Name of the Student:_____
Max. Marks : 25 Marks **Time : 25 Minutes**

Q1.

When light of wavelength 590 nm is directed at an uncharged surface of a certain metal X, electrons are emitted from the metal surface causing a photoelectric current.

(a) When the metal surface is charged positively, the photoelectric current decreases and becomes zero when the potential of the surface is +0.35 V.

(i) Calculate the maximum kinetic energy of a photoelectron emitted from the surface when the metal surface is uncharged.

answer = _____ J

(2)

(ii) Calculate the work function of the metal surface, in J.

answer = _____ J

(3)

(b) When the experiment was repeated using a different metal, Y, illuminated by light of the same wavelength, there was no photoelectric emission when the metal surface was uncharged.

(i) Explain this observation.

_____

_____

(2)

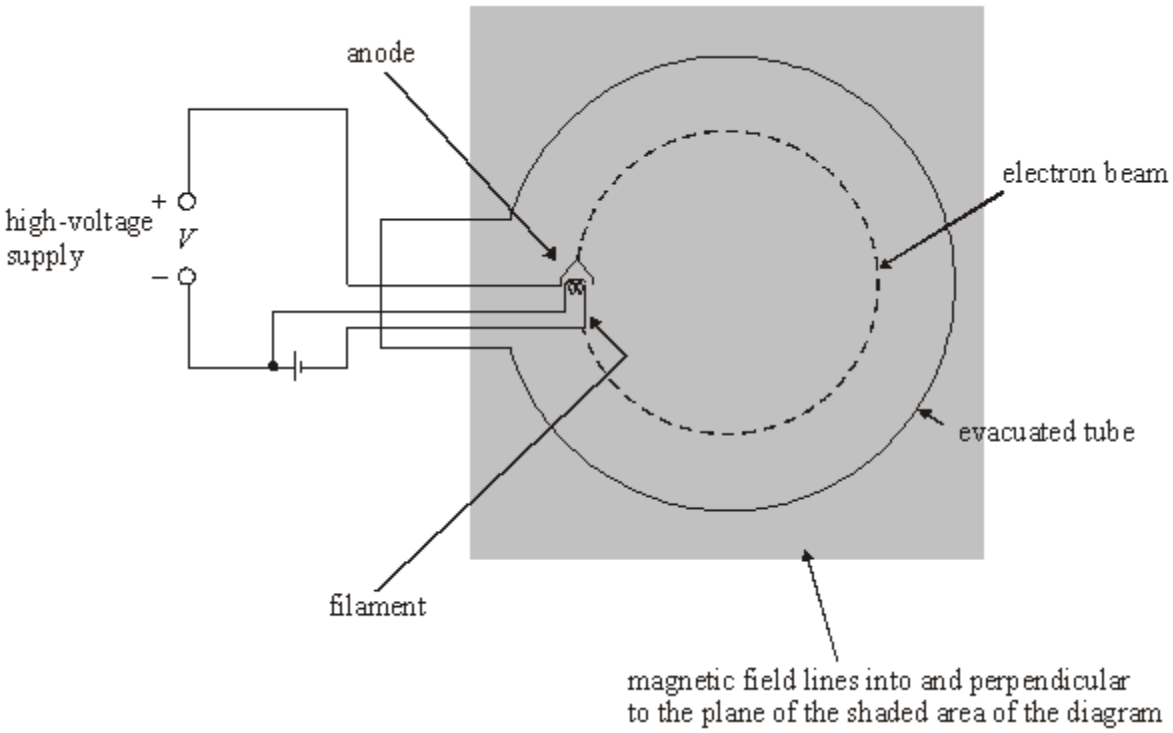
(ii) How did this observation contribute to the failure of the wave theory of light?

(2)

(Total 9 marks)

Q2.

The figure below shows an electron gun in an evacuated tube. Electrons emitted by *thermionic emission* from the metal filament are attracted to the metal anode which is at a fixed potential, *V*, relative to the filament. Some of the electrons pass though a small hole in the anode to form a beam which is directed into a uniform magnetic field.



(a) (i) Explain what is meant by thermionic emission.

(ii) Show that the speed, v, of the electrons in the beam is given by

$$v = \left(\frac{2eV}{m}\right)^{\frac{1}{2}}$$

where m is the mass of the electron and e is the charge of the electron.

(3)

(b) The beam of electrons travels through the field in a circular path at constant speed.

(i) Explain why the electrons travel at constant speed in the magnetic field.

(ii) Show that the radius, r, of the circular path of the beam in the field is given by

$$r = \left(\frac{2mV}{B^2e}\right)^{\frac{1}{2}}$$

where B is the magnetic flux density and V is the pd between the anode and the filament.

(iii) The arrangement described above was used to measure the specific charge of the electron, e/m. Use the following data to calculate e/m.

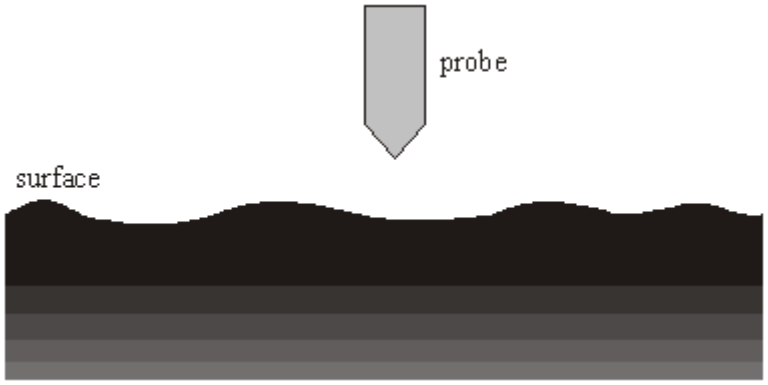
B = 3.1 mT
r = 25 mm
V = 530 V

(7)

(Total 10 marks)

Q3.

In a scanning tunnelling microscope (STM), a metal probe with a sharp tip is scanned across a surface, as shown in the figure below.



(a) Explain why electrons transfer between the tip of the probe and the surface when the gap between the tip and the surface is very narrow and a pd is applied across it.

(3)

(b) Describe how an STM is used to obtain an image of a surface.

(3)

(Total 6 marks)