2022 Ph H2 Q7

Section: Electricity

Topic: Sources, Internal Resistance, Acceleration of Charges

Protons accelerated between plates A and B by 2.8 kV. (a) Explain why they accelerate. (b) (i) Show KE at plate A, (ii) work done by potential difference, (iii) final speed at B. (c) Effect of doubling plate separation.

Worked solution

(a) The protons are positively charged particles. The electric field between plates exerts a force F = qE on them, causing acceleration from the positive plate towards the negative plate.

(b)(i) KE at plate A

$KE = \frac{1}{2}mv^2$
$= 0.5 \times (1.67\times10^{-27}) \times (3.8\times10^{5})^2$
$= 1.21e\text{-}16\ J$

Answer: 1.2×10^{-16} J (shown)

(b)(ii) Work done across potential difference

$W = qV$
$= (1.60\times10^{-19}) \times (2.8\times10^{3})$
$= 4.48e\text{-}16\ J$

Answer: 4.5×10^{-16} J

(b)(iii) Speed at plate B

Total KE = KE_A + W
= 1.21e-16 + 4.48e-16 = 5.69e-16 J
½mv² = KE ⇒ v = √(2KE/m)
= √(2×5.69e-16 / 1.67×10⁻²⁷)
= 8.25e+05 m s⁻¹

Answer: 8.3×10^{5} m s^{-1}

(c) Doubling the plate separation halves the electric field strength (E = V/d). However, the proton still experiences the same potential difference (2.8 kV), so it gains the same energy qV and reaches the same final speed.

Answer: No effect on final speed

Final answers

(a) Accelerated by electric force qE

(b)(i) KE_A = 1.2×10^{-16} J

(b)(ii) W = 4.5×10^{-16} J

(b)(iii) v_B = 8.3×10^{5} m s^{-1}

(c) Final speed unchanged

Revision tips

- Electric fields exert F = qE on charged particles.

- Work done by potential difference: $W = qV$.
- Kinetic energy change = work done.
- Doubling distance halves field strength but potential difference (energy gained) is unchanged.
- Check significant figures when asked to SHOW.