Higher Electric Fields Questions

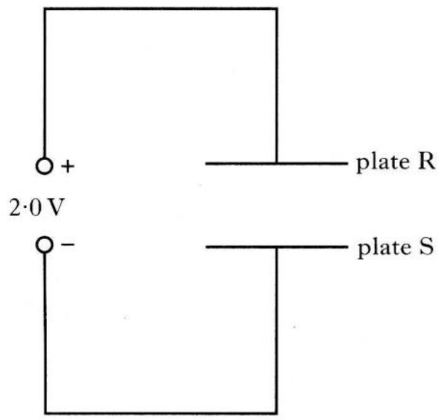
Data required: Mass of an electron = 9.11 x 10^{-31}kg. **(In Data Book)**

Charge on an electron = (-) 1.6 x10^{-19}C. **(In Data Book)**

Mass of a proton = 1.673 x 10^{-27}kg. **(In Data Book)**

Charge on a proton = 1.6 x10^{-19}C. **(Not in Data Book!!!)**

1. Two parallel metal plates R and S are connected to a **2.0V** dc supply as shown below.



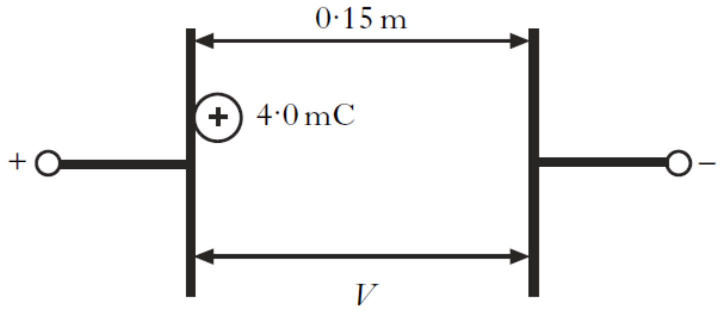
a) **Draw the electric field pattern** between the plates R and S.
b) **Calculate the gain in potential energy** of the electron as it is moved from plate R to plate S.

2. An electron is accelerated through a potential difference of **2.6kV**.

Calculate the kinetic energy gained by the electron.

3. A potential difference V is applied between two metal plates which are **0.15m apart**.

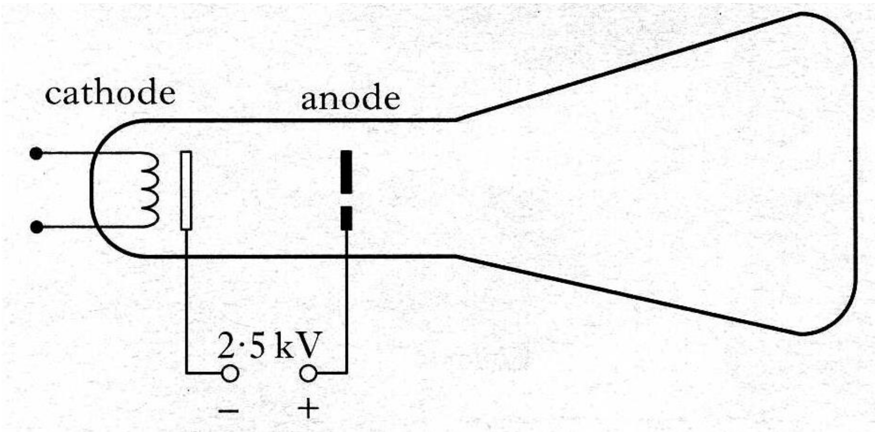
A charge of **+4.0 x10^{-3}C** is released from rest at the positively charged plate as shown below.



Calculate the potential difference between the plates if the charge hits the negative plate with a **kinetic energy of 8.0J**.

4. The diagram below shows an arrangement to accelerate electrons.

The potential difference between the cathode and the anode is **2.5kV**.

