Additional examination-style questions

1 **(a)** Describe, in terms of electric and magnetic fields, the nature of electromagnetic waves travelling in a vacuum. You may wish to draw a labelled diagram. *(3 marks)*

(b) Electrons are emitted from a metal plate when monochromatic light is incident on it, provided that the frequency of the light is greater than or equal to a threshold value.
You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

(i) How did Einstein explain this effect?

(ii) Discuss the significance of Einstein's explanation. *(4 marks)*

AQA 2006

2 **Figure 1** 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.

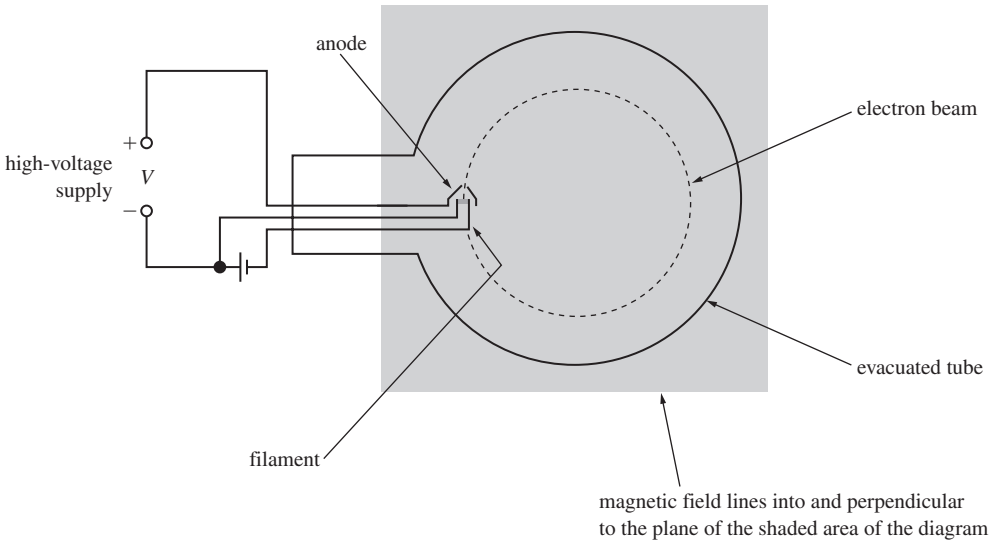

Figure 1

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

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

$$v = \frac{2eV^{½}}{m},$$

where m is the mass of the electron and e is the charge of the electron. *(3 marks)*

(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

$$r = \frac{2mV^{½}}{B^2e},$$

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 marks)

AQA 2006

3 π mesons, travelling in a straight line at a speed of 0.95 c, pass two detectors 34 m apart, as shown in **Figure 2**.

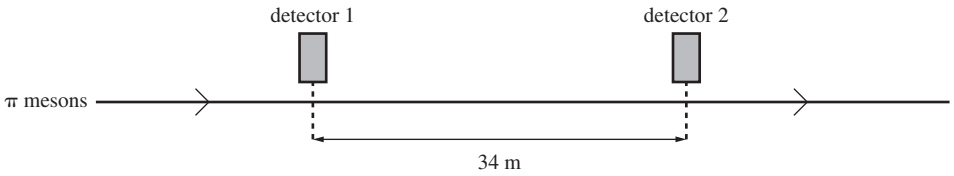

Figure 2

(a) Calculate the time taken, in the frame of reference of the detectors, for a π meson to travel between the two detectors.

(b) π mesons are unstable and decay with a half-life of 18 ns when at rest. Show that approximately 75% of the π mesons passing the first detector decay before they reach the second detector. *(5 marks)*

AQA 2006

4 A narrow beam of electrons, all with the same kinetic energy, is directed between two horizontal deflecting plates, X and Y, in a vacuum tube, as shown in **Figure 3**.

