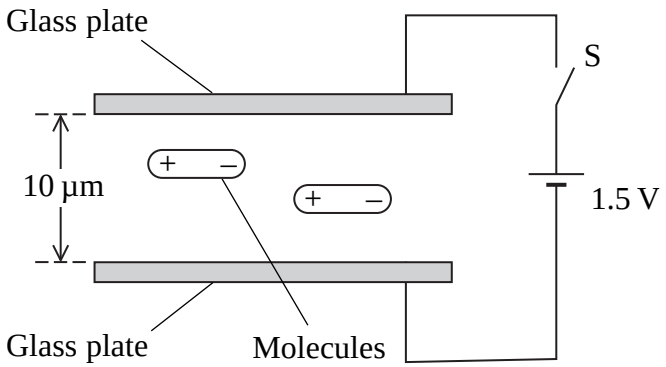
1 Liquid crystal displays (LCDs) are made from two parallel glass plates, 10 μm apart, with liquid crystal molecules between them. The glass is coated with a conducting material.



The molecules are positive at one end and negative at the other. They are normally aligned parallel with the glass plates as shown.

The switch S is closed and 1.5 V is applied across the glass plates.

(a) Calculate the electric field strength between the plates.

(2)

Electric field strength = ...

(b) Explain what happens to the liquid crystal molecules.

(3)

(Total for Question = 5 marks)

2 The diagram represents a proton.

(a) Draw lines to represent its electric field.

(3)

(b) Calculate the electrostatic force on the electron in a hydrogen atom.

Average distance between proton and electron = 5.4×10^{-11} m

(3)

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Force = ...

(Total for Question = 6 marks)

3 (a) Explain what is meant by a uniform electric field.

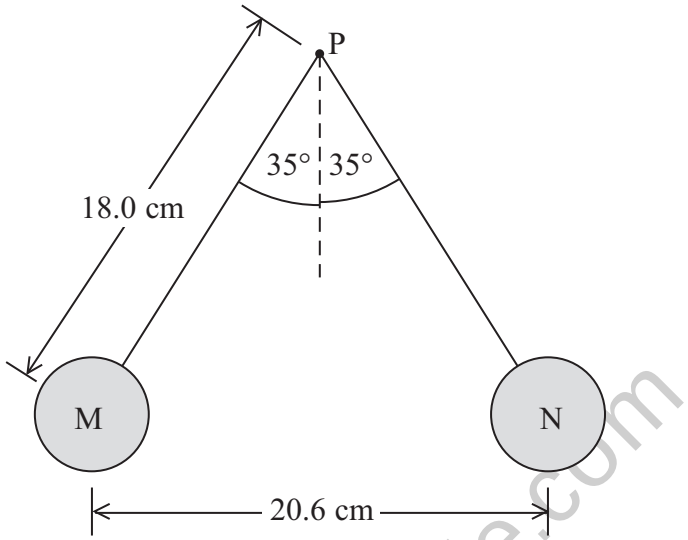
(2)

(b) Describe how a uniform electric field can be demonstrated in a laboratory.

(3)

(Total for Question = 5 marks)

4 Two identical table tennis balls, M and N, are attached to non-conducting threads and suspended from a point P. The balls are each given the same positive charge and they hang as shown in the diagram. The mass of each ball is 2.7 g.



(a) Draw a free-body force diagram for ball M, label your diagram with the names of the forces.

(2)

(b) (i) Show that the tension in one of the threads is about 3×10^{-2} N.

(3)

(ii) Show that the electrostatic force between the balls is about 2×10^{-2} N.

(2)

(iii) Calculate the charge on each ball.

(3)

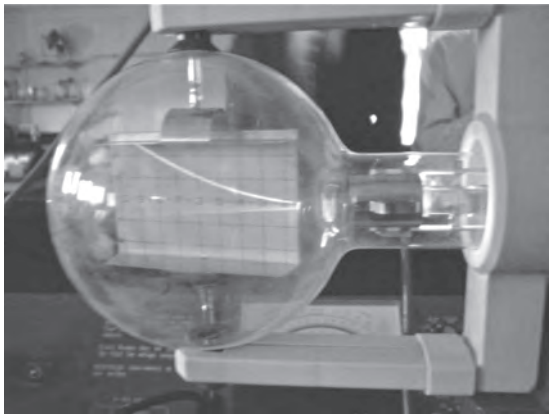
Charge = ...

