

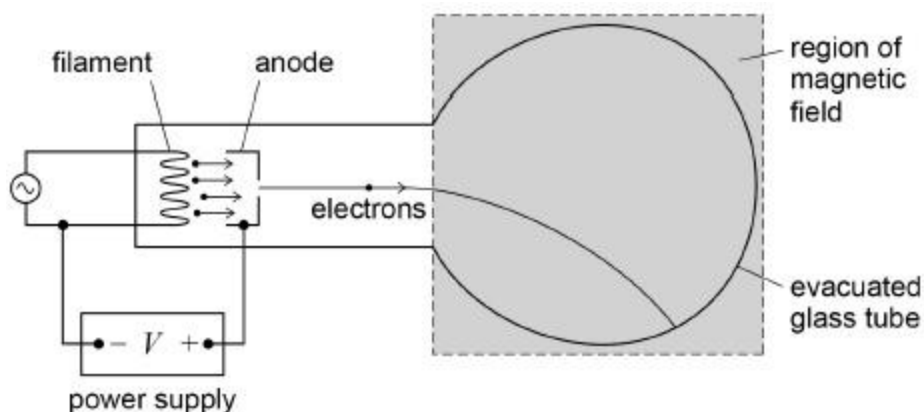
Name of the Student: _____

Max. Marks : 23 Marks

Time : 23 Minutes

Q1.

The diagram shows apparatus which can be used to determine the specific charge of an electron.



Electrons are emitted from the filament and accelerated by a potential difference between the filament and anode to produce a beam. The beam is deflected into a circular path by applying a magnetic field perpendicular to the plane of the diagram.

- (a) Describe the process that releases the electrons emitted at the filament.

(3)

- (b) The table shows the data collected when determining the specific charge of the electron by the method shown in the diagram.

potential difference V that accelerates the electrons	320 V
radius r of circular path of the electrons in the magnetic field	4.0 cm
flux density B of the applied magnetic field	1.5 mT

Show that the specific charge of the electron is given by the expression $\frac{2V}{B^2 r^2}$

(2)

- (c) Using data from the table, calculate a value for the specific charge of the electron. Give your answer to an appropriate number of significant figures.

specific charge of the electron = _____ C kg⁻¹

(2)

- (d) At the time when Thomson measured the specific charge of the particles in cathode rays, the largest specific charge known was that of the hydrogen ion.

State how Thomson's result for the specific charge of each particle within a cathode ray compared with that for the hydrogen ion and explain what he concluded about the nature of the particles.

(2)

(Total 9 marks)

Q2.

Figure 1 shows a modern version of the apparatus used by Hertz to investigate the properties of electromagnetic waves. Electromagnetic waves are continuously emitted from a dipole transmitter. The electromagnetic waves are detected by a dipole receiver.

An oscilloscope is used to display the amplitude of the detected signal at the dipole receiver.

Figure 1



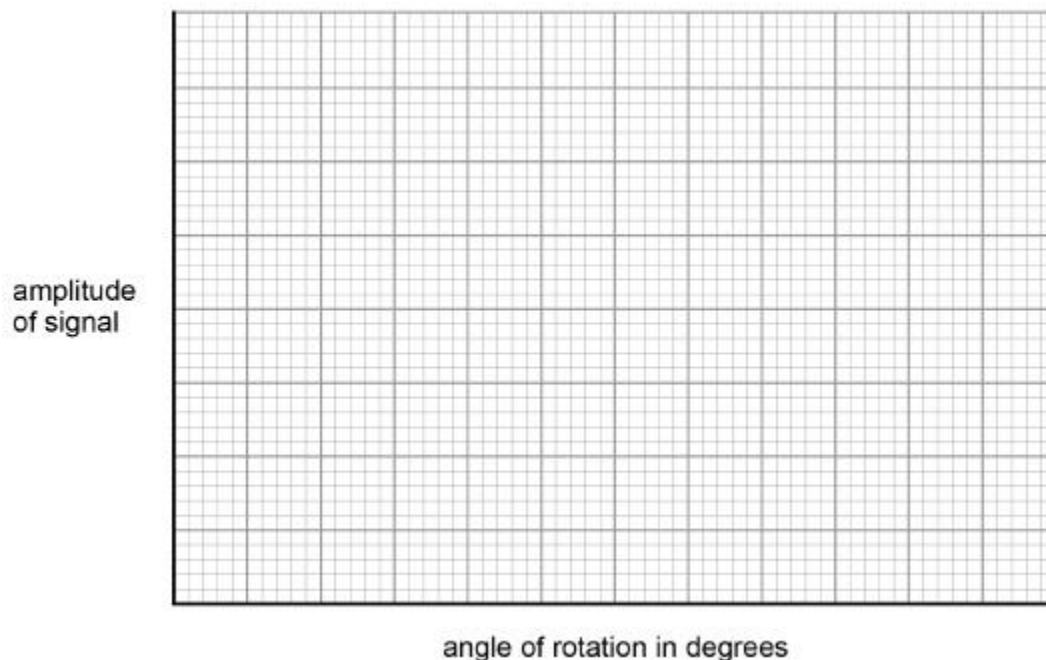
Figure 2 shows the same apparatus when the dipole receiver has been rotated through an angle of 90°