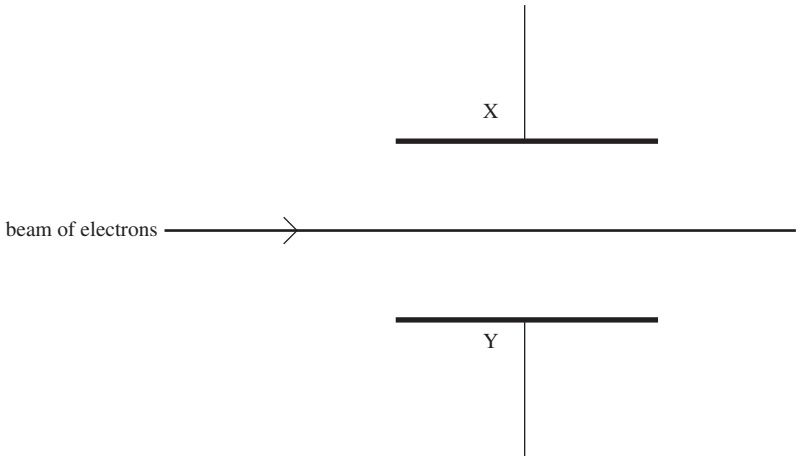

Figure 3

(a) State and explain the effect on the electron beam of applying a constant pd between X and Y, with X negative relative to Y. *(2 marks)*

(b) With a constant pd, V, between X and Y, a uniform magnetic field is applied perpendicular to the plane of the diagram between the plates. The magnetic flux density is adjusted to a certain value B_0, so that the beam is undeflected.

(i) Explain why the beam is undeflected at this value of the magnetic flux density.

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

$$v = \frac{V}{B_0 d},$$

where d is the perpendicular distance between plates X and Y. *(4 marks)*

(c) Electrons are accelerated from rest through a pd of 3800V to a speed of 3.7×10^7 m s^{-1}. Use this information to calculate the specific charge e/m of the electron. *(3 marks)*

AQA 2007

5 **Figure 4** shows a radio wave transmitter T and a detector D. The detector consists of a metal loop connected to a suitable meter.

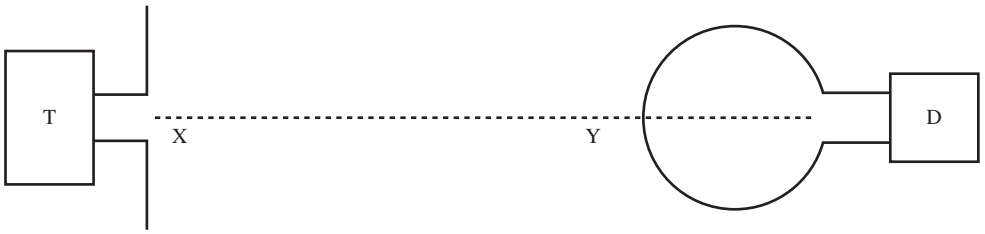

Figure 4

(a) Explain why radio waves from the transmitter induce an alternating emf in the metal loop. You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer. *(3 marks)*

(b) When the metal loop is rotated through 90° about the line XY, the detector signal falls to zero. Explain why the signal decreases and why it falls to zero. *(3 marks)*

AQA 2007

6 **Figure 5** represents the Michelson-Morley interferometer.

