Name	Class	Index Number

PIONEER JUNIOR COLLEGE
JC2 Preliminary Examination

PHYSICS **8866/02**
Higher 1

Paper 2 Structured Questions

17 September 2015

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.

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

This document consists of **23** printed pages.

Data

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

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

Section A

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

1 A student takes measurements to determine the acceleration of free fall. He throws a ball of mass 0.010 kg vertically upwards with a velocity of 25 m s^{-1} from ground level.

The variation with time *t* of the vertical velocity *v* of the ball is shown in Fig. 1.1.

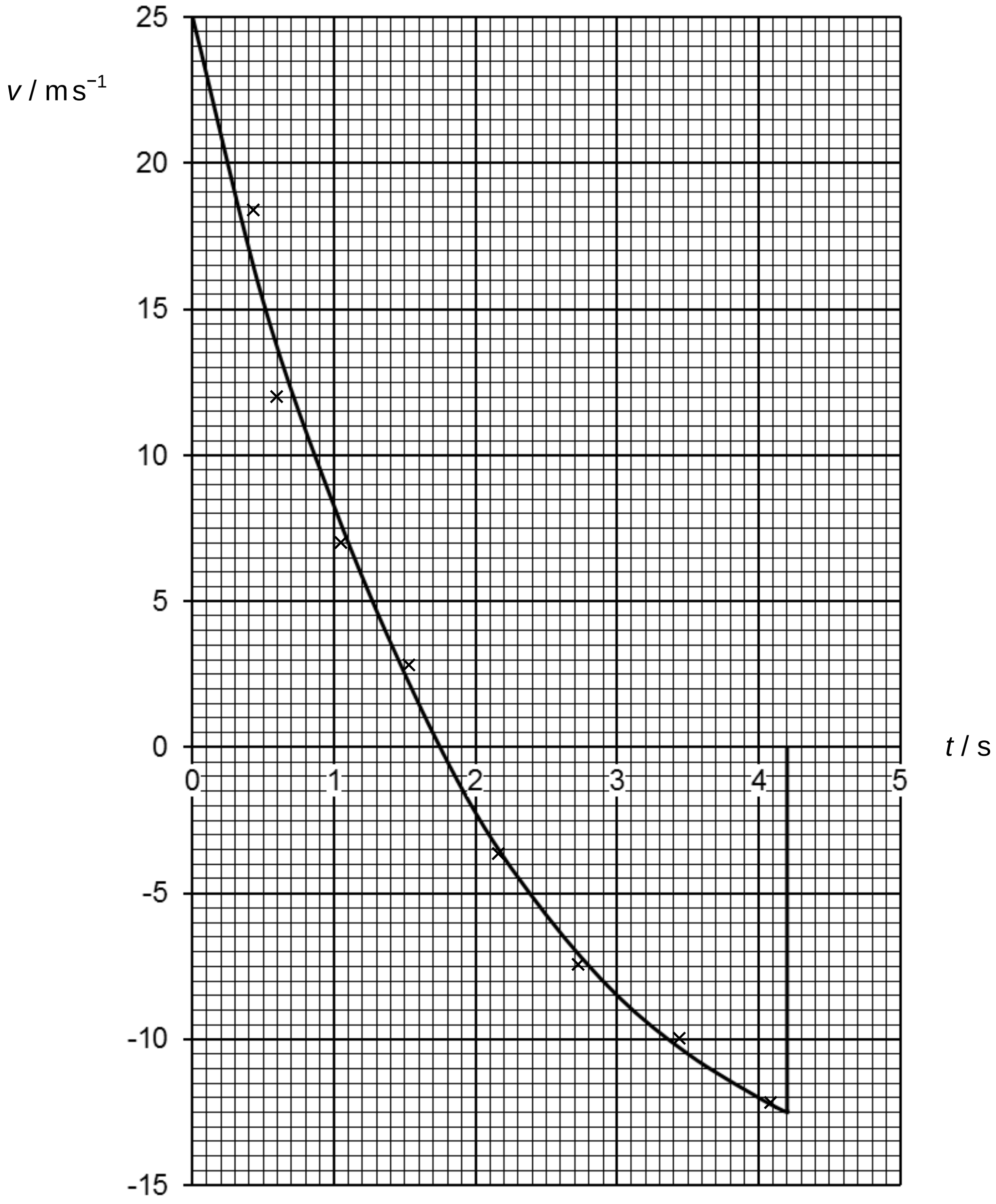

Fig. 1.1

(a) Using Fig. 1.1, explain

(i) how it can be deduced that air resistance is present in this experiment,

....

