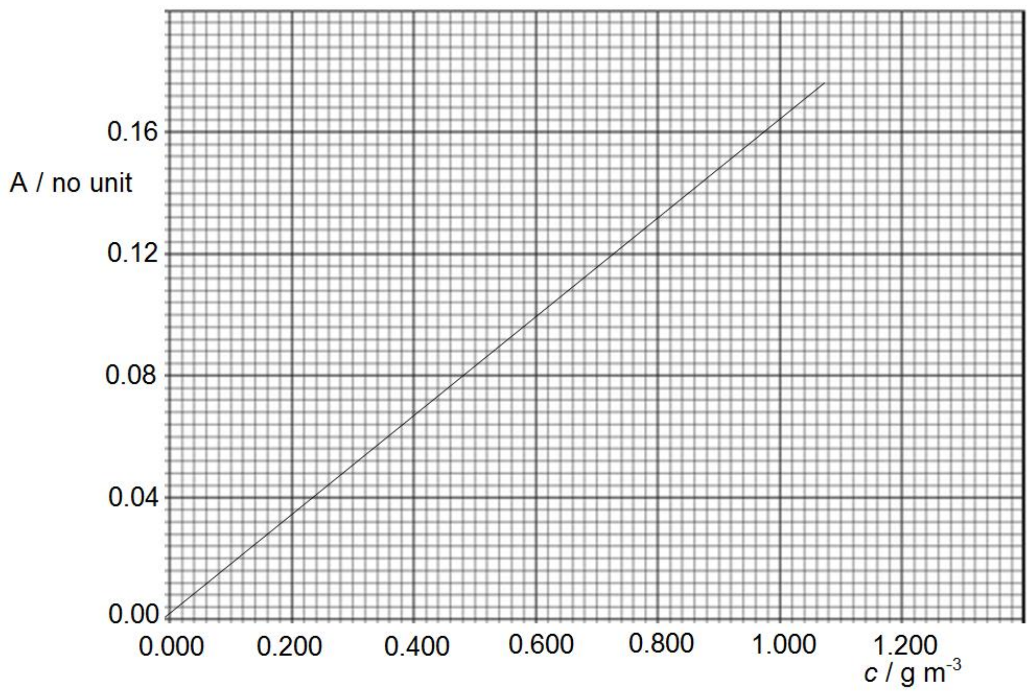


Fig. 5.2

(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]**

$I = I_0 e^{-kc}$

$\frac{I_0}{I} = e^{kc}$

Taking log on both sides,

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

$A = kc$

A graph of absorbance, *A*, against concentration, *c*, with k as the positive gradient of 0 as the vertical intercept is expected.

The linear calibration graph in Fig. 5.2 plotted is consistent with the equation of the form $A = kc$, hence indicates the relation $I = I_0 e^{-kc}$.

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

gradient =…………………....... **[2]**

Gradient of the calibration graph

$\frac{y_2 - y_1}{x_2 - x_1} = 0.159$

Gradient of calibration graph = 0.159

Workings for gradient must be shown, in particular, substitution of points must be shown.

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

value of k =…………………......

unit of k =…………………...... **[1]**

Solution:

Value is to be the same as the gradient for the graph. ecf here.

Value to be consistent with the unit of *k* to get the 1 mark. acceptable units: g^{-1} m^3.

(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	0.160	1.45	4.26

Fig. 5.3

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

Solution:

ln (I / mW) is obtained from ln I_0 - A

To determine the value of I_0, read off from table the value of ln I when A = 0

Since $A = \ln I_0 - \ln I$, therefore $\ln I_0 = \ln I = 1.61$ (when A = 0)

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	0.066	1.54	4.66
0.580	0.096	1.51	4.53
0.800	0.132	1.48	4.39
1.000	0.164	1.45	4.26

