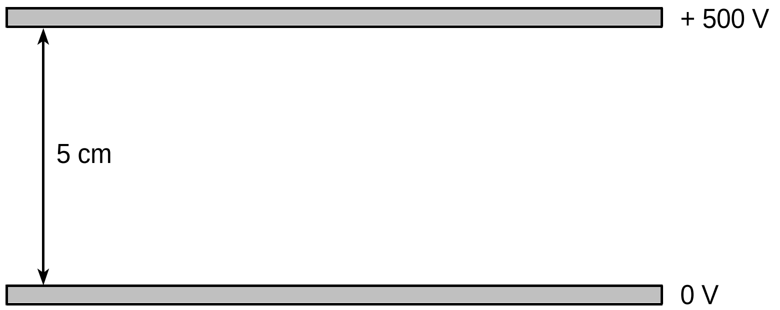
TAP 409-3: Uniform electric fields

Data required:

charge of electron = 1.6×10^{-19} C

mass of electron = 9.11×10^{-31} kg.

1) Here are two closely spaced metal plates connected to a 500 V supply.



Draw solid lines to represent the electric field both between the plates and just outside the plates. Add arrows to indicate the direction of the field.

2) Add, and label, dotted lines to the diagram of question 1, to represent lines of equipotential at 100 V intervals.

3) In an experiment to measure the charge on an oil drop, the potential difference between two parallel metal plates 5 mm apart was 300 V.

a) Calculate the electric field strength between the plates.

b) Calculate the electrical force on a small oil drop carrying a charge of 3.2×10^{-18} C.

4) Calculate the energy, in joules, gained by an electron accelerated through a potential difference of 50 kV in an X-ray machine.

5) Calculate the speed of an electron with a kinetic energy of 100 eV.

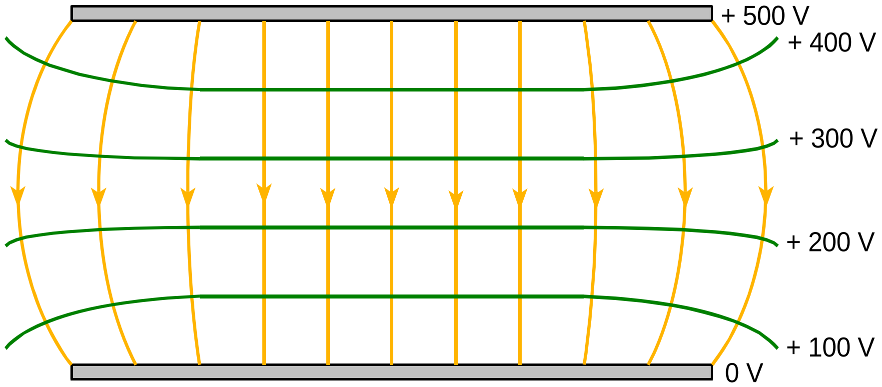
Hints

3. Remember to convert millimetres to metres.
4. Use the magnitude of the electronic charge. The negative sign is best ignored in this calculation.
5. Remember to convert the electron volts into joules.

Practical advice

These questions are intended to be easy, to reinforce understanding and to build confidence

Answers and worked solutions



2) Green lines above (without arrows).

3)

a) $E = V/d = 300 / 0.005 = 6 \times 10^4$ V m^{-1}.

b) $F = EQ = 6 \times 10^4 \times 3.2 \times 10^{-18} = 1.92 \times 10^{-13}$ N

4) $W = QV = 1.6 \times 10^{-19} \times 50{,}000 = 8 \times 10^{-15}$ J

5) The energy gained will have a positive value. Both the charge and the potential difference are negative:

$$\begin{aligned} 100 \text{ eV} &= 100 \times (1.6 \times 10^{-19} \text{ J}) \\ &= 1.6 \times 10^{-17} \text{ J} \\ \tfrac{1}{2}mv^2 &= 1.6 \times 10^{-17} \text{ J} \end{aligned}$$

so

$$\begin{aligned} v &= \{[2 \times (1.6 \times 10^{-17} \text{ J})]/(9.1 \times 10^{-31} \text{ kg})\}^{1/2} \\ &= 5.9 \times 10^{6} \text{ m s}^{-1}. \end{aligned}$$

External reference

This activity is taken from Advancing Physics chapter 16, 10W