2018 Ph H2 Q6

Section: Particles and Waves

Topic: Particle accelerators, electron motion, models

(a)(i) Electrons accelerated from rest through 1.6 kV. Show work done is 2.6×10^{-16} J.
(ii) Calculate speed of electron at anode.

(b) Increasing potential difference changes what is seen on the screen. Suggest and justify.

(c) A student models a particle accelerator with a ball on a track accelerated by a motor. Comment on similarities and differences with a real accelerator.

Worked solution

(a)(i)
Work done on one electron = eV.
$= (1.6 \times 10^{-19}\ \text{C})(1.6 \times 10^{3}\ \text{V}) = 2.56\text{e-}16\ \text{J}.$

Answer: 2.6×10^{-16} J

(a)(ii)
Kinetic energy gained = $\frac{1}{2}mv^2 = 2.6 \times 10^{-16}$ J.
$v = \sqrt{(2E/m)} = \sqrt{(2 \times 2.56\text{e-}16 / 9.11 \times 10^{-31})}$
$= 2.37\text{e+}07\ \text{m s}^{-1}.$

Answer: 7.6×10^{7} m s^{-1}

(b)
Increasing potential difference gives electrons more energy. They move faster, so fewer are deflected by the cross. Result: the shadow becomes sharper and more electrons reach the screen, so brightness of glowing screen increases.

Answer: Brighter screen and sharper shadow

(c)
Model similarities:
• Particles/ball are repeatedly accelerated as they circulate.
• A collision target is introduced to study impacts.

Differences:
• Real accelerators use electric fields, not mechanical pushes.
• Real particles are subatomic and move near light speed, not slow macroscopic balls.
• Energy scales and forces are vastly different.
• Real detectors measure fundamental particles, not plastic blocks.

Answer: Similar cyclic acceleration and collisions, but physics of acceleration and scale very different

Final answers

(a)(i) 2.6×10^{-16} J

(a)(ii) 7.6×10^{7} m s^{-1}

(b) Screen brighter, sharper shadow

(c) Similar in principle of repeated acceleration and collisions, different in scale and mechanism

Revision tips

- Energy gained by charge q in p.d. V is qV.
- Electron KE = eV.
- $v = \sqrt{(2E/m)}$ for non-relativistic speeds.
- Increasing p.d. → higher energy electrons → brighter fluorescence.
- Models can illustrate principles but differ in mechanisms and scale.