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

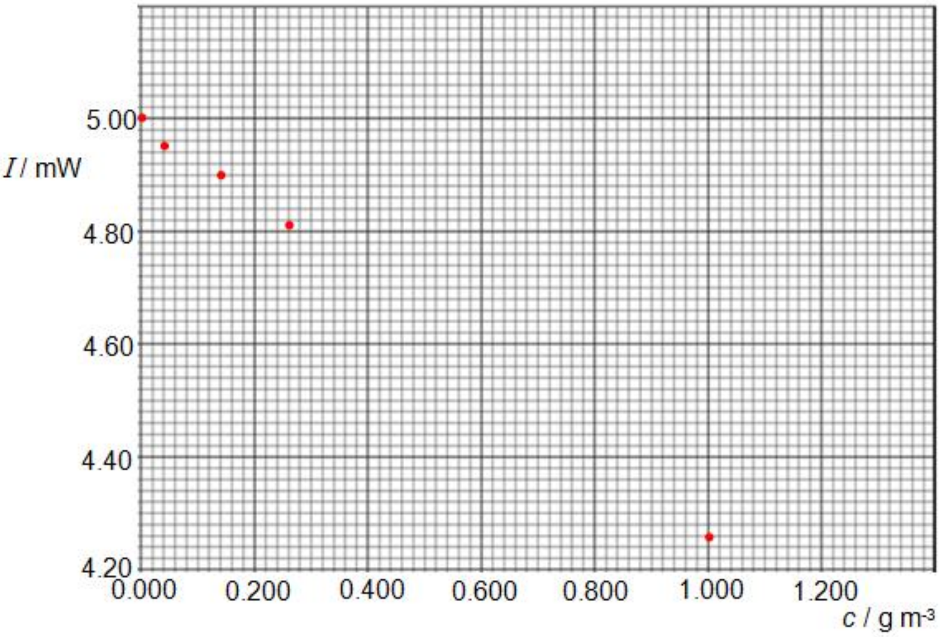
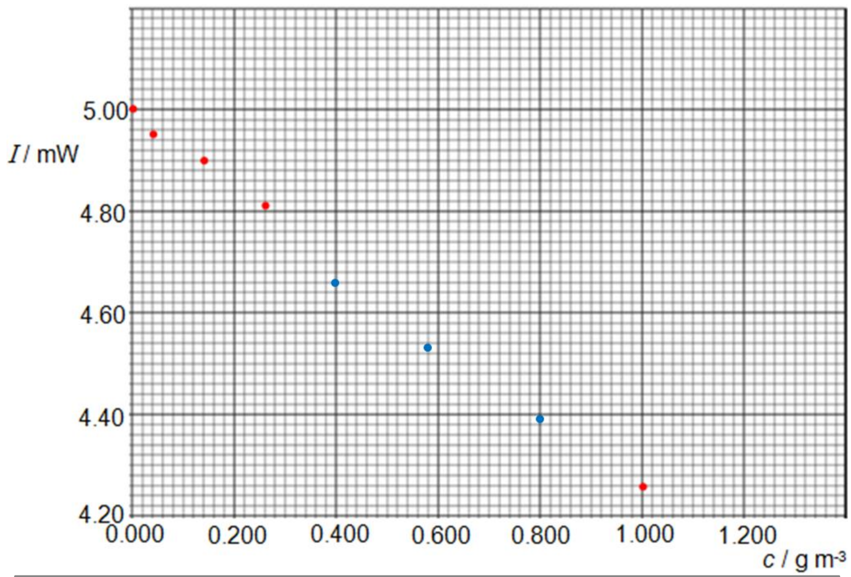
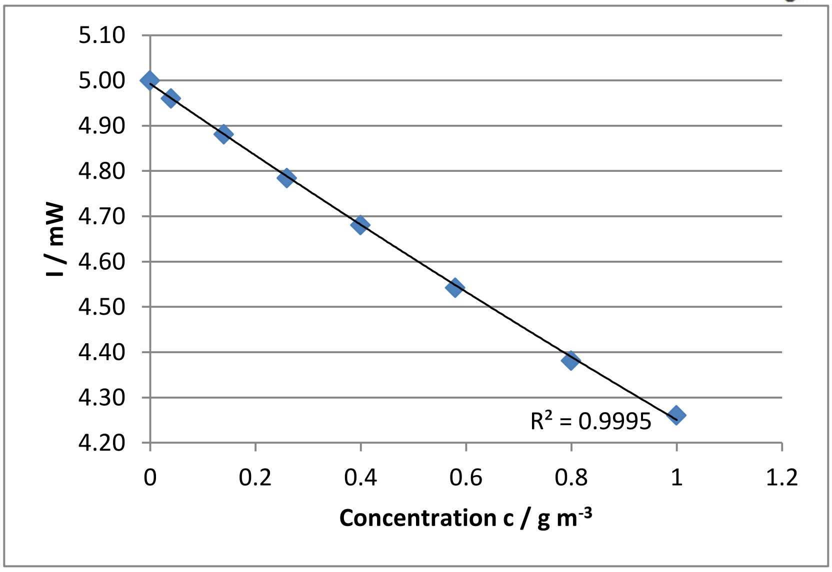


Fig. 5.4 **[3]**



5.00
I / mW
4.80
4.60
4.40
4.20
0.000
0.200
0.400
0.600
0.800
1.000
1.200
c / g m-3



5.10
5.00
4.90
4.80
4.70
4.60
4.50
4.40
4.30
4.20
I / mW
R² = 0.9995
0
0.2
0.4
0.6
0.8
1
1.2
Concentration c / g m-3

Section B

6 **(a)** State Newton's second law of motion. **[1]**

It states that the **rate of change of momentum** of a body is **proportional** to the **resultant force** acting on it, and the **direction of momentum change** takes place in the direction of the resultant force.

