769.

Problem 51.66 (RHK)

We will apply Bohr's model to the positronium atom. This consists of a positive and a negative electron revolving around the centre of mass, which lies halfway between them. (a) *We have to find the relation between this spectrum and the hydrogen spectrum.* (b) *We have to find the radius of the ground-state orbit.*

Solution:

This problem can be answered by replacing the electron mass m_e in the results of the Bohr's model of the hydrogen atom by the reduced mass

$$\mu = \frac{m_e m_e}{m_e + m_e} = \frac{m_e}{2}.$$

The energies of the positronium states using the Bohr's model will therefore be given by

$$E_{positronium}(n) = -\frac{1}{2}\frac{\mu c^2}{n^2}\alpha^2 = -\frac{1}{4}\frac{m_e c^2}{n^2}\alpha^2$$

$$= \frac{1}{2}\left(-\frac{1}{2}\frac{m_e c^2}{n^2}\alpha^2\right)$$

$$= -\frac{13.6}{2n^2}\ \text{eV}$$

$$= \frac{E_{hydrogen}(n)}{2}.$$

(b)

As the mass of the electron m_e in the hydrogen atom relations is replaced by the reduced by $\mu = m_e/2$ in the positronium, the radius of the ground-state orbit of the positronium will be twice that of the hydrogen atom and therefore will be 1.058×10^{-10} m.