Electric Fields - 2

1.

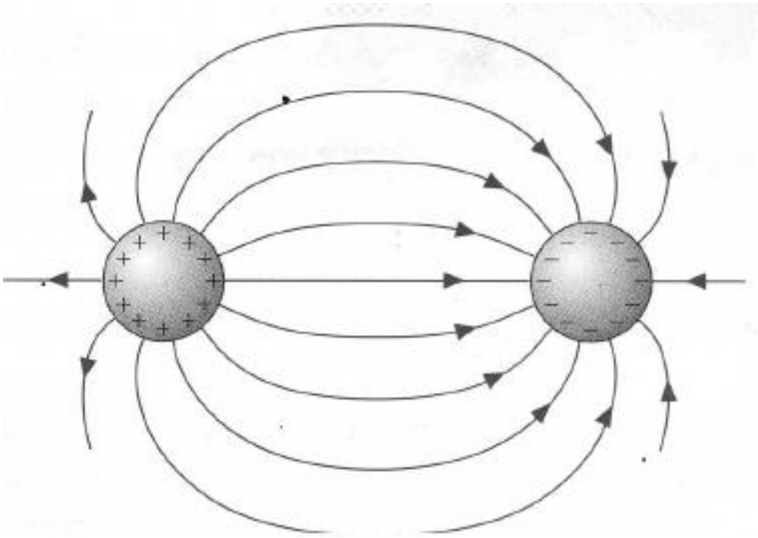

Fig. 3

There is an electric field at the positively charged sphere in Figure 3. This is caused by the negatively charged sphere. The sphere carries a charge of $+5.0 \times 10^{-9}$ C. It experiences a force of magnitude 1.4×10^{-4} N.

(a) Calculate the electric field strength at the positive sphere.

(b) Calculate the force on the negatively charged sphere.

2.

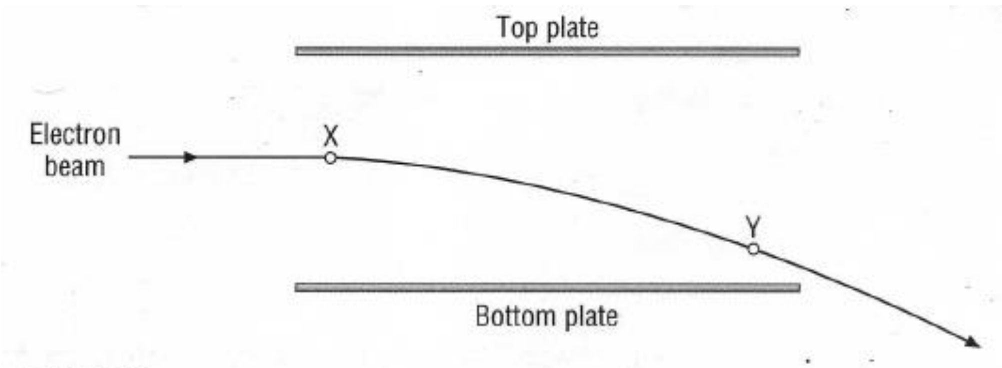

Figure 7

Copy Figure 7, which shows an electron beam passing between a pair of parallel conducting plates.

(a) Label the plates positive and negative.

(b) Draw arrows to indicate the relative magnitudes and directions of the force on the electron beam at points X and Y.

(c) The electric field strength between the plates is 8.0×10^4 N C^{-1}. Calculate the magnitude of the force on an electron at point X.

3.