(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.

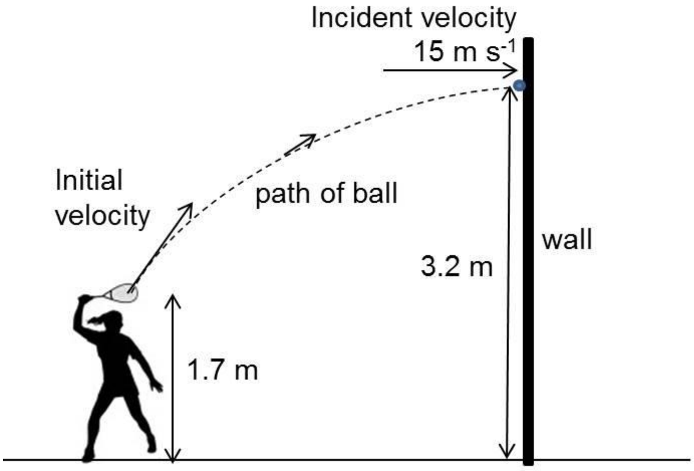


Fig. 6.1

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

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

Taking upwards as positive,

Using $v_y^2 = u_y^2 + 2as$

$0 = u_y^2 + 2(-9.81)(3.2 - 1.7)$

$u_y = 5.4 \text{ m s}^{-1}$

(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]**

Applying Newton's 2nd law of motion, and taking rightwards as positive

$F = \dfrac{m(v-u)}{t} = \dfrac{0.024(-12-15)}{0.15}$

= - 4.32 N (Force on ball by wall which acts to the left)
[for magnitude of F]

By Newton's 3rd law of motion, Force on wall by ball = - Force on ball by wall
= 4.32 N

Force on wall acts to the right.

(iii) State and explain whether the collision of the ball with the wall is elastic. **[1]**

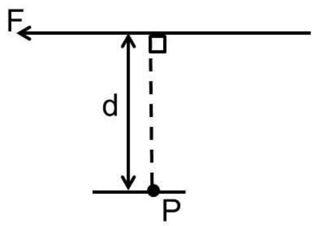
It is **not elastic** as the speed of the ball has decreased from 15 m s^{-1} to 12 m s^{-1} which means that the **KE of the ball-wall system**, which is ½ mv^2, has **decreased**.

(iv) Explain why the ball does not rebound to the point from where it was hit by the racket. **[2]**

As the **horizontal velocity** is **reduced** after collision, with the **same time of flight** before collision with the wall, the **horizontal displacement** during rebound **will be reduced**. (The ball will land closer to the wall.)

Students must mention the reduction in both horizontal velocity and displacement.

(c) Define the terms *moment of a force* and draw a sketch to illustrate its meaning. **[2]**



It is the **turning effect of a force** which is equal to the **product of the force F and the perpendicular distance d** of the **line of action of the force from the pivot**.

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

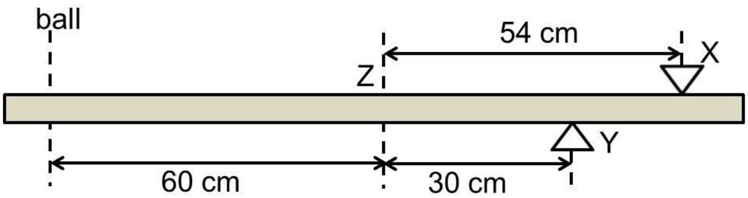


Fig. 6.2

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.

