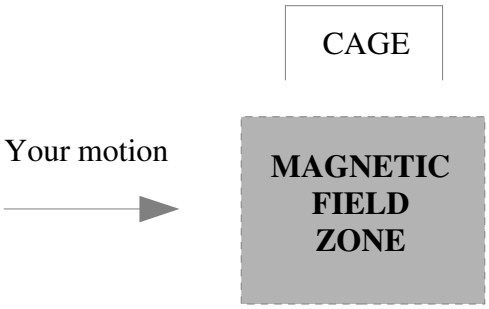
Motion of Charged Particles in Magnetic Fields Questions

1. An electric criminal trying to run from the laws of physics, you have escaped imprisonment but not your charge of 2.31 mC. You're about to find out that crime doesn't pay, because the local lawmen have constructed a trap for you – a uniform magnetic field which will apply 250N to you as you enter it at right angles, directing you into their grasp.

   a) Calculate the magnitude of their magnetic field strength if you're travelling at 12.2 ms^{-1}. /2

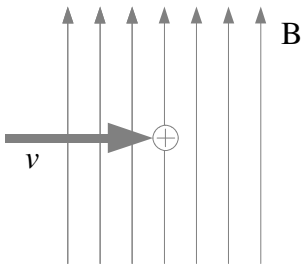
   b) Their trap is set up as shown below. Draw or state the direction (relative to the page) of their uniform magnetic field (assume you are *positively* charged).



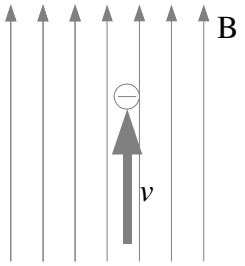
/1

2. Determine the direction of the force on the following charged particles (write 'No force' where applicable):

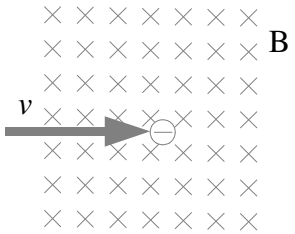
   a) Proton moving to right



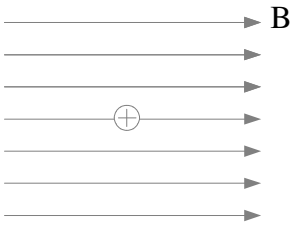
   b) Electron moving up page



   c) Electron moving to right



   d) Proton with no motion



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3.

   a) Derive an expression for the radius r of the uniform circular motion of an ion of mass m and charge q orbiting in a cyclotron with a uniform magnetic field of strength B and travelling at speed v. /3

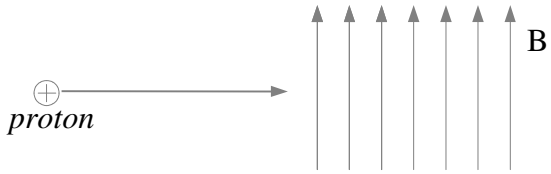
   b) Derive an expression for the period T of the ion's motion. /2

   c) Hence describe the relationship between the speed v of the ion and the period of its motion, and explain why this relationship is important to the function of the cyclotron. /2

   d) Describe the nature and direction of the magnetic field needed to deflect ions into a circular path in the dees of a cyclotron. /2

MORE QUESTIONS ON OTHER SIDE

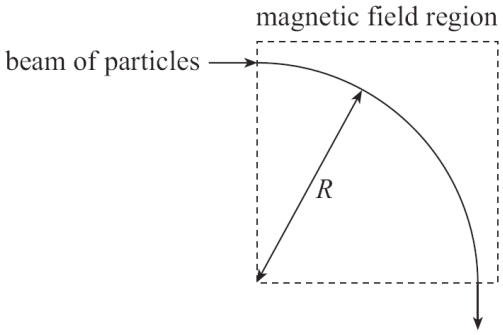
4. A proton enters a uniform magnetic field with a velocity perpendicular to the field, as shown below. Assume the system is in a vacuum, and ignore the effect of gravity.



a) Explain why the kinetic energy of the proton remains constant. /2

b) Describe and explain the path of a neutron if it enters the magnetic field at the same position and with the same velocity. /2

5. A region where a uniform magnetic field is used to direct a beam of positive particles is shown in the diagram below. The particles have a charge of $+1.60\times10^{-19}$ C and are moving with a speed of 1.00×10^{7} ms^{-1}. The beam of particles enters at right angles to the magnetic field and follows a circular path of radius *R*.



a) State the direction of the magnetic field in the region shown. /1

b) Explain why the beam follows a circular path within the region shown. /2

c) The magnetic field in the region is 0.330 T. Calculate the ratio $\frac{R}{M}$ of the radius of the path *R* to the mass of the particles *M* in the beam. State the units of this ratio. /3

6.

a) Show that the kinetic energy *K* of the ions that emerge at radius *r* from a cyclotron is given by $K = \frac{q^2B^2r^2}{2m}$ /2

b) Calculate the kinetic energy of a proton that emerges at a radius of 0.12 m from a cyclotron with a magnetic field of 0.80 T. /2

c) Calculate the period of the proton's motion before it escaped the cyclotron.

/2