....

.... [1]

(ii) how the magnitude of the acceleration of free fall can be determined.

....

.... [1]

(b) State and explain how the time taken for the upward motion t_u compares with the time taken for the downward motion t_d.

....

....

.... [2]

(c) Calculate the magnitude of the maximum force due to air resistance on the ball.

force = ... N [2]

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

....

.... [1]

(b) Formula One (F1) cars experience a very large acceleration when speeding up, slowing down and turning. They also experience a large resistive force when travelling at high velocities.

The resistive force F_r experienced by a typical F1 car of mass 691 kg (inclusive of driver), moving at high velocities through air is given by

$$F_r = \frac{1}{2} D \rho A v^2 ,$$

where
D is the drag coefficient, equal to 0.850, ρ is the density of air, equal to 1.20 kg m^{-3}, A is the effective area against air resistance, equal to 1.71 m^2, and v is the velocity of the object in m s^{-1}.

(i) Determine the resistive force experienced by the F1 car when moving at 300 km h^{-1}.

resistive force = ... N [2]

(ii) Given that the power of the F1 car is 5.67×10^5 W when moving at 300 km h^{-1}, calculate

1. the driving force on the F1 car

driving force = ... N [1]

2. the acceleration of the F1 car

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

(iii) Fig. 2.1 shows the side view of the F1 car hitting a barrier.

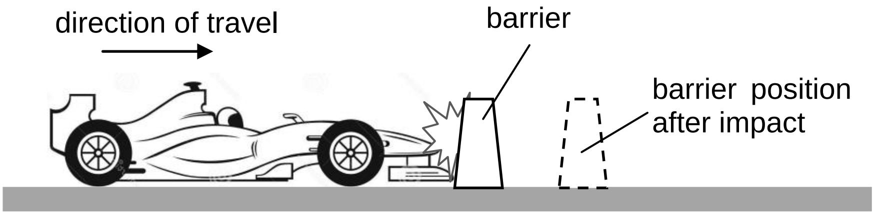

Fig. 2.1

Explain how the shifting of the barrier during impact can be a safety feature.

....

....

....

.... [2]

3 A rock climber of mass 70 kg is climbing a vertical cliff as shown in Fig.3.1. He ties himself to a secure point on the cliff by a rope of unstretched length 15 m. When he has climbed a height of 15 m above the secure point, he slips and falls. The elastic rope obeys Hooke's law with a force constant of 200 N m^{-1}.

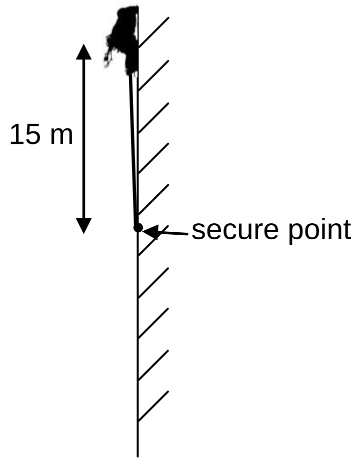

Fig. 3.1

(a) Calculate the speed of the falling climber just before the rope starts to stretch.

speed = ... m s^{-1} [2]

(b) Calculate the maximum distance below the secure point that the climber falls.

distance = ... m [3]

(c) Due to the elasticity of the rope, the climber oscillates up and down until he comes to a complete stop.

Calculate the distance below the secure point when the climber stops moving.

distance = ... m [2]

(d) Suggest a safety feature of climbing ropes.

....

.... [1]

4 **(a)** **(i)** Explain what is meant by *intensity* of a wave.

....

.... [1]

(ii) Fig. 4.1 shows a skyrocket which explodes 100 m above the ground. Three observers are spaced 100 m apart, at positions A, B and C. The observer at A is directly below the explosion.