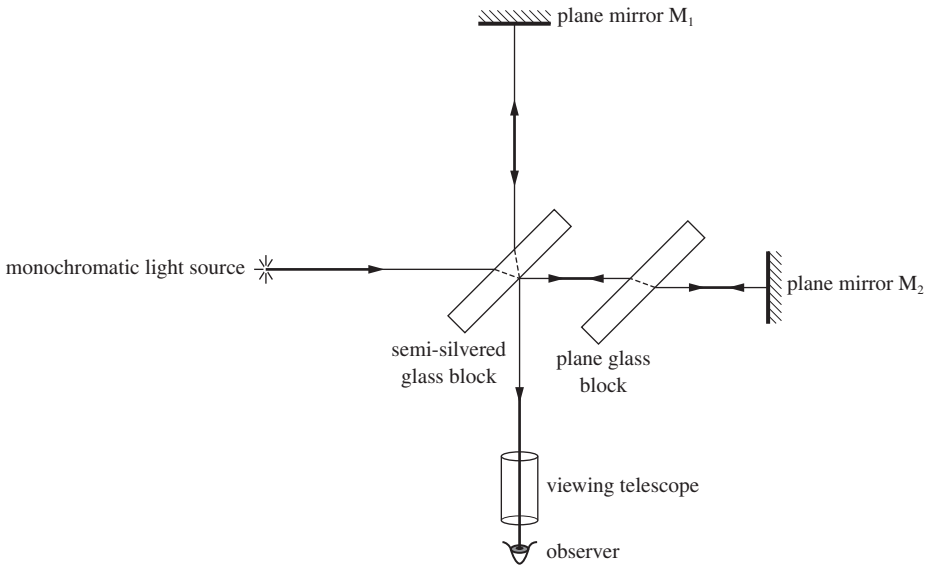

Figure 5

(a) **(i)** What was the principal purpose for which Michelson and Morley designed this apparatus?

(ii) Explain why interference fringes are observed through the telescope. *(3 marks)*

(b) Michelson and Morley expected the interference fringes would shift when the apparatus was rotated through 90°.

(i) Why was it thought that a fringe shift would be observed?

(ii) What conclusion did Michelson and Morley draw from the observation that the fringes did not shift? *(3 marks)*

AQA 2007

7 **Figure 6** shows a charged oil droplet between two oppositely-charged horizontal parallel plates X and Y which are 6.0 mm apart.

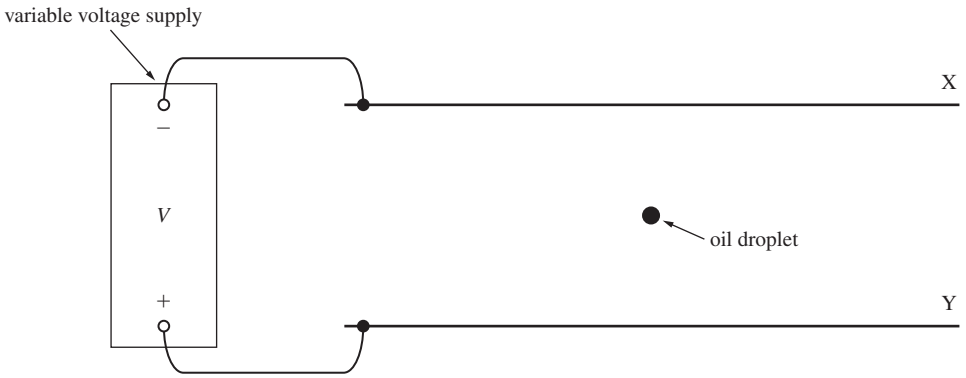

Figure 6

(a) When the potential difference between the two plates is zero, the droplet falls vertically at a steady speed of 7.8×10^{-5} m s^{-1}.

density of oil droplet = 960 kg m^{-3}
viscosity of air = 1.8×10^{-5} N s m^{-2}

(i) Explain why the droplet falls at a steady speed.

(ii) Show that the radius of the droplet is 8.2×10^{-7}m.

(iii) Show that the mass of the droplet is 2.2×10^{-15} kg. *(6 marks)*

(b) The potential difference between X and Y is adjusted until the droplet becomes stationary.

(i) Explain why the droplet becomes stationary.

(ii) The droplet is stationary when the potential difference is 410 V. Show that the charge of the droplet is 3.2×10^{-19} C .

(iii) Discuss the significance of this result and the results of similar tests on other charged droplets. *(5 marks)*

AQA 2008

8 A particle has a rest mass of 1.9×10^{-28} kg. Calculate

(i) the speed of the particle at which its mass would be 9.5×10^{-28} kg,

(ii) the kinetic energy, in J, of the particle at this speed. *(6 marks)*

AQA 2008