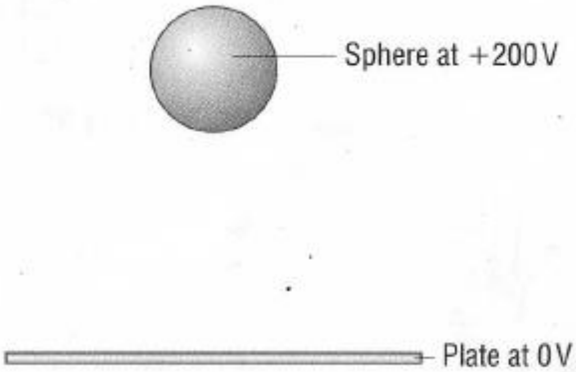

Figure 8

Figure 8 shows a positively charged metal sphere held above an earthed metal plate, that is, held at 0 V.
Copy the diagram and draw at least five electric field lines between the sphere and the plate.

4.

In a classical model of a hydrogen atom, the electron revolves around the proton in a circle of radius 5.3×10^{-11} m. What force does the proton exert on the electron?

5.

Oil of density 810 kg m^{-3} is sprayed as a fine mist into the space between two horizontal parallel plates, which are 5.0 mm apart. One oil droplet of radius 5.6×10^{-7} m has a charge on it equal to the charge on a single electron. This droplet is observed through a microscope to remain stationary between the plates when there is a potential difference of 183 V across the plates, as shown in Figure 3. Calculate the charge on an electron.

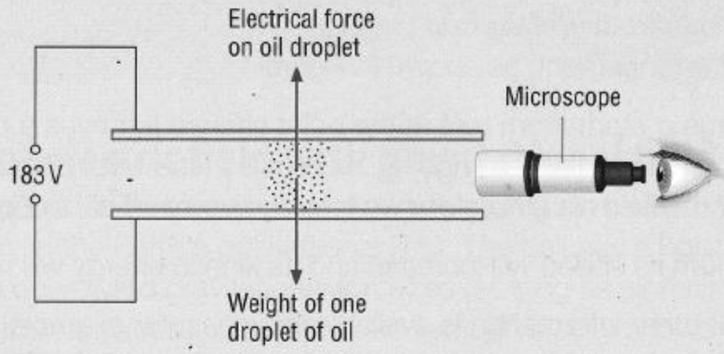

Figure 3 A fine mist of oil drops is viewed in an electric field

6.

The force between two equal point charges of 6.0×10^{-12} C a distance of 9.0 mm apart is 4.0×10^{-9} N.

(a) Calculate the force between the charges when **(i)** one charge changes to 9.0×10^{-12} C or **(ii)** the distance between them changes to 12 mm.

(b) Calculate the magnitude of the electric field strength at either charge.

(c) Use Coulomb's law and the definition of electric field strength to show that the electric field strength E at a distance r from a point charge Q is given by $E = kQ/r^2$.

7.

In a cathode-ray tube, electrons leave a cathode (which is negative) and are accelerated for a distance of 4.0 cm by a uniform electric field of electric field strength 1.20×10^5 N C^{-1} (Figure 3). They then pass through a hole in the anode (which is positive) and enter a region in which the electric field strength is zero. Calculate:

(a) the speed of an electron when it reaches the anode

(b) the time it takes to reach the screen of the cathode-ray tube, that is 28 cm from the anode.

8.

Two horizontal parallel metal plates, 1.2×10^{-2} m apart, are connected to a 600 V power supply.

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

(b) A tiny sphere of weight 3.3×10^{-14} N has acquired a charge so that it is held in equilibrium midway between the plates by the electric field as shown in Figure 4.

(i) State the magnitude and direction of the electric force on the sphere.

(ii) Calculate the magnitude of the charge on the sphere.

(iii) The voltage between the plates is suddenly doubled. Describe the motion of the sphere.

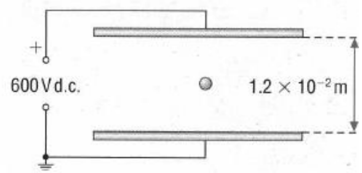

Figure 4

9.

Show that the units of magnetic flux density, usually T (tesla), can be written as N s C^{-1} m^{-1}.

10.

Figure 4 shows the directions of the current I in a short section of wire and the magnetic flux density B at the wire.