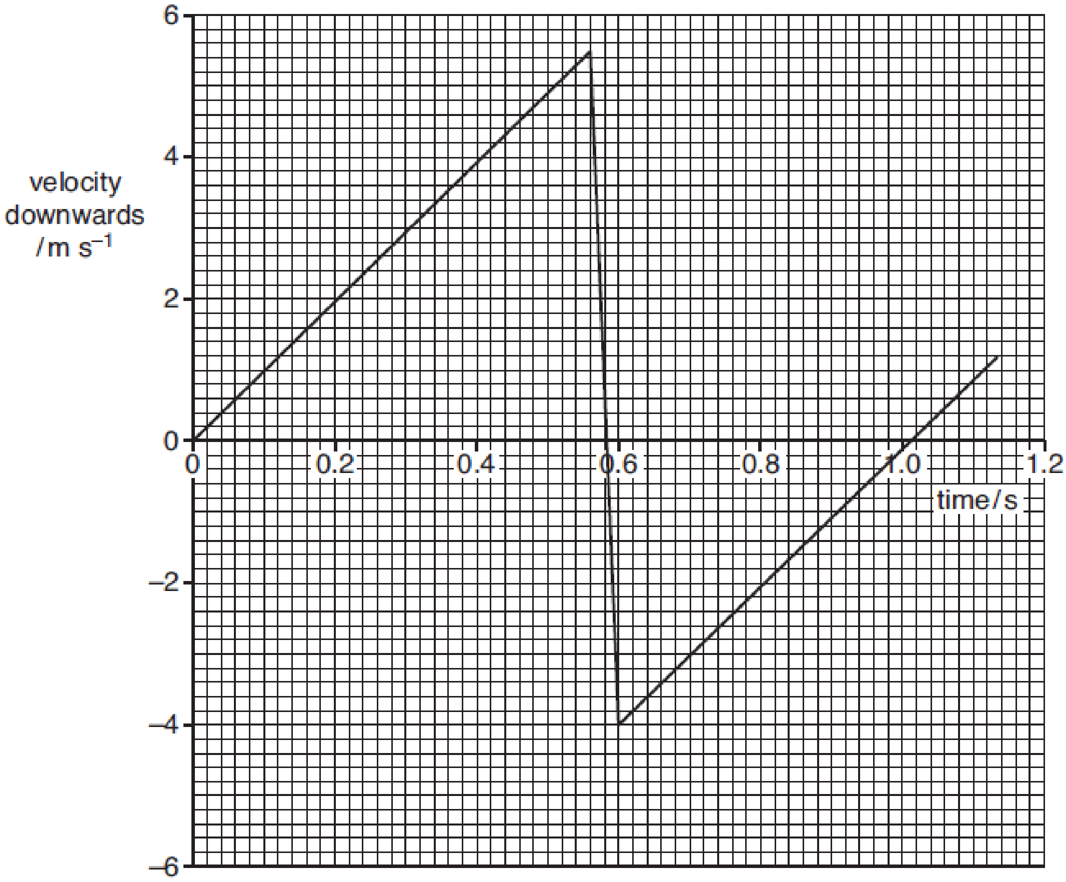


Fig 6.3

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]**

$$\Delta p = m \times \Delta v$$
$$= 150 \times 10^{-3} \times (5.5 + 4.0)$$
$$= 1.43 \text{ kg m s}^{-1}$$

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

force = ………………. N **[1]**

$$\text{Force by bar} = \frac{\Delta p}{\Delta t} = \frac{1.43}{0.04}$$
$$= 35.8 \approx 36 \text{ N}$$

A0

(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]**

Taking Moments about Y,
By principle of moments,
ACM = CM
36 x 90 + 0.5 x g x 30 = F_X x (54-30)
F_X = 141 N

(ii) the support Y,

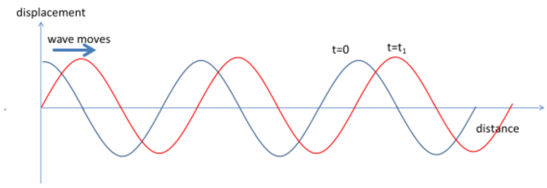
force by Y = ………………. N **[2]**

Consider Vertical Equilibrium,
Taking upwards as positive,

$F_Y + (-141) + (-0.5 \times 9.81) + (-36) = 0$
$F_Y = 182$ N

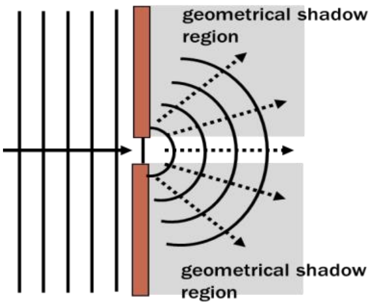
7 (a) Explain, using diagrams, what is meant by the terms below in relation to waves.

(i) progressive wave **[2]**



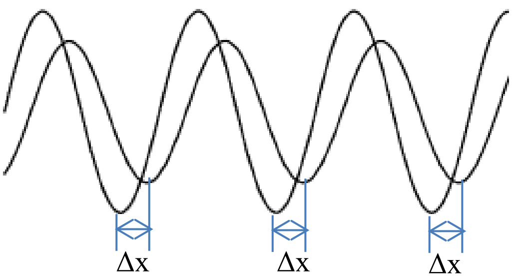
Solution:
A progressive wave is a wave in which **energy is transferred from one point to another by means of vibrations or oscillations** within the wave.

(ii) diffraction **[2]**



Solution:
Diffraction is the **spreading of waves** when they pass through an opening or around an obstacle into the geometrical shadow regions.

(iii) coherence **[2]**



Solution:
Coherence between two waves is when two waves have **constant phase difference** over time.

(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. 7.1a illustrates nine particles, equally spaced along the line **AB**, in still air.