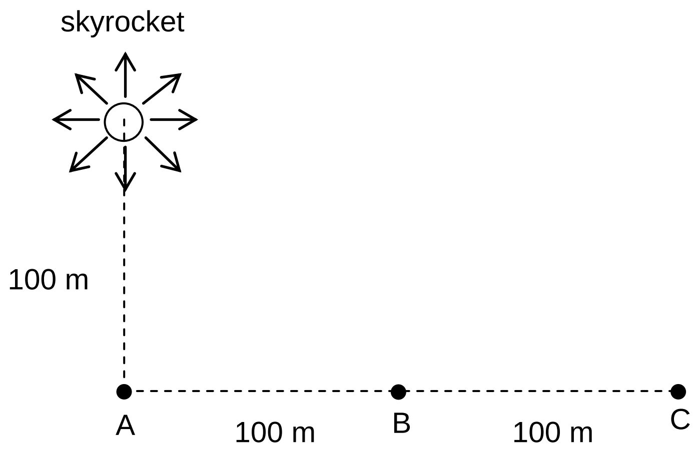

Fig. 4.1

Calculate the ratio of the sound intensity heard by the observer at A to the sound intensity heard by the observer at C.

ratio of the sound intensity = ... [3]

(b) Stationary sound waves can be formed in bottles and pipes.

(i) State the conditions for the establishment of a well-defined stationary wave.

....

.... [1]

(ii) A bottle containing water resonates as air is blown across its open top. Explain what happens to the fundamental frequency as the level of water in the bottle decreases.

....

....

.... [2]

(iii) A pipe open at both ends resonates at a fundamental frequency f_1. When one end is covered and the pipe is again made to resonate, the fundamental frequency is f_2.

1. On Fig. 4.2 and Fig. 4.3, sketch the fundamental modes of the stationary waves found in a pipe open at both ends and of a pipe with one end covered.

Fig. 4.2

Fig. 4.3

[1]

2. Hence or otherwise, calculate the ratio $\frac{f_1}{f_2}$.

ratio = ... [2]

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

....

.... [1]

(b) A cross-sectional plan view of a solenoid of length 0.300 m is shown in Fig. 5.1.

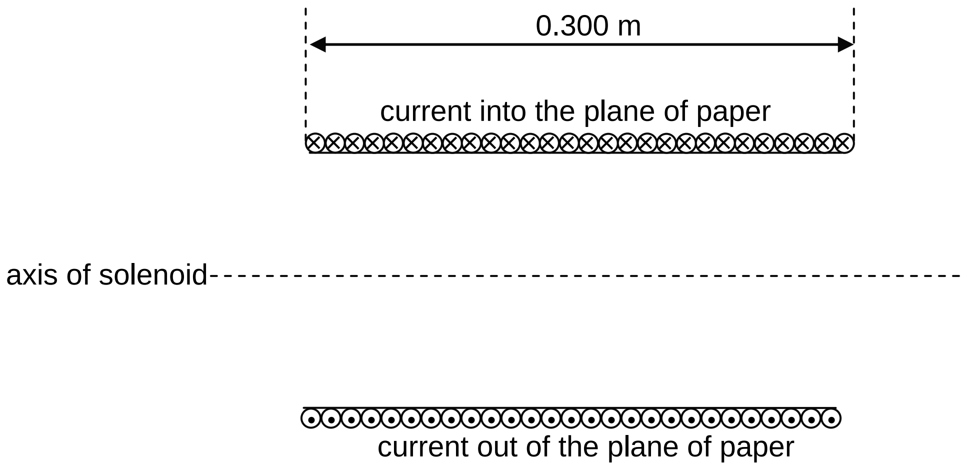

Fig. 5.1

(i) Based on the indicated direction of current flow in the solenoid, sketch on Fig. 5.1 the magnetic flux pattern within the solenoid. [1]

(ii) The magnetic flux density B (in tesla) inside the solenoid and parallel to its axis is given by the expression

$$B = \mu_0 n I$$

where $\mu_0 = 4\pi \times 10^{-7}\ \text{H m}^{-1}$ is the permeability of free space, n is the number of turns per metre length of the solenoid and I is the current (in amperes) in the solenoid.

Given that there are 900 turns in the solenoid and a current of 4.0 A flows through the solenoid, calculate the magnetic flux density inside the solenoid.

magnetic flux density = ... T [2]

(iii) State the effect on the magnetic flux density in **(ii)** when a ferrous core is inserted into the solenoid.

.... [1]

(c) A current balance with a rectangular frame PQRS pivoted at R and S is shown in Fig. 5.2 (a) and Fig. 5.2 (b). The segments RS and XY are non-conducting. Segment SPQR is a metallic wire and a current flows through it.

