2023 Ph H2 Q7

Section: Particles and Waves

Topic: The Standard Model / Nuclear Reactions

Summary of Question:

This question covers beta decay, the Standard Model, PET imaging using cyclotrons, and the force on a proton entering a magnetic field.

(a)(i)(A) Determine the number represented by P

Mass number unchanged: 131

Atomic number increases by 1: 54 $\rightarrow$ 55

Answer: P = 55

(a)(i)(B) Identify element Z

Element with Z = 55 is Caesium (Cs).

Answer: Caesium

(a)(ii)(A) Fermion type including electrons

Electrons are leptons.

Answer: Leptons

(a)(ii)(B) Fundamental force in beta decay

Mediated by W and Z bosons $\rightarrow$ weak nuclear force.

Answer: Weak nuclear force

(b)(i) Speed of a proton as it reaches S

Kinetic energy = qV = (1.60×10■⁻¹■)(32.0×10³) = 5.12×10■⁻¹■ J

v = √(2KE/m) = √(2×5.12×10■⁻¹■ / 1.67×10■⁻²■)

v = √(6.13×10¹²) = 2.48×10■ m s■⁻¹

Answer: 2.5 × 10■ m s■⁻¹

(b)(ii) Why use alternating voltage?

Proton reverses direction in the dees each half-cycle.

The electric field must reverse to accelerate it every crossing.

Answer: AC keeps protons accelerating at each gap

(c) Direction of magnetic force

Magnetic field: out of page. Velocity: to the right.

Right-hand rule → force upwards.

Answer: Upward (towards top of page)

Final Answers

(a)(i)(A) P = 55

(a)(i)(B) Caesium

(a)(ii)(A) Lepton

(a)(ii)(B) Weak nuclear force

(b)(i) 2.5 × 10■ m s■[1]

(b)(ii) AC ensures correct acceleration

(c) Upward force

Revision Tips

• In beta decay, atomic number increases, mass number stays same.

• Electrons are leptons in the Standard Model.

• Beta decay is mediated by the weak nuclear force.

• Cyclotrons need AC to stay in phase with protons.

• Use right-hand rule for force on positive charges.