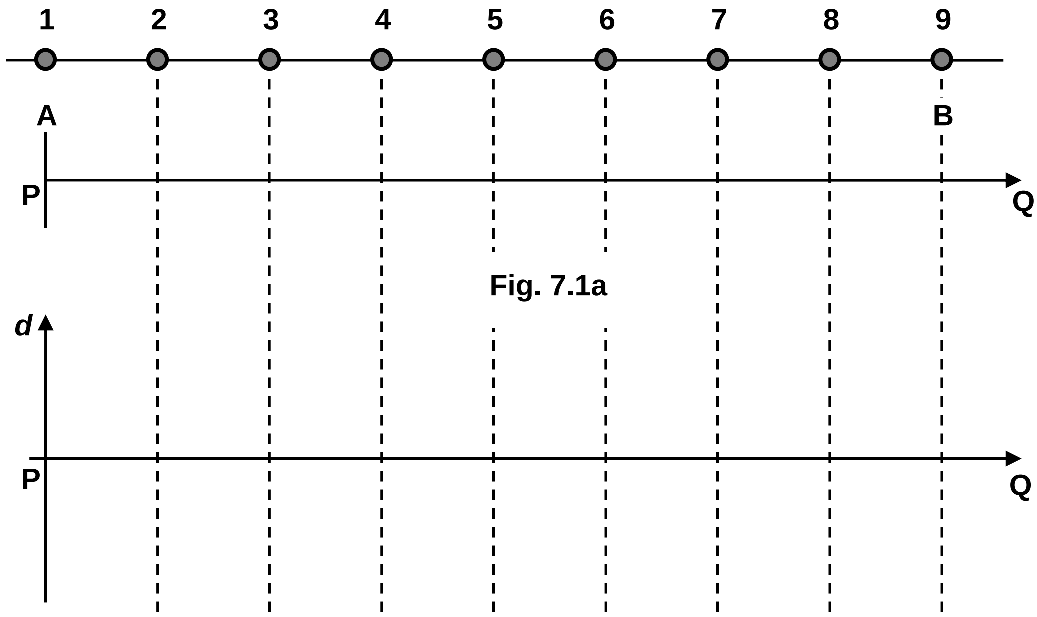


Fig. 7.1a

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]**

Solution:

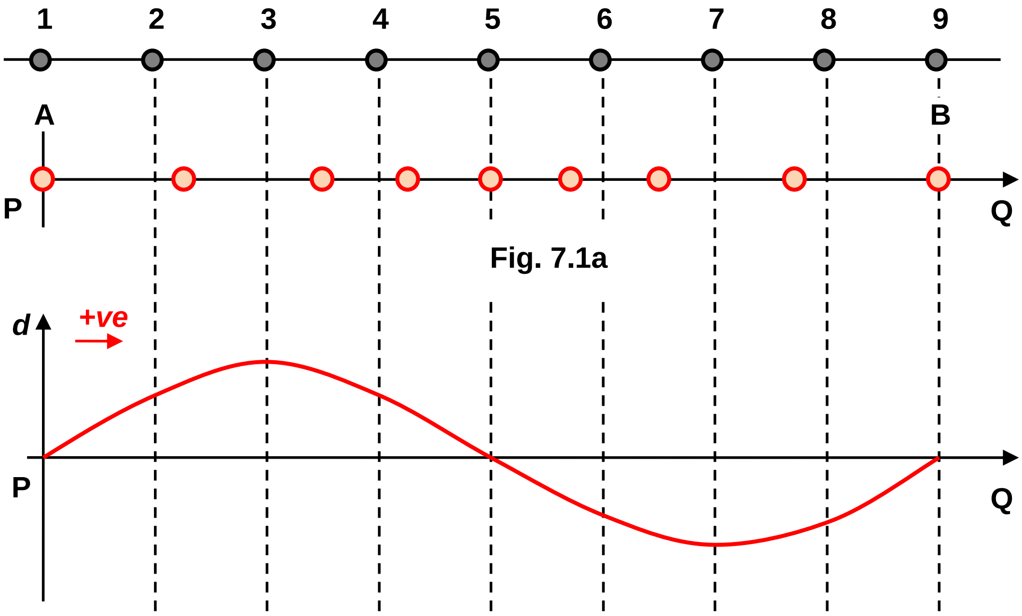


Fig. 7.1a

Fig. 7.1b

For part (i), positions of particles must conform to 1 wavelength, with clear differences in displacements of particles.

For part (ii), wave must correspond to diagram in (i) and displacement of particles to the right is taken to be positive on the graph.

(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]

Point H, a point of high pressure **occurs at where particle 5 is** as this is where **compressions occur due to neighbouring air particles 4 and 6 coming closer to one another.**

Identifying and labelling of H correctly at particle 5.

(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. **[2]**

As a **stationary wave is being formed, the wave will not progress and each particle will oscillate with different amplitudes**.

