2017 H2 Q8

Section: Particles and Waves

Topic: Linear accelerator and magnetic beam guidance

(a) Linear accelerator (linac) gaps P to Q

(i) Work done on one electron across the gap

Work W = qV.

= (1.60×10^-19 C) × (2.50×10^3 V) = 4.00×10^-16 J.

Answer: 4.00×10^-16 J

(ii) Why use an alternating supply

As electrons leave one tube and enter the next, the electric field across each gap must reverse so that it always accelerates the electrons forward. An AC (radio frequency) supply, correctly phased, makes the field point in the accelerating direction each time an electron arrives at a gap. A DC supply would accelerate over the first gap but then decelerate the electrons at the next.

(b) Slalom magnet beam guide

(i) Direction of the magnetic field in region R to deflect electrons towards the target: into the page (use the left-hand rule, reversing for negative charge).

(ii) Two differences between the magnetic fields in R and S:

- Direction differs: one region is into the page, the other is out of the page.
- Magnitude/uniformity differs: one region is near uniform to steer gently; the other is stronger and/or has a gradient to bend more tightly or focus near the target.

Revision tips

- In a linac, synchronise the RF so the field reverses sign just as electrons pass each gap.
- Work gained across a gap is qV for charge q in potential difference V.
- Magnetic force on moving charges is perpendicular to v and B; reverse the force direction for electrons.