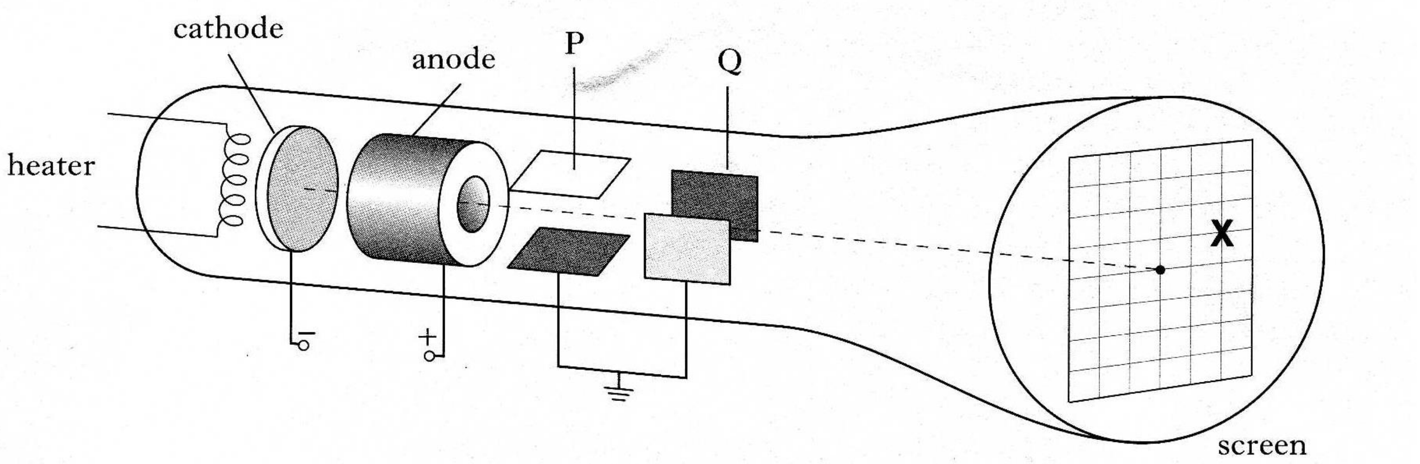


a) **Explain how** the electron accelerates between the cathode and the anode.

b) **Calculate the speed of an electron** when it reaches the anode, if it is initially at rest at the cathode.

5.

The diagram below shows a cathode ray tube used in an oscilloscope.



The electrons which are emitted from the cathode start from rest and reach the anode with a speed of $4 \cdot 2 \times 10^7\ m\,s^{-1}$.

(*a*) (i) Calculate the kinetic energy in joules of each electron just before is reaches the anode.

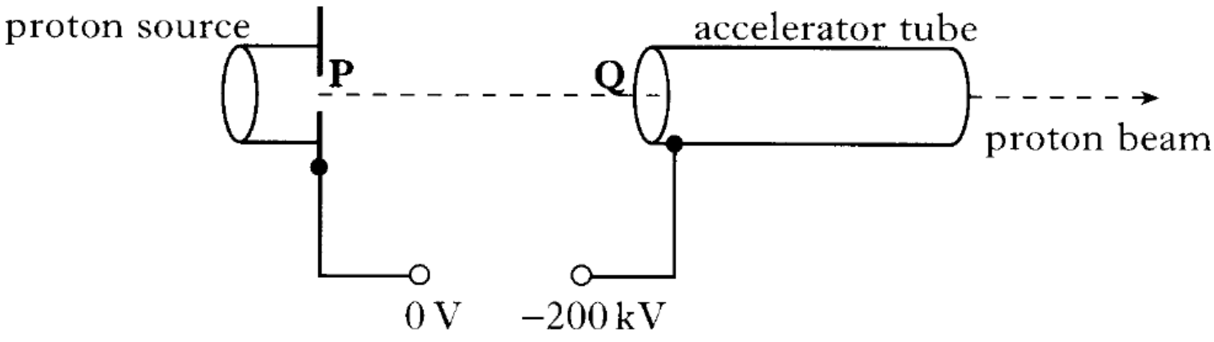
(ii) Calculate the p.d. between the anode and the cathode.

(*b*) Describe how the spot at the centre of the screen produced by the electrons can be moved to position **X**.