In the current scenario, the **wave will progress towards X with each particle moving left and right, reaching the same amplitude** over time.

(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.

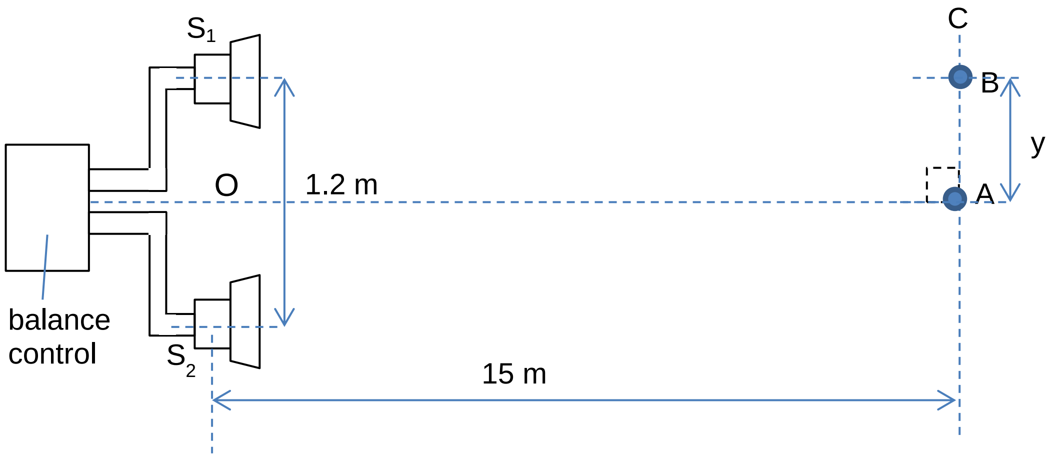


Fig. 7.2 (not to scale)

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]**

Using $x = \dfrac{\lambda D}{a}$ where $\lambda = \dfrac{v}{f}$

$y = \dfrac{(\frac{330}{1000})(15)}{(1.2 \times 2)}$, x is twice that of y (x = 2y) since B is at minimum intensity

y = 2.1 m

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

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

Since B is a point of minimum intensity, the path difference of S_1 and S_2 at point B,

$$S_1B - S_2B = \frac{\lambda}{2} = \frac{0.33}{2} = 0.165\ m$$

For other wavelengths λ, point B will be at zero intensity if the path difference is odd multiple of $\frac{\lambda}{2}$.

Therefore,

$$(2n+1)\frac{\lambda}{2} = 0.165\ m$$

$$\lambda = 0.11$$

Using $f = \frac{v}{\lambda}$,

$$f = \frac{330}{\lambda}$$

f =3000 Hz

(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]**

Since amplitude ∝ voltage and amplitude^2 ∝ intensity,
initially at A, constructive interference occurs as two waves meet in phase to give I_{max}.
<u>Thus amplitude proportional to 6 V + 6 V = 12 V,</u>
<u>hence I_{max} ∝ (12 V)^2 = 144 V^2</u>

At B, destructive interference occurs as two waves meet in antiphase,
Thus amplitude proportional to 6 V - 6 V = 0 V giving I_{min} = 0.

When the speakers are adjusted to 9 V and 3 V,
<u>the resultant amplitude at B is proportional to 9 V – 3 V = 6 V.</u>
<u>Hence I_{min} ∝ (6 V)^2 = 36 V^2</u>
I_{min}= ¼ I_{max}

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]**

1. The line emission spectrum appears as **<u>bright lines on a dark background</u>** and the absorption spectrum appears as **<u>dark lines on a continuous bright coloured background.</u>**

2. **<u>Excitation</u>** of the gas atoms to produce line emission spectrum is through **<u>supplying thermal energy to the atoms by heating.</u>**
OR <u>Excitation</u> of the gas atoms to produce line emission spectrum is usually through **<u>bombarding the atoms with electrons</u>**.
The bright lines are due to the **<u>photons given off when the excited atoms de-excite.</u>**

To produce line absorption spectrum, **<u>excitation of the gas atoms is by absorption of photons</u>**. Thus a light source is required.
<u>Dark lines correspond to the photons that were absorbed by the atoms and re-radiated randomly in any direction when the atom de-excite.</u>

(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.

