Hydrogen is the simplest atom of nature. There is one proton in its nucleus and an electron moves around the nucleus in a circular orbit. According to Niels Bohr, this electron moves in a stationary orbit. When this electron is in the stationary orbit, it emits no electromagnetic radiation. The angular momentum of the electron is quantized, i.e., $mvr = (nh/2\pi)$, where m = mass of the electron, v = velocity of the electron in the orbit, r = radius of the orbit, and $n = 1, 2, 3, \ldots$ When transition takes place from Kth orbit to Jth orbit, energy photon is emitted. If the wavelength of the emitted photon is λ, we find that $\frac{1}{\lambda} = R\left[\frac{1}{J^2} - \frac{1}{K^2}\right]$, where R is Rydberg's constant.

On a different planet, the hydrogen atom's structure was somewhat different from ours. The angular momentum of electron was $P = 2n(h/2\pi)$, i.e., an even multiple of $(h/2\pi)$.

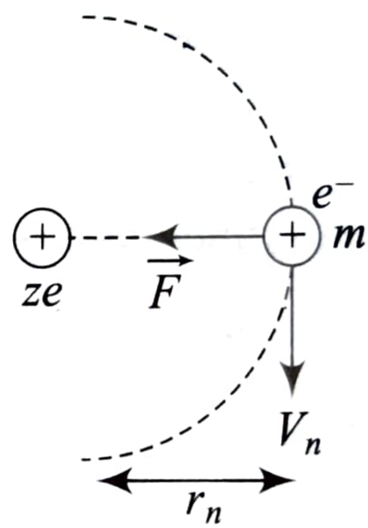

Fig. 4.61

Answer the following questions regarding the other planet based on above passage:

1. The minimum permissible radius of the orbit will be

   a. $\frac{2\varepsilon_0 h^2}{m\pi e^2}$ b. $\frac{4\varepsilon_0 h^2}{m\pi e^2}$ c. $\frac{\varepsilon_0 h^2}{m\pi e^2}$ d. $\frac{\varepsilon_0 h^2}{2m\pi e^2}$

2. In our world, the velocity of electron is v_0 when the hydrogen atom is in the ground state. The velocity of electron in this state on the other planet should be

   a. v_0 b. $v_0/2$ c. $v_0/4$ d. $v_0/8$

3. In our world, the ionization potential energy of a hydrogen atom is 13.6 eV. On the other planet, this ionization potential energy will be

   a. 13.6 eV b. 3.4 eV c. 1.5 eV d. 0.85 eV

1. b. On other planet: $mvr = 2n\dfrac{h}{2\pi} \Rightarrow v = \dfrac{nh}{\pi mr}$

$$\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2} \quad \Rightarrow \quad \frac{mn^2h^2}{n^2m^2r^3} = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2}$$

Putting $n = 1$, we get $r = \dfrac{4h^2\varepsilon_0}{m\pi e^2}$

2. b. On our planet: $v_0 = \dfrac{e^2}{2\varepsilon_0 nh}$

On other planet: $v = \dfrac{e^2}{2\varepsilon_0(2n)h} = \dfrac{v_0}{2}$

3. b. On our planet: $E_n = -\dfrac{13.6}{n^2}$

On other planet: $E_n' = -\dfrac{13.6}{(2n)^2}$

$$\Rightarrow \quad E_n' = \frac{E_n}{4} = -3.4 \text{ eV}$$