Your answer must make reference to the relative sizes and polarity (signs) of the voltages applied to plates P and Q.

6.

The diagram below shows the basic features of a proton accelerator. It is enclosed in an evacuated container.



Protons released from the proton source start from rest at **P**.
A potential difference of 200 kV is maintained between **P** and **Q**.

(*a*) What is meant by the term *potential difference of 200 kV*?

(*b*) Explain why protons released at **P** are accelerated towards **Q**.

(*c*) Calculate:

(i) the work done on a proton as it accelerates from **P** to **Q**;

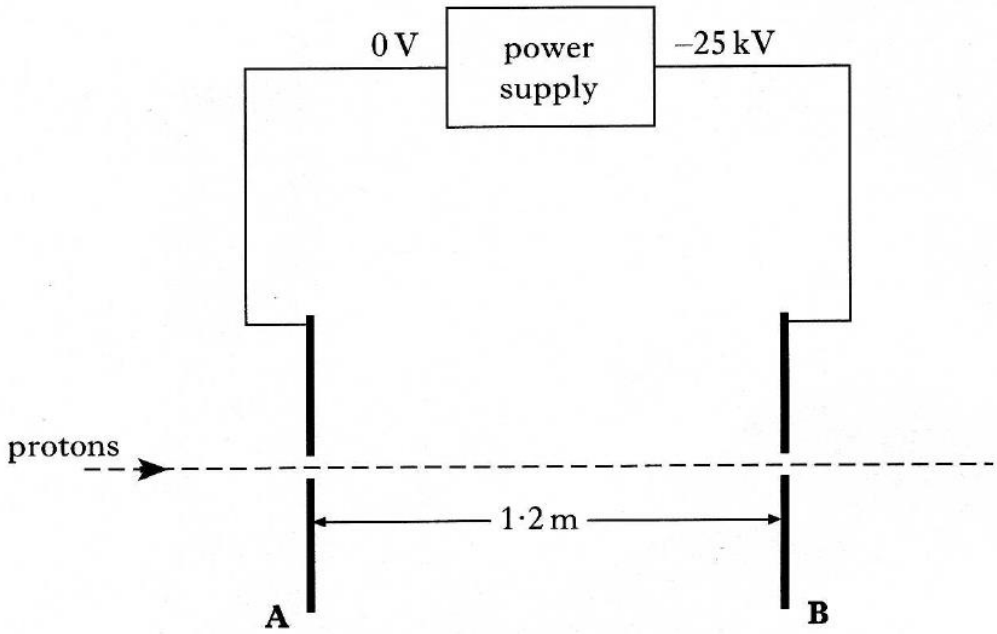
(ii) the speed of a proton as it reaches **Q**.

(*d*) The distance between **P** and **Q** is now halved.

What effect, if any, does this change have on the speed of a proton as it reaches **Q**? Justify your answer.

7.

A particle accelerator increases the speed of protons by accelerating them between a pair of parallel metal plates, **A** and **B**, connected to a power supply as shown below.



The potential difference between **A** and **B** is 25 kV.

(*a*) Show that the kinetic energy gained by a proton between plates **A** and **B** is $4{\cdot}0 \times 10^{-15}$ J.

(*b*) The kinetic energy of a proton at plate **A** is $1{\cdot}3 \times 10^{-16}$ J.