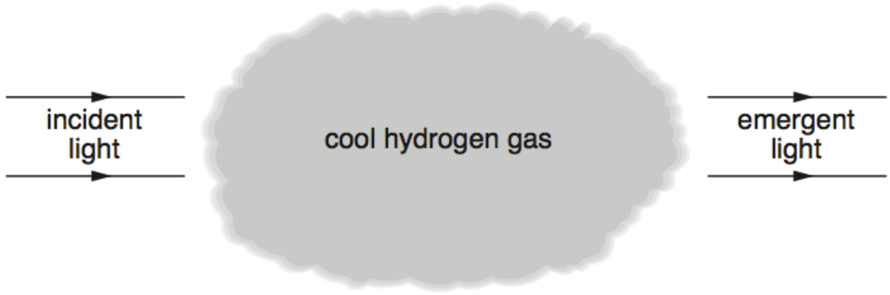


Fig. 8.1

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

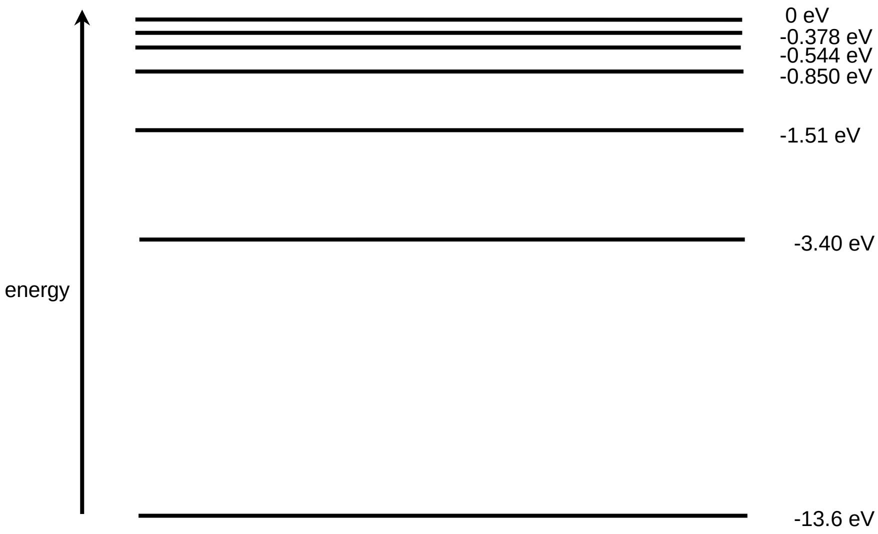


Fig. 8.2

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

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

The transition that will absorb a photon with wavelength 700 nm is

$$\Delta E_{700nm} = \frac{hc}{\lambda_{700nm}}$$

$$= \frac{\left(6.63\times10^{-34}\right)\left(3.0\times10^{8}\right)}{700\times10^{-9}}$$

$$= 2.84\times10^{-19}\,\text{J}$$

$$= 1.78\text{ eV}$$

The transition that will absorb a photon with wavelength 400 nm is

$$\Delta E_{400nm} = \frac{hc}{\lambda_{400nm}}$$
$$= \frac{(6.63 \times 10^{-34})(3.0 \times 10^{8})}{400 \times 10^{-9}}$$
$$= 4.97 \times 10^{-19}\,\text{J}$$
$$= 3.12\ \text{eV}$$

Therefore the allowed electronic transitions lie in the range
$1.78\ \text{eV} < \Delta E < 3.12\ \text{eV}$.

Therefore, there are only 4 allowable transitions (transitions from -3.40 eV energy level to higher energy levels).

(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.

