A uniform magnetic field B exists in a region. An electron projected perpendicular to the field goes in a circle. Assuming Bohr's quantization rule for angular momentum, calculate (a) the smallest possible radius of the electron (b) the radius of the nth orbit and (c) the minimum possible speed of the electron.

According to Bohr's quantization rule

$$mvr = \frac{nh}{2\pi}$$

'r' is less when 'n' has least value i.e. 1

$$\text{or, } mv = \frac{nh}{2\pi R} \qquad \ldots(1)$$

$$\text{Again, } r = \frac{mv}{qB}, \qquad \text{or, } mv = rqB \qquad \ldots(2)$$

From (1) and (2)

$$rqB = \frac{nh}{2\pi r} \quad [q = e]$$

$$\Rightarrow r^2 = \frac{nh}{2\pi eB} \Rightarrow r = \sqrt{h/2\pi\, eB} \qquad [\text{here } n = 1]$$

b) For the radius of nth orbit, $r = \sqrt{\dfrac{nh}{2\pi eB}}$.

c) $mvr = \dfrac{nh}{2\pi}$, $r = \dfrac{mv}{qB}$

Substituting the value of 'r' in (1)

$$mv \times \frac{mv}{qB} = \frac{nh}{2\pi}$$

$$\Rightarrow m^2v^2 = \frac{nheB}{2\pi} \quad [n = 1, q = e]$$

$$\Rightarrow v^2 = \frac{heB}{2\pi m^2} \Rightarrow \text{or } v = \sqrt{\frac{heB}{2\pi m^2}}.$$