(a) The current is in the direction H–G. In which direction is the force on the wire?

(b) The free electrons are drifting in the direction G–H. In which direction is the average force on them?

(c) The wire carries a current of 0.24 A. The length of wire in the magnetic field is 60 mm. The magnetic flux density B is 30 mT. Calculate the force on the wire.

(d) Through what angle must the wire be rotated and in which plane to reduce the force on the wire to **(i)** half the value in (c) and **(ii)** zero?

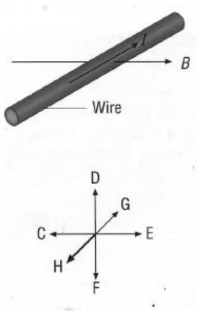

Figure 4

11.

In a particle accelerator, protons are accelerated from rest in a vacuum by a potential difference (p.d.) V and then directed at right angles into a magnetic field of flux density 0.039 T. They travel in a semicircle that must have a radius less than 0.63 m if they are to remain within the magnetic field.

(a) What is the maximum value of V that can be used to satisfy this condition?

(b) How long does a proton take to complete a semicircle of the maximum allowed radius?

12.

Here are three possible paths of an electron in a vacuum: A straight line, B circular path, C parabolic path. Which path best describes the motion of an electron initially moving:

(a) at right angles to a magnetic field, **(b)** at right angles to an electric field and **(c)** parallel to a magnetic field?

13.

(a) Calculate the magnitude of the force on an electron moving at 2.0×10^7 m s^{-1} as it enters a region of uniform magnetic field of flux density 5.0×10^{-3} T perpendicular to its path.

(b) Calculate the acceleration of the electron and hence the radius of its orbit in the field.

14.

Figure 5 shows a beam of protons passing through a hole into a region where there is a uniform electric field of strength E.

(a) Copy the diagram and sketch on it a possible path for the protons.

(b) A uniform magnetic field of flux density B is now applied at right angles (into the plane of the diagram), and the electric field is switched off. Sketch a possible path for the protons.

(c) The electric field is switched on again. Explain why it is now possible for some of the protons to pass undeflected to the detector.

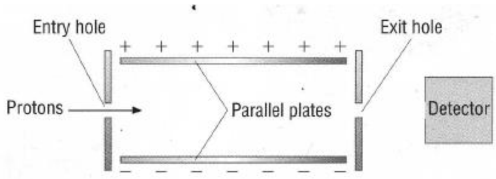

Figure 5

15.

The fuel in nuclear fission reactors to generate electricity is $^{235}_{92}U$. In natural uranium over 99% is $^{238}_{92}U$ and only 0.7% is $^{235}_{92}U$. In one 'separation process', each atom of natural uranium is combined with six atoms of fluorine to make the molecule UF_6. The molecules are ionised and, using a velocity selector, made into a beam of particles each with the same velocity.

(a) Explain why the UF_6 ions of $^{238}_{92}U$ have more momentum than those of $^{235}_{92}U$.

(b) The ion beam passes through a region of uniform magnetic field directed at right angles to their velocity as shown in Figure 6 before being collected in a trap.
The figure shows the path of the UF_6 ions of $^{235}_{92}U$. Copy the diagram and add the path of the UF_6 ions of $^{238}_{92}U$.

(c) Hence explain how this device works as a separator. Why would UF_6 ions of $^{238}_{92}U$ reach the collector if the apparatus was not kept under a good vacuum?

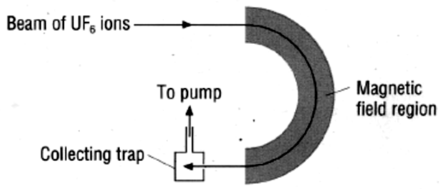

Figure 6

16.

A large ion of mass 5.8×10^9 u and charge $+18e$ is accelerated constantly towards a detector by a potential difference of 870 V. Assuming the ion starts from rest, calculate the time taken for the ion to travel 47 cm to the detector.