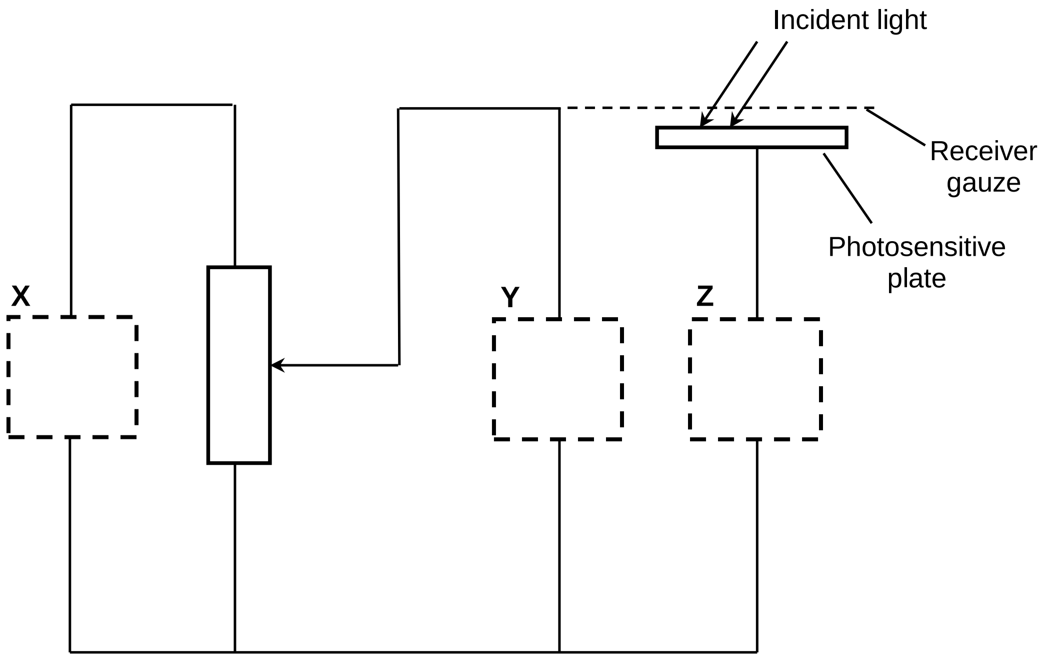
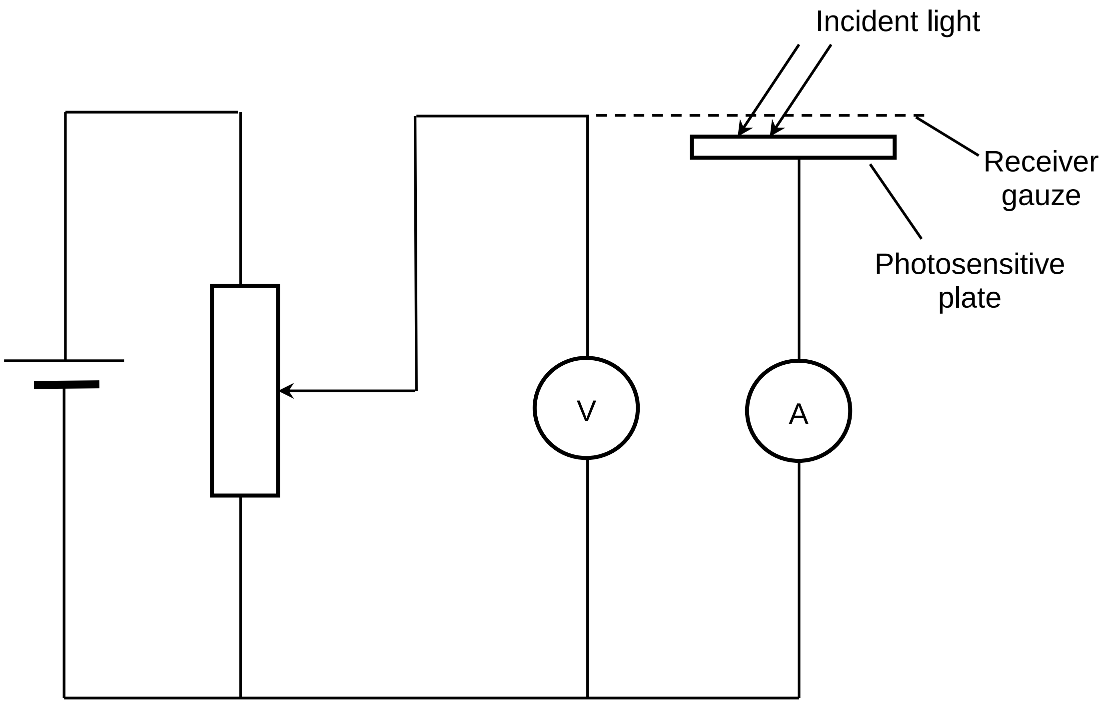


Fig. 8.3

(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]**



Award 1 mark for each correct connection of the ammeter and the voltmeter.
1 mark is awarded to the correct usage of the circuit symbols.
1 mark is awarded for the orientation of the dry cell.

(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. **[4]**

Q and R are not appropriate as the incident light has photons with energies ranging from $1.78\text{ eV} < \Delta E < 3.12\text{ eV}$. Therefore, with a **work function that is more than range of energies**, **electrons will not have absorbed enough energies to be emitted from the metal**.

P, however, has a work function of only 2.55 eV. **Photons present in the incident light have energies that are larger than 2.55 eV.** Therefore, **P is the best choice**.

(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]**

$$E_{pulse} = N_{photons} E_{photon}$$
$$N_{photons} = \frac{E_{pulse}}{E_{photon}} = \frac{P\Delta t}{\Delta E}$$
$$= \frac{(1.0\times10^{-2})(10.0\times10^{-9})}{3.12\times(1.6\times10^{-19})}$$
$$= 2.00\times10^{8}$$

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]**

$$F_{avg} = N_{photons}\frac{\Delta p}{\Delta t}$$
$$= N_{photons}\frac{\left(\frac{h}{\lambda}\right)}{\Delta t}$$
$$= 2.00\times10^{8}\times\frac{\left(\frac{6.63\times10^{-34}}{400\times10^{-9}}\right)}{10.0\times10^{-9}}$$
$$= 3.32\times10^{-11} N$$