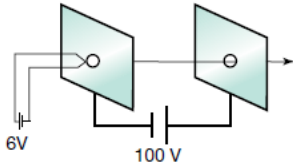# Energy in electric fields.

1. Electrons from a hot filament are emitted into the space between two parallel plates and are accelerated across the space between them.

6V

100 V

(a) How much energy would be gained by an electron in crossing the space between the plates in Joules and electronvolts?

(b) How would your answer to (a) change if the plate separation was halved?

(c) How would your answer to (b) change if the terminals of the 100 V battery were reversed?

(d) How would the size of the electric field between the plates, and thus the electric force on the electron, change if the plate separation was halved?

(e) Explain how your answers to (b) and (d) are connected.

2. How much work is required to carry electron from the positive terminal of a 12V battery to the negative terminal?

3. How much electrical potential energy does a proton lose as it falls through potential difference of 5 kV?

4. Two parallel plates are positioned 12 cm apart and connected to a 24 V DC power supply. This creates an electric field between the plates.
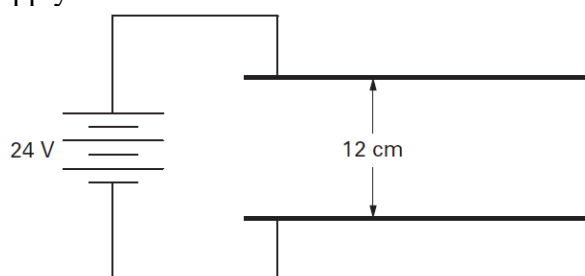
a Calculate the strength of the electric field between the plates.

b Which of the following will happen to an electron placed at rest next to the positive plate?
A The electron will move towards the negative plate.
B The electron will move to a position equidistant from the positive and negative plates.
C The electron will remain where it is.
D The electron will drift out of the region of the plates.

c Which of the following will happen to a neutron placed at rest next to the negative plate?
A The neutron will move towards the positive plate.
B The neutron will move to a position equidistant from the positive and negative plates.
C The neutron will remain where it is.
D The neutron will drift out of the region of the plates.

d An electron is moved from next to the positive plate to next to the negative plate. Calculate the energy gained by the electron in electron volts.

e What is the size of the force exerted on the electron in **d**?

f Draw the electric field pattern between the two plates in this diagram.

5. A charge of 114 μC is moved from point X to point Y and requires 2.8×10^{-5} J of work to be done on it.
a What is the electric potential difference between the two points?

b Which point is at a higher potential, X or Y? Justify your answer.

c What is the direction of the electric field? Justify your answer.

6. Two parallel metal plates are separated by 20 mm and have a voltage of 120 V between them.
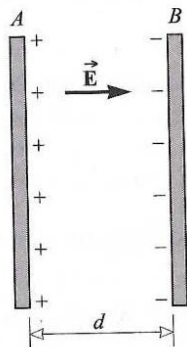**a** What is the size of the electric field between the plates?

b How much work is done (in joules) to move an electron from the positive plate to the negative plate?

c How much potential energy would the electron in **b** gain?

d If the electron is released at the negative plate, what speed will it have when it reaches the positive plate?

7. In the figure below let E = 2.0 kV/m and d = 5.0 mm.

A proton with the mass $m = 1.67 \times 10^{-27}$ kg is shot from plate B towards plate A with initial speed of 100 km/s. What will be its speed just before it strikes plate A?

8. Two parallel metal plates separated by 2.4 cm have a potential difference of 100 V between them. An electron with speed 4×10^6 m/s passes perpendicular through a hole in the positive plate. How far from the positive plate will it travel?

9. In an inkjet printer, small drops of ink are given a controlled charge and fired between two charged plates. The electric field deflects each drop and thus controls where the drop lands on the page. Let m = the mass of the drop, q = the charge of the drop, v = the speed of the drop, l = the horizontal length of the plate crossed by the drop, and E = electric field strength.
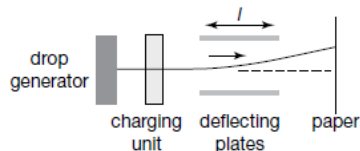
(a) Develop an expression for the deflection of the drop. Ignore the gravity.

(b) With the values $m = 1.0 \times 10^{-10}$ kg, $v = 20$ m/ s, $l = 1.0$ cm and $E = 1.2 \times 10^6$ N/C, calculate the charge required on the drop to produce a deflection of 1.2 mm.