An electron and a photon are separated by a distance r so that the potential energy between them is $u = k \log r$, where k is a constant.

26. In such an atom, radius of nth Bohr's orbit is

a. $\dfrac{2nh}{\pi\sqrt{mk}}$ b. $\dfrac{nh}{2\pi\sqrt{2mk}}$ c. $\dfrac{nh}{2\pi\sqrt{mk}}$ d. $\dfrac{nh}{4\pi\sqrt{mk}}$

27. The expression for various energy levels of the above said hypothetical atom is

a. $\dfrac{k}{2}\left[1 + \log\dfrac{n^2h^2}{4\pi^2 mk}\right]$ b. $2k\left[2 + \log\dfrac{n^2h^2}{4\pi^2 mk}\right]$

c. $k\left[2 + \log\dfrac{n^2h^2}{4\pi^2 mk}\right]$ d. $\dfrac{k}{2}\left[1 + \log\dfrac{n^2h^2}{2\pi^2 mk}\right]$

Sol. For a conservative force field,

$$-\frac{dU}{dr} = F$$

Since $U = k \log r$,

$$-\frac{dU}{dr} = -\frac{k}{r} = F$$

This force $F = -k/r$ provides the centripetal force for circular motion of electron.

$$\frac{mv^2}{r} = \frac{k}{r} \qquad \text{(i)}$$

Applying Bohr's quantization rule,

$$mvr = \frac{nh}{2\pi} \qquad \text{(ii)}$$

From Eqs. (i) and (ii), we get

$$r = \frac{nh}{2\pi\sqrt{mk}}$$

$\frac{1}{2} mv^2$ $= \frac{K}{2}$

From Eq. (i),

$$\text{KE of electron} = \frac{1}{2}\mathrm{m}v^2 = \frac{1}{2}k$$

Total energy of electron = KE + PE

PE of electron = $k \log r$

$$= \frac{1}{2}k + k \log r$$

$$E = \frac{K}{2}\left[1 + \log \frac{n^2h^2}{4\pi^2 mk}\right]$$