Q.4. The ionization energy of a hydrogen like Bohr atom is 4 Rydbergs. (i) What is the wavelength of the radiation emitted when the electron jumps from the first excited state to the ground state ? (ii) What is the radius of the first orbit for this atom? (1984- 4 Marks)

Solution.

(i) $E_n = -\frac{\text{I.E.}}{n^2}$ for Bohr's hydrogen atom.

Here, I.E. $= 4R$ $\therefore E_n = \frac{-4R}{n^2}$

$\therefore E_2 - E_1 = \frac{-4R}{2^2} - \left(-\frac{4R}{1^2}\right) = 3R$ ..(i)

$E_2 - E_1 = h\nu = \frac{hc}{\lambda}$ ..(ii)

From (i) and (ii)

$\frac{hc}{\lambda} = 3R$

$\therefore \lambda = \frac{hc}{3R} = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{2.2 \times 10^{-18} \times 3} = 300\text{Å}$

(ii) The radius of the first orbit

Bohr's radius of hydrogen atom = 5×10^{-11} m (given)

$|\text{En}| = +0.22 \times 10^{-17} Z^2 = 4R = 4 \times 2.2 \times 10{-}18$

$\therefore Z = 2$

$\therefore r_n = \frac{r_0}{Z} = \frac{5 \times 10^{-11}}{Z} = \frac{5 \times 10^{-11}}{2} = 2.5 \times 10^{-11}\text{m}$