The frame PQRS is placed inside the same solenoid in **(b)** such that it lies within the magnetic field of the solenoid. When a rider of mass 2.0 g is placed at Y, the plane of the frame PQRS is maintained in a horizontal plane and is coaxial with the solenoid.

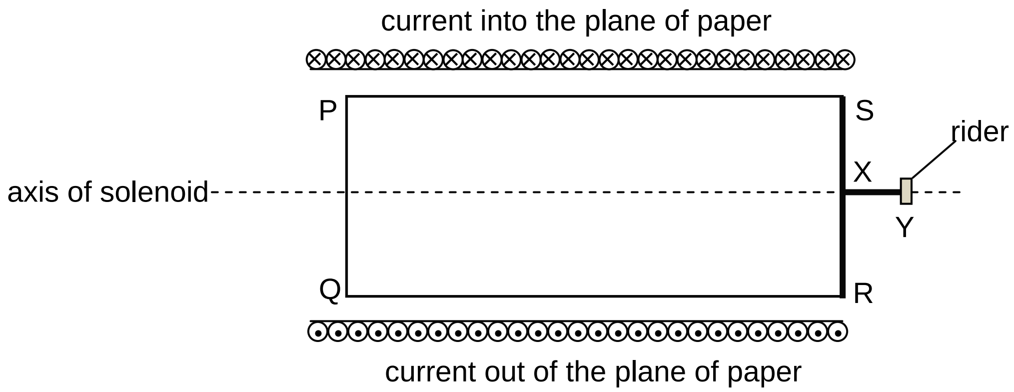

Fig. 5.2 (a) plan view (not to scale)

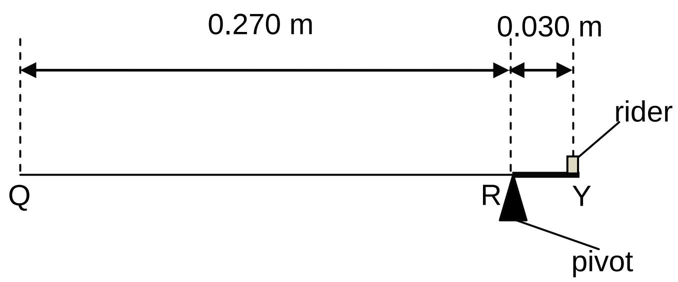

Fig. 5.2 (b) side view (not to scale)

(i) On Fig. 5.2 (a), draw an arrow to show the direction of current flow in the segment PQ for the plane of the frame to be horizontal. [1]

(ii) Given that segment PQ has a length of 0.080m, use your answer in (**b)(ii)** to determine the magnitude of current flowing in segment PQ. You may assume that the frame PQRS and segment XY have negligible mass.

current = ... A [2]

Section B

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

6 **(a)** Define

(i) work,

....

.... [1]

(ii) power.

....

.... [1]

(b) Using equations of motion, derive an expression for the kinetic energy E_k of an object of mass m moving at speed v.

[3]

(c) On a wind farm, moving air does work on the blades of a wind turbine and electrical energy is generated. Fig. 6.1 shows such a wind turbine with blades which rotates about a horizontal axis. The diameter of the blades is 40.0 m and wind of velocity 10.0 m s^{-1} blows along the horizontal axis. Assume that the air stops completely after passing through the blades.

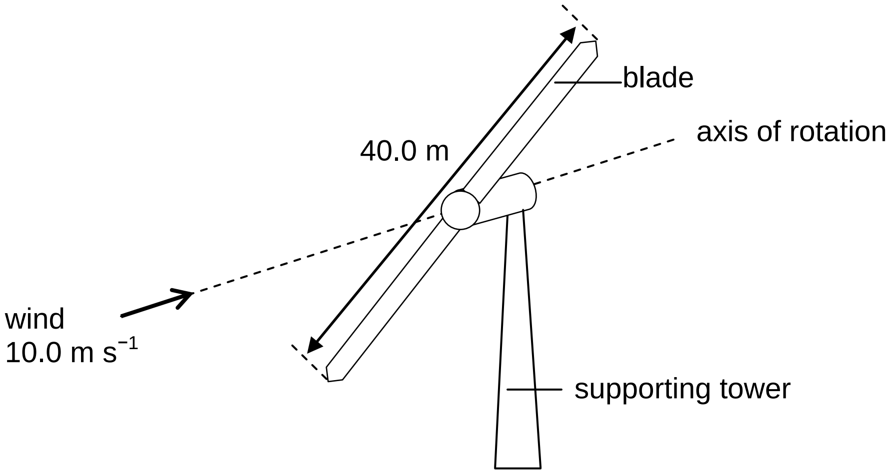

Fig. 6.1

(i) Complete the box in Fig. 6.2 which shows the energy conversion for the system of wind and wind turbine.

kinetic energy of wind →

1. ....

