Answers - Electric Fields - 2

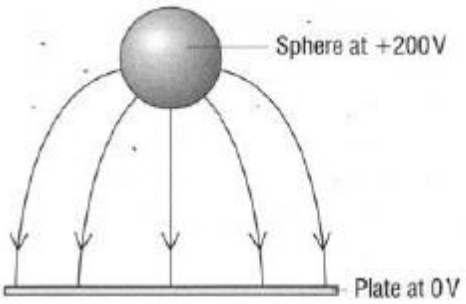
1.

(a) 2.8×10^{4} N C^{-1}
(b) 1.4×10^{-4} N towards the positive sphere

2.

(a) Top plate negative, bottom positive
(b) Vertical downward arrows of equal length
(c) 1.3×10^{-14} N

3.



4.

The charge on a proton is $+1.60 \times 10^{-19}$ C, and the equal and opposite charge on the electron is -1.60×10^{-19} C. Substituting into the equation for force gives

$$F = \frac{+1.60 \times 10^{-19}\ \text{C} \times -1.60 \times 10^{-19}\ \text{C}}{4\pi \times 8.85 \times 10^{-12}\ \text{C}^2\ \text{m}^{-2}\ \text{N}^{-1} \times (5.3 \times 10^{-11}\ \text{m})^2} = -8.19 \times 10^{-8}\ \text{N}$$

Note how the units coulomb (C) and metre (m) cancel to give the answer in newtons. The negative sign shows the force to be in the opposite direction to *r*. Therefore the force is inwards and hence attractive, thus causing the centripetal acceleration of the electron.

5.

volume of droplet = volume of a sphere of radius r
$= 4\pi r^3/3 = 4\pi \times (5.6 \times 10^{-7})^3/3 = 7.36 \times 10^{-19}\ m^3$
mass of droplet = $7.36 \times 10^{-19}\ m^3 \times 810\ kg\ m^{-3} = 5.96 \times 10^{-16}\ kg$
weight of droplet = $mg = 5.96 \times 10^{-16}\ kg \times 9.81\ N\ kg^{-1} = 5.84 \times 10^{-15}\ N$

Since the droplet is stationary, the weight of the droplet acting downwards must be balanced by the electrical force acting upwards.

From the definition of electric field strength, $E = F/q$

giving $Eq = 5.84 \times 10^{-15}$.

Now, using the other way of finding the field, $E = V/d = 183\ V/0.0050\ m$
$= 36\,600\ V\ m^{-1}$.

Finally, $36\,600 \times q = 5.84 \times 10^{-15}$ and $q = 5.84 \times 10^{-15}/36\,600 = 1.60 \times 10^{-19}\ C$.

6.

(a) **(i)** 6.0×10^{-9} N; **(ii)** 2.25×10^{-9} N;
(b) 670 N C^{-1}

7.

(a) Electric field strength = V/d, therefore $V = 1.20 \times 10^5 \times 0.040 = 4800$ V or 4800 J/C.
The charge on an electron is 1.6×10^{-19} C.
Energy gained = $4800\ J/C \times 1.60 \times 10^{-19}\ C = 7.68 \times 10^{-16}$ J.
This is the kinetic energy of the electron, that is,
$7.68 \times 10^{-16} = \frac{1}{2} mv^2 = 0.5 \times 9.11 \times 10^{-31} \times v^2$, giving

$$v = \sqrt{\frac{2 \times 7.68 \times 10^{-16}}{9.11 \times 10^{-31}}} = 4.11 \times 10^7\ m\ s^{-1}$$

(b) The electron then coasts at constant speed until it reaches the screen.
Time taken = $0.28\ m/4.11 \times 10^7\ m\ s^{-1} = 6.8 \times 10^{-9}$ s.

8.

(a) 5.0×10^4 N C^{-1};
(b) **(i)** 3.3×10^{-14} N upwards;
(ii) $6.6. \times 10^{-19}$ C;
(iii) accelerates upwards until it hits the top plate.

10.

(a) DF; **(b)** DF; **(c)** 4.3×10^{-4} N;

(d) **(i)** Rotate the wire clockwise (viewed in the direction DF) through 60° in the plane CGEH;

(ii) Rotate another 30° to make the wire lie in the direction CE.

11.

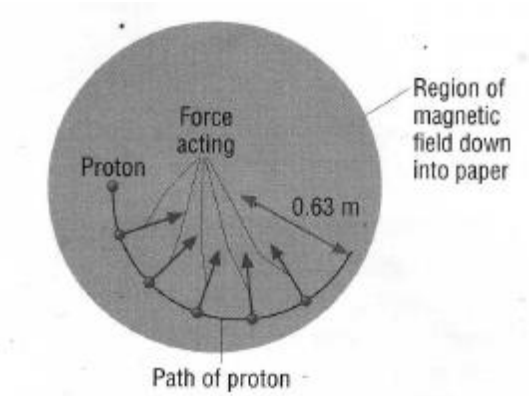


Figure 2 A proton moves in a circle in a magnetic field that is downwards into the page

A diagram showing the arrangement is drawn in Figure 2.

The proton has mass 1.67×10^{-27} kg and charge $+1.60 \times 10^{-19}$ C.

(a) For the limiting condition, when the radius is 0.63 m, the velocity v can be obtained from

$$v = \frac{rBQ}{m} = \frac{0.63 \times 0.039 \times 1.60 \times 10^{-19}}{1.67 \times 10^{-27}} = 2.35 \times 10^{6} \text{ m s}^{-1}$$

The work done on the proton by the p.d. V is QV, and this becomes the kinetic energy of the electron.

So $\frac{1}{2} mv^2 = QV$, giving

$$V = \frac{mv^2}{2Q} = 1.67 \times 10^{-27} \times \frac{2.35 \times 10^{62}}{2 \times 1.60 \times 10^{-19}} = 2.89 \times 10^{4} \text{ V}$$

(b) For a radius of 0.63 m, the semicircle will have a length $\pi \times 0.63 = 1.98$ m. At speed 2.35×10^{6} m s^{-1}, this distance will therefore take a time of $1.98/2.35 \times 10^{6} = 0.842$ μs.

12.

(a) B; **(b)** C; **(c)** A.

13.

(a) 1.6×10^{-14} N;
(b) 1.8×10^{16} m s^{-2}, 2.2 cm

14.

(a) Parabolic path bending downwards.
(b) Circular path bending upwards initially.
(c) Sum of forces exerted by magnetic and electric forces on proton is 0; no net force on proton so it moves at constant velocity.

15.

(a) Same velocity but greater mass;
(b) Circle of larger radius, so passes beneath collector trap;
(c) Collisions with air molecules could change the velocity or charge of the ions, causing some to enter the collecting trap.

16.

0.0414 s