Figure 2



- (a) Sketch a graph on **Figure 3** to show how the amplitude detected by the dipole receiver varies with angle of rotation as the receiver is turned through 360° . Start your graph from the position shown in **Figure 1**.

Figure 3



- (b) Maxwell derived the equation $c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$ for the speed c of electromagnetic waves, where μ_0 is the permeability of free space and ϵ_0 is the permittivity of free space.

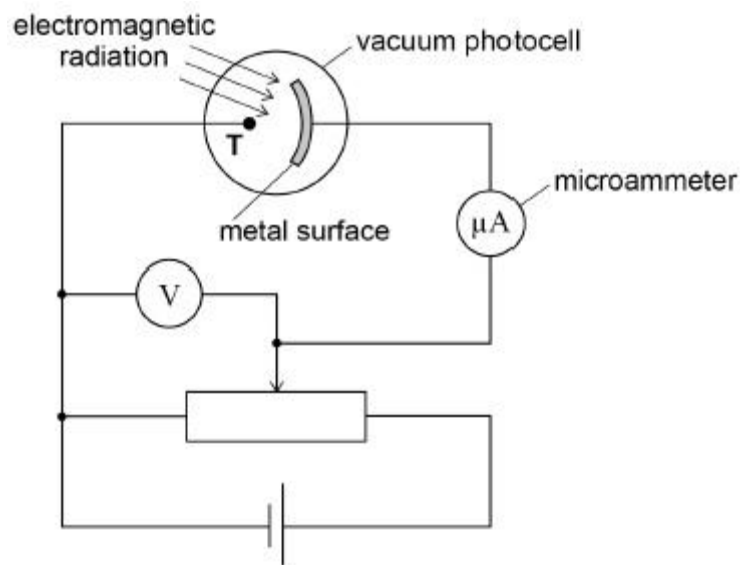
Explain, using a suitable calculation, why this equation led to the conclusion that light is an electromagnetic wave.

(2)

(Total 5 marks)

Q3.

The diagram shows a vacuum photocell in which a metal surface is illuminated by electromagnetic radiation of a single wavelength. Electrons emitted from the metal surface are collected by terminal **T** in the photocell. This results in a photocurrent, I , which is measured by the microammeter.



The potential divider is adjusted until the photocurrent is zero.

The potential difference shown on the voltmeter is 0.50 V

The work function of the metal surface is 6.2 eV

- (a) Calculate the wavelength, in nm, of the electromagnetic radiation incident on the metal surface.

wavelength = _____ nm

(3)

- (b) The intensity of the electromagnetic radiation is increased. No adjustment is made to the potential divider.

The classical wave model and the photon model make different predictions about the effect on the photocurrent.

Explain the effect on the photocurrent that each model predicts and how experimental observations confirm the photon model.

(3)

- (c) The potential divider in the diagram is returned to its original position so that a photocurrent is detected by the microammeter.
The potential divider is then adjusted to increase the potential difference shown on the voltmeter.

Explain why the photocurrent decreases when this adjustment to the potential divider is made.

(2)

- (d) The apparatus shown in the diagram above is used to investigate three different metal surfaces **A**, **B** and **C**.

The table shows, for each of the three surfaces, a voltmeter reading ***V*** and the corresponding photocurrent ***I***. The same source of electromagnetic radiation is used throughout the investigation.

<i>V/V</i>	<i>I/μA</i>
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Metal surface A	1.5	56
Metal surface B	2.5	56
Metal surface C	2.5	78

Which conclusion about the relationship between the work functions of **A**, **B** and **C** is correct?

Tick (✓) the correct box.

A > B > C.

☐

A < B < C.

☐

B > A > C.

☐

B < A < C.

☐

(1)

(Total 9 marks)