(11.2) In the hydrogen atom the K-electron radius is assumed to be 0.529*10-10 m (the Bohr radius). (a) Calculate the orbital velocity of the electron assuming its mass to be $\boldsymbol{m_e}$. (b) How much larger is its real mass because of the velocity? Does this affect the calculations in (a)?

(a)

$r := 0.529 \cdot 10^{-10} \cdot m$ $m_e := 9.109390 \cdot 10^{-31} \cdot kg$ $q_e := 1.6021773 \cdot 10^{-19} \cdot coul$

$\varepsilon_0 := 8.8541878 \cdot 10^{-12} \cdot \frac{amp \cdot sec}{volt \cdot m}$ $\varepsilon_0 = 8.854 \cdot 10^{-12} \cdot kg^{-1} \cdot m^{-3} \cdot sec^2 \cdot coul^2$

$F := \left(\frac{q_e}{r}\right)^2 \cdot \frac{1}{4 \cdot \pi \cdot \varepsilon_0}$ From physics. $F = 8.244 \cdot 10^{-8} \cdot kg \cdot m \cdot sec^{-2}$

$v := \sqrt{\frac{r \cdot F}{m_e}}$ From mechanics $v = 2.19 \cdot 10^6 \cdot m \cdot sec^{-1}$

(b)

$c := 2.99792458 \cdot 10^8 \cdot \frac{m}{sec}$ $\beta := \frac{v}{c}$ $\beta = 7.299 \cdot 10^{-3}$

$m_r := \frac{m_e}{\sqrt{1 - \beta^2}}$ Eqn.(4.19)

$\frac{m_r - m_e}{m_e} = 2.664 \cdot 10^{-3} \cdot \%$ Thus the mass has increased by 0.003%

$v_r := \sqrt{\frac{r \cdot F}{m_r}}$ $v_r = 2.19 \cdot 10^6 \cdot m \cdot sec^{-1}$

$\Delta v := \frac{v - v_r}{v}$ $\Delta v = 1.332 \cdot 10^{-3} \cdot \%$ The velocity is practically the same.