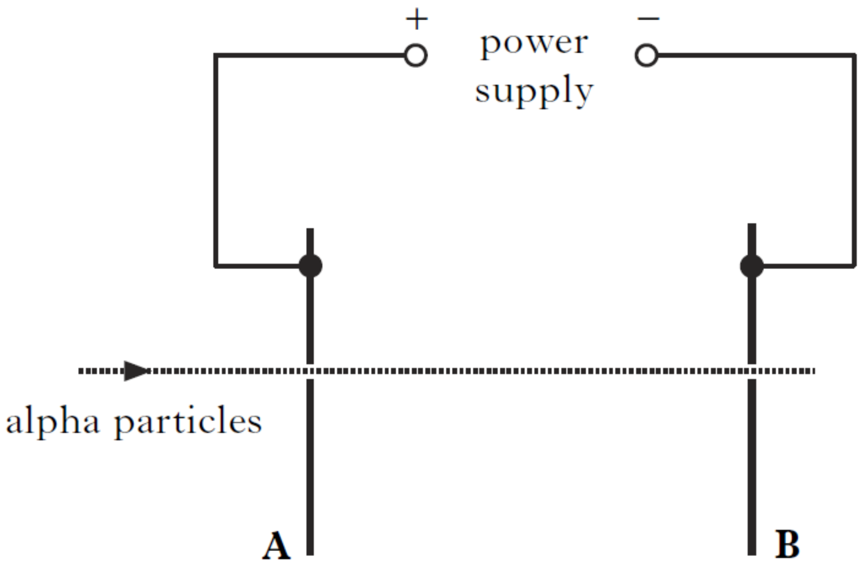
Calculate the velocity of the proton on reaching plate **B**.

(*c*) The plates are separated by a distance of 1·2 m.

Calculate the force produced by the particle accelerator on a proton as it travels between plates **A** and **B**.

8.

The apparatus shown in the diagram is designed to accelerate alpha particles.



An alpha particle travelling at a speed of $2{\cdot}60 \times 10^{6}\,\mathrm{m\,s^{-1}}$ passes through a hole in plate A. The mass of an alpha particle is $6{\cdot}64 \times 10^{-27}\,\mathrm{kg}$ and its charge is $3{\cdot}2 \times 10^{-19}\,\mathrm{C}$.

(*a*) When the alpha particle reaches plate B, its kinetic energy has increased to $3{\cdot}05 \times 10^{-14}\,\mathrm{J}$.

Show that the work done on the alpha particle as it moves from plate A to plate B is $8{\cdot}1 \times 10^{-15}\,\mathrm{J}$.

(*b*) Calculate the potential difference between plates A and B.

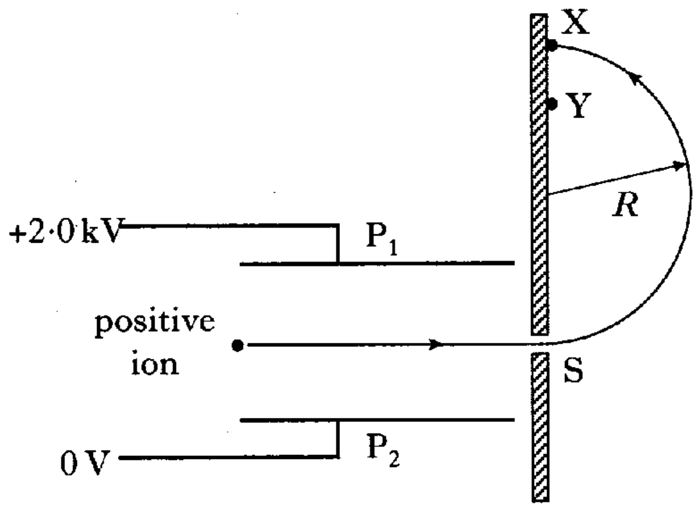
(*c*) The apparatus is now adapted to accelerate **electrons** from A to B through the same potential difference.

How does the increase in the kinetic energy of an electron compare with the increase in kinetic energy of the alpha particle in part (*a*)?

Justify your answer.