....

2. ....

....

→ electrical energy

Fig. 6.2

[2]

(ii) Taking the density of air to be 1.29 kg m^{-3}, calculate

1. the mass of air incident on the blades in one second,

mass of air in one second = ... kg [2]

[Turn over

2. the kinetic energy lost by the wind in one second,

kinetic energy lost in one second = ... J [2]

3. the electrical power output of the wind turbine if it is 40 % efficient.

electrical power output = ... W [2]

(d) Explain why the supporting tower for the wind turbine must be rigid.

....

....

....

.... [3]

(e) Discuss two disadvantages of using wind turbines as a source of power supply for a conventional 500 MW power station.

1. ....

....

....

2. ....

....

.... [4]

7 (a) Define

(i) *resistance* of a conductor,

....

.... [1]

(ii) the *ohm*.

....

.... [1]

(b) Circuits M and N are each set up using a battery of four identical cells as shown in Fig. 7.1. The voltmeter readings for the respective circuits are as shown. The voltmeters in both circuits are identical and can be assumed to be ideal. XY is a uniform metal wire with length 0.60 m and resistance R_{XY}. Wire XY has a diameter of 0.060 mm. The resistance R of the variable resistor is set at 3.0 Ω.

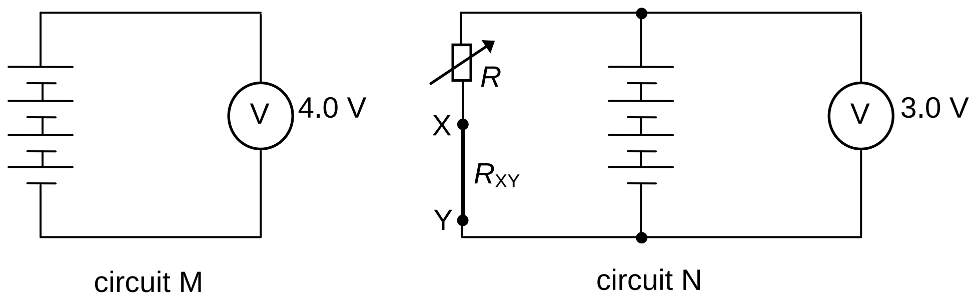

Fig. 7.1 (not to scale)

(i) Explain why the voltmeter in circuit M records a larger reading than the voltmeter in circuit N.

....

....

....

.... [2]

(ii) Given that wire XY has a resistivity of $1.72 \times 10^{-8}\ \Omega\ \text{m}$, calculate the resistance R_{XY}.

R_{XY} = ... Ω [2]

[Turn over

(iii) Determine the current through wire XY.

current = ... A [2]

(iv) Hence, calculate the rate of flow of electrons through the battery in circuit N.

rate of flow of electron = ... s^{-1} [2]

(v) Calculate the internal resistance *r* of a single cell.

r = ... Ω [2]

(c) One of the cells in the battery is reversed in both circuits M and N as shown in Fig. 7.2. The voltmeter readings are now changed. The current through wire XY in circuit N is now 0.24 A and the resistance R_{XY} changes.

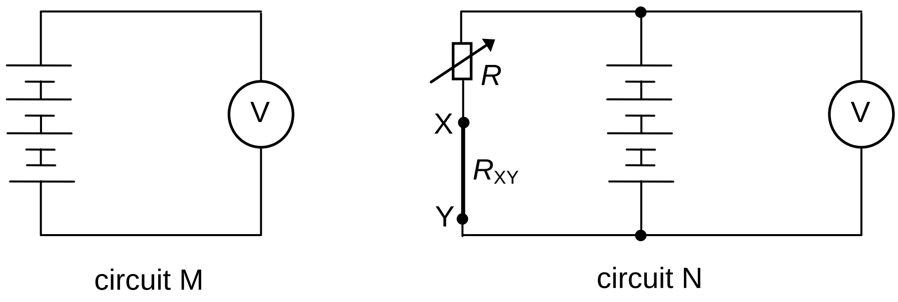

Fig. 7.2 (not to scale)

(i) With the resistance of the variable resistor still set at 3.0 Ω, determine the new resistance of wire XY.

resistance = ... Ω [2]

(ii) Suggest why the answers in **(b)(ii)** and **(c)(i)** are different.