(c) State and explain what would have happened if the charge given to ball M was greater than the charge given to ball N.

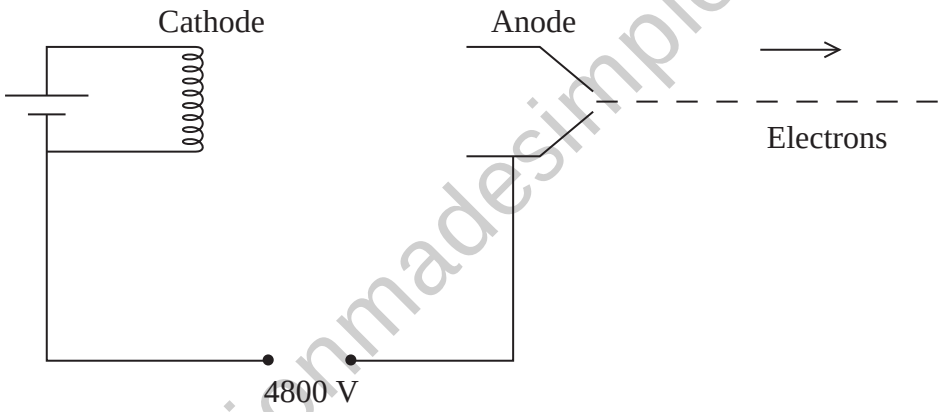
(2)

(Total for Question = 12 marks)

5 A teacher is using an electron beam tube to demonstrate the deflection of electrons in a uniform electric field.



A potential difference (p.d.) of 4800 V is applied between the cathode and anode of the tube. The cathode is heated and electrons are emitted from its surface. These electrons are then accelerated from rest and pass through a hole in the anode.



(a) State the name of the process by which electrons are emitted from the cathode.

(1)

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(b) Show that the speed v of the electrons as they leave the anode is about 4×10^7 m s^{-1}.

(3)

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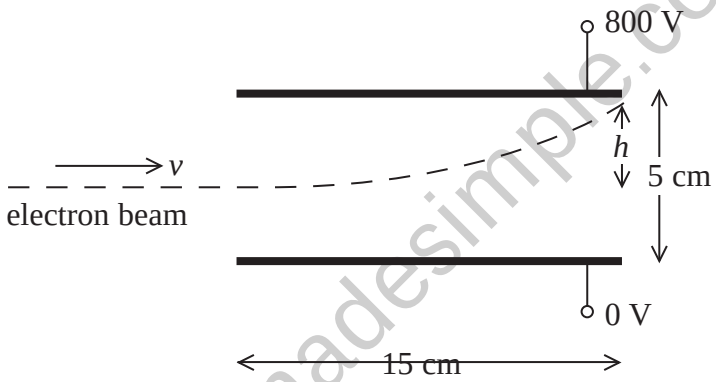
(c) After leaving the anode, the electrons follow a parabolic path as they pass between a pair of parallel plates with a p.d. of 800 V between them. There is a uniform electric field between the plates.



(i) Calculate the force due to the electric field that acts on an electron while it is between the plates.

(3)

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Force = ...

(ii) An electron experiences an upward acceleration a as it travels between the plates. Its vertical displacement h after a time t is given by

$$h = \frac{1}{2} at^2$$

Calculate the value of h as the electron leaves the plates.

(4)

h = ...

(d) (i) Keeping the p.d. between the cathode and anode at 4800 V, the p.d. between the parallel plates is decreased.
Draw the new path of the electrons on the diagram in (c). Label this path A.

(1)

(ii) Keeping the p.d. between the parallel plates at 800 V, the p.d. between the cathode and anode is decreased.
Draw the new path of the electrons on the diagram in (c). Label this path B.

(1)

(Total for Question = 13 marks)