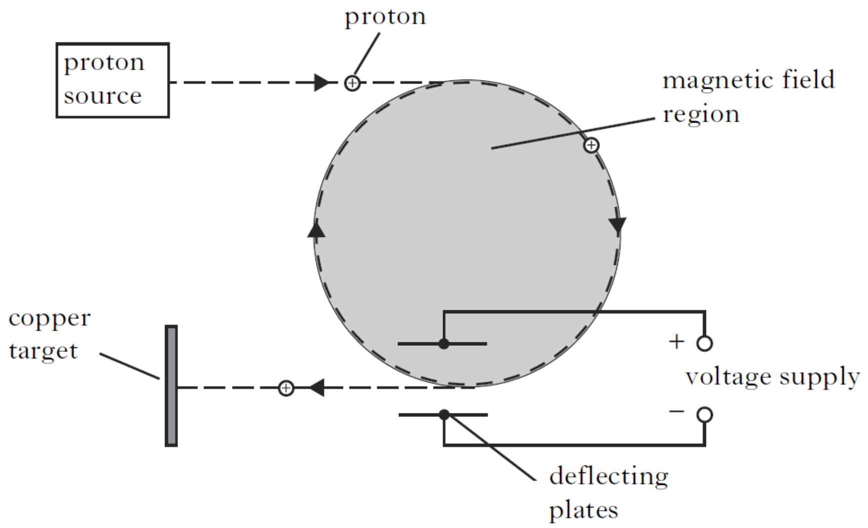
9. A positive ion passes through an electric field between the plates P_1 and P_2. It then passes through a narrow slit S into a uniform magnetic field.

The ion travels with a uniform speed **v** in a straight line between the plates and moves into a semi-circular path of Radius **R** after it passes through the slit.



State the direction of the magnetic field in relation to the page.

10. A beam of protons enters a region of uniform magnetic field at right angles to the field. The protons follow a circular path in the magnetic field until a potential difference is applied across the deflecting plates. The deflected protons then hit a copper target.



a) **State the direction** of the magnetic field in relation to the page.

b) The radius of the circular path of the protons can be found from $\mathbf{r = \frac{mv}{qB}}$

Calculate the **radius of the protons** in the circular path if they have a speed of **6.0 x10^{6}ms^{-1}** and the magnetic field strength **B** is **0.75T**.

(T = Tesla, the unit of magnetic field strength)

11.

Cyclotrons consist of two D shaped regions, known as Dees, separated by a small gap. An electric field between the Dees accelerates the charged particles. A magnetic field in the Dees causes the particles to follow a circular path. Negatively charged hydrogen ions (H^-) are released from point A and follow the path as shown in Figure 9A.