....

....

....

.... [2]

(iii) Calculate the efficiency of power transfer of the battery in circuit N.

efficiency = ... % [2]

(d) Wire XY in Fig. 7.2 is now replaced by a fixed resistor with resistance equal to that in **(c)(i).**

For this new arrangement for circuit N, suggest whether it is possible to adjust the resistance of the variable resistor so that maximum power is delivered by the battery to both the external resistors.

....

....

....

....

.... [2]

8 **(a)** An electron in a hydrogen atom transits from an initial orbit n_i to a final orbit n_f, as shown in Fig. 8.1. A photon emitted in the process is capable of ejecting a photoelectron from tungsten, as shown in Fig. 8.2. The work function energy of tungsten is 4.58 eV. A minimum stopping potential V_s of 7.51 V is required to prevent the photoelectron from reaching the collector plate. The photoelectron is assumed to be emitted normal to the tungsten surface.

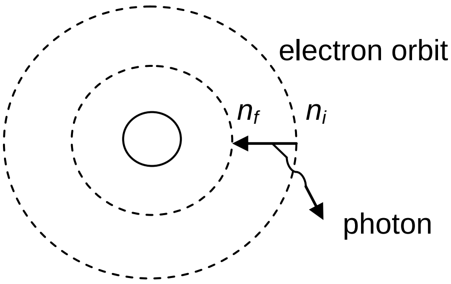

Fig. 8.1

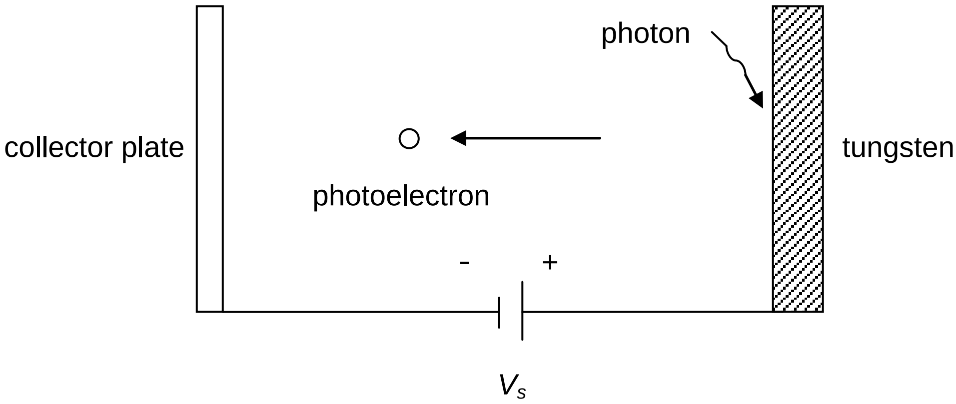

Fig. 8.2

(i) Explain the meaning of the following terms.

1. photon

....

.... [1]

2. energy level of an electron in an atom

....

.... [1]

3. work function energy

....

.... [1]

[Turn over

(ii) If the energy of an electron at n_f is –13.60 eV, calculate the energy of an electron at n_i.

energy = ... eV [3]

(iii) Calculate the wavelength of the photon emitted when the electron transits from n_i to n_f.

wavelength = ... m [1]

(iv) Hence, state the type of electromagnetic radiation released.

.... [1]

(v) The intensity of electromagnetic radiation is increased. Explain why the minimum stopping potential remains the same at 7.51 V.

....

....

....

....

.... [2]

(vi) A photoelectron is found to be emitted at an angle of 60° to the tungsten surface instead. Calculate the minimum stopping potential required to prevent the photoelectron from reaching the collector plate.

stopping potential = ... V [2]

(b) Neon discharge lamps are used in advertisements and signboards.

(i) Explain the physical processes occurring within neon discharge lamps which lead to the emission of light.

....

....

....

....

....

.... [3]

(ii) Explain whether light emitted by neon discharge lamps consists of a continuous spectrum or only a few colours.

....

....

.... [2]

(iii) Estimate the rate at which photons are emitted from a 40 W neon discharge lamp.

rate of emission = ... s^{-1} [3]

End of paper