ppQ A2 magnetic forces

1. (a) (i) State the condition for a charged particle to experience a force in a magnetic field.

The charged particle must be in motion so it produces its own magnetic field (✓)

A component of its motion must be normal / at 90° to the field lines it is crossing (✓)

OR: Must not be travelling along the lines of the magnetic field. [2]

(ii) State an expression for the magnetic force \( F \) acting on a charged particle in a magnetic field of flux density \( B \).

Explain any other symbols you use.

\[ F_B = B q v \sin \theta \] (✓) where: \( q \) is the charge on the particle, \( v \) is the velocity of the particle and the angle between the field lines and the direction of motion. (✓) [2]

(b) A sample of a conductor with rectangular faces is situated in a magnetic field, as shown in the diagram.

The magnetic field is normal to face ABCD in the downward direction. Electrons enter face CDHG at right-angles to the face. As the electrons pass through the conductor, they experience a force due to the magnetic field.

(i) On the diagram, shade the face to which the electrons tend to move as a result of this force. face BCFG (✓) shown [1]

(ii) The movement of the electrons in the magnetic field causes a potential difference between two faces of the conductor.

Using the lettering from the diagram, state the faces between which this potential difference will occur.

FACE BCFG and FACE ADEH (✓) [1]

(c) Explain why the potential difference in (b) causes an additional force on the moving electrons in the conductor.

The separation of charges across the two faces produces a Hall voltage \( \Rightarrow \) electric field (✓)

The field exerts an electric force on other electrons moving through the sample. (✓) [2]

2. The magnetic field is normal to the direction of motion of the particle. The path of the particle in the field is the arc of a circle of radius \( r \).

(a) Explain why the path of the particle in the field is the arc of a circle.

The magnetic force produced on the particle provides the centripetal force on the (constant speed) particle (✓) because it is always normal / at 90° to the direction of motion (✓). [2]

(b) A charged particle of mass \( m \) and charge \( +q \) is travelling with velocity \( v \) in a vacuum. It enters a region of uniform magnetic field of flux density \( B \) as shown in the diagram. Show that the radius \( r \) is given by the expression

\[ r = \frac{mv}{Bq} \]

Centripetal force \( F_C = \) Magnetic force \( F_B \) (✓)

\[ \Rightarrow mv^2/r = B q v \quad (✓) \Rightarrow r = \frac{mv}{B q} \] [2]

(c) A uniform magnetic field is produced in the region PQRS, as shown in the diagram below. At point X, a gamma-ray photon interaction causes two particles to be formed. The paths of these particles are shown. Explain why there are two spiral paths in the shape shown in the diagram.

Spirals in opposite directions so the particles have opposite charge (✓)

Symmetrical sized spirals so equal initial speeds (✓)

Radii diminish so the particles are slowing down. (✓) [3]