a) equation 4.77 → use μ instead of m_e

↳ E is proportional to m, so, the fractional error is given by

$$\frac{\Delta E_1}{E_1} = \frac{\Delta m}{\mu} = \frac{m-\mu}{\mu} = \frac{m - \frac{mM}{m+M}}{\frac{mM}{m+M}} = \frac{m(m+M)}{mM} - 1 = \frac{m^2}{mM} + \frac{mM}{mM} - 1 = \frac{m}{M} = \frac{9.109\times10^{-31}}{1.673\cdot10^{-27}} = 5.44\times10^{-4} = 0.054\%$$

b) R is proportional to m;

$$\Delta\frac{1}{\lambda} = \frac{1}{\lambda_a} - \frac{1}{\lambda_b} = \frac{1}{\lambda}(a-b) = -\frac{1}{\lambda}(b-a) = -\frac{1}{\lambda}\Delta\lambda$$

larger ⇒ smaller

$$\frac{\Delta\frac{1}{\lambda}}{\frac{1}{\lambda}} = \frac{\Delta R}{R} = \frac{\Delta\mu}{\mu} = \frac{-\frac{1}{\lambda^2}\Delta\lambda}{\frac{1}{\lambda}} = -\frac{\Delta\lambda}{\lambda}$$

in magnitude

$$\frac{\Delta\lambda}{\lambda} = \frac{\Delta\mu}{\mu} =$$

$$\mu = \frac{m\, m_p}{m+m_p}$$

$$\Delta\mu = \frac{m(2m_p)}{m+2m_p} - \frac{m\,m_p}{m+m_p} = \frac{m\,m_p}{(m+2m_p)(m+m_p)}\left(2m+2m_p-m-2m_p\right)$$

$$= \frac{m^2 m_p}{(m+m_p)(m+2m_p)} = \frac{m\mu}{m+2m_p}$$

$$\frac{\Delta\lambda}{\lambda} = \frac{m}{m+2m_p} \approx \frac{m}{2m_p}$$

$$\Delta\lambda = \frac{m}{2m_p}\lambda_h$$

↑ hydrogen wavelength

$$\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right) = \left(\frac{1}{4} - \frac{1}{9}\right)R = \frac{5}{36}R$$

$$\lambda = \frac{36}{5R} = \frac{36}{5(1.097\times10^7)} = 6.563\times10^{-7}\,m$$

$$\Delta\lambda = \frac{9.109\times10^{-31}}{2(1.673\times10^{-27})}\left(6.653\times10^{-7}\right) = 1.79\times10^{-10}\,m$$

c) $\mu = \frac{m\,m}{m+m} = \frac{m^2}{2m} = \frac{m}{2}$; it follows (by replacing m_e by $\frac{m_e}{2}$ in eq. 4.77) that the energy is half of that for hydrogen: $\frac{1}{2}\cdot 13.6\,eV = 6.8\,eV$

ground state potential has −, but to remove electron, we need to supply the binding energy of +13.6 eV.

d)