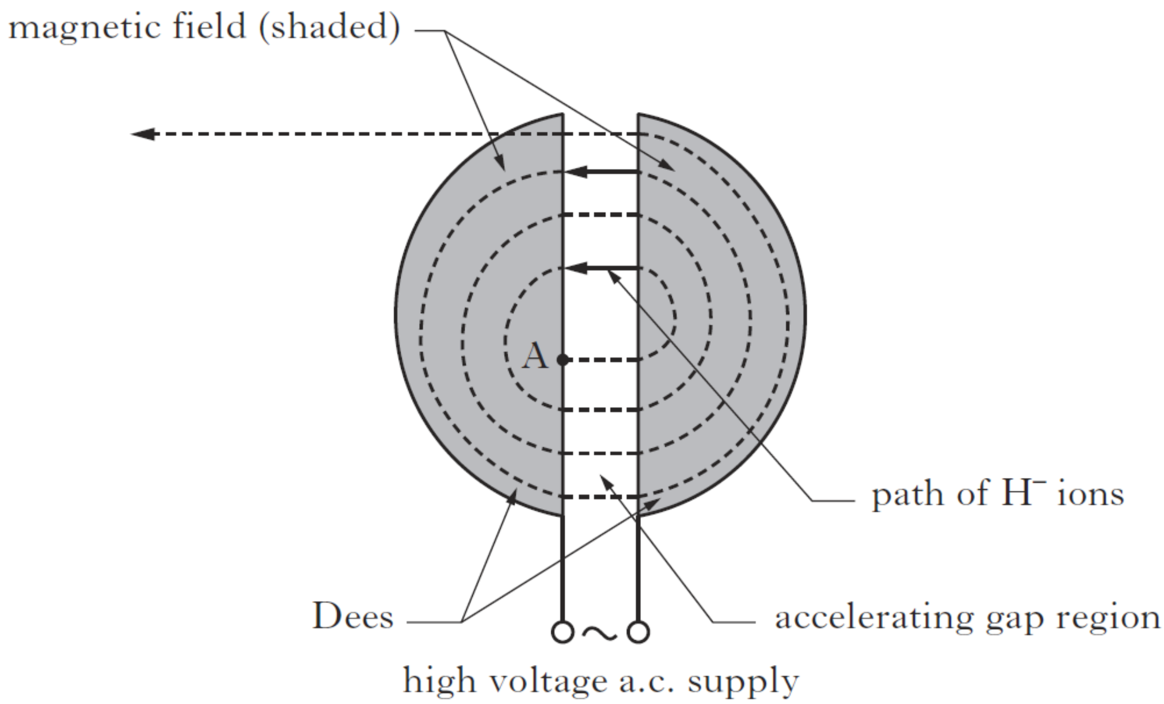


Figure 9A

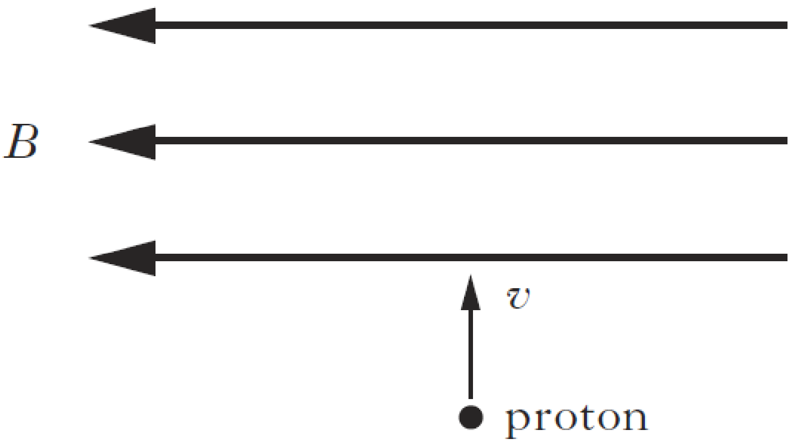
(*a*) (i) State the direction of the magnetic induction B.

(ii) Explain why an a.c. supply must be used to provide the electric field.

(*b*) The energy gained by the H^- ion for one transit of the gap region is $1{\cdot}5 \times 10^{-14}$ J.

How many transits of the gap would occur before relativistic effects should be taken into account?

12. a) A proton moving at a **constant speed v** enters a uniform **magnetic field of strength B**.



Within the field the proton follows a circular path of **radius r**.

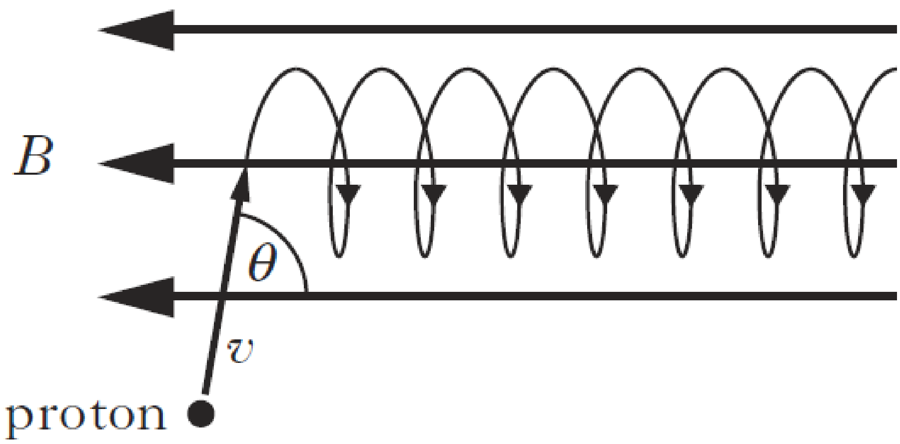
i) Explain why the proton follows a circular path.

ii) Given that the radius of the circular path for the proton is $\mathbf{r = \frac{mv}{qB}}$

show that

$$r = \frac{1{\cdot}05 \times 10^{-8} v}{B}.$$

b) Another proton travelling at the same speed **v** enters the magnetic field at an angle **ϴ** to the magnetic field lines as shown below.



Explain the shape of the proton in the magnetic field.