Key Concepts

Chapter 7

Magnetic field

Magnetic force

Alpha particles

Takeaways

From the force relationship above, it can be deduced that the units of magnetic field are $\frac{N \cdot s}{C \cdot m}$ or $\frac{N}{A \cdot m}$. This unit is named the tesla. It is a large unit, and the smaller unit, gauss, is used for small fields like the earth's magnetic field. A tesla is 10,000 gauss.

Things to Watch Out For

The force is perpendicular to both the velocity **(v)** of the charge (q) and the magnetic field **(B)**. The magnetic force on a stationary charge or a charge moving parallel to the magnetic field is zero. The direction of the force is given by the right-hand rule.

Magnetic Force

The speed of an alpha particle is 4.5×10^4 m/s, and the magnitude of the magnetic force is 7.5×10^{-15} N. What is the magnitude of the magnetic field if the particle is traveling perpendicular to the field? ($e = 1.6 \times 10^{-19}$ C)

1) Determine the charge of the object that the force is acting on.

$2 \times 1.6 \times 10^{-19}\ C = 3.2 \times 10^{-19}\ C$

The magnetic field is acting on an alpha particle. An alpha particle has two protons and two neutrons. Because the charge of one proton is 1.6×10^{-19} C, multiply that by 2.

Remember: *The sign of the charge will depend on the particle. If you have an electron, the charge is negative. If you are dealing with a proton, the charge is positive.*

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2) Set up the force equation.

$F = qvB \sin \theta$

In this formula, F is the magnitude of the magnetic force on the moving charge, q is the magnitude of the charge, v is the magnitude of the velocity of the moving charge, B is the magnitude of the magnetic field, and θ is the angle between the magnetic field and the velocity of the charge. The question states that the particle is moving perpendicular to the field, so θ is 90°.

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3) Solve for the magnitude of the magnetic field.
Solve for B in the equation from step 2 and plug in values.

$$B = \frac{F}{qV}$$

$$= \frac{7.5\times10^{-15}\ \text{N}}{(3.2\times10^{-19}\ \text{C})(4.5\times10^{4}\ \text{m/s})}$$

$$= 0.521\ \text{T}$$

Similar Questions

1) A beam of electrons moves at right angles to a 0.60 T field. The electrons have a velocity of 2.5×10^7 m/s. What force acts on the electrons? What force acts if the beam of electrons moves at an angle of 45° to the field?
2) What is the force felt from a magnetic field on an electron where the speed of an electron is 5×10^3 m/s, the magnitude of the magnetic field is 1.5 T, and the particle travels at a 30° angle to the field?
3) A proton moves at right angles to a 0.003 T field directed out of the page. The proton moves from right to left with a speed of 5×10^6 m/s. What is the magnitude and direction of the force that the proton experiences?