Blatt 3

g)

$$R_x = \frac{R_\infty}{1+\frac{m_e}{m_K}} \qquad \frac{E}{hc} = -R_x \frac{Z^2}{n^2}$$

Pickeringserie 1. Linie: $n=4,\ m=5$

$$\Delta \frac{E}{hc} = 4\ R_\infty \left(\frac{1}{4^2} - \frac{1}{5^2}\right) \left(\frac{1}{1+\frac{m_e}{m_{4\,He}}} - \frac{1}{1+\frac{m_e}{m_{3\,He}}}\right)$$

$$= 9876{,}33\ \frac{1}{cm} \cdot 4{,}483 \cdot 10^{-5} = 0{,}4428\ \frac{1}{cm}$$

$$\Delta E = 5{,}5 \cdot 10^{-5}\ eV$$

3. Linie: $n=4,\ m=7$

$$\Delta \frac{E}{hc} = 4\ R_\infty \left(\frac{1}{4^2} - \frac{1}{7^2}\right) \left(\frac{1}{1+\frac{m_e}{m_{4\,He}}} - \frac{1}{1+\frac{m_e}{m_{3\,He}}}\right)$$

$$= 0{,}828\ \frac{1}{cm}$$

$$\Delta E = 1{,}03 \cdot 10^{-4}\ eV$$

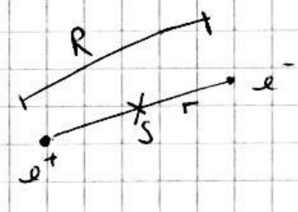
Verwechslungsgefahr von

$$4\ R_{He^+} \left(\frac{1}{4^2} - \frac{1}{m^2}\right) = R_{He^+} \left(\frac{1}{2^2} - \frac{1}{(\frac{m}{2})^2}\right) \qquad \text{für } m = 6, 8, 10, \ldots$$

mit

$$4\ R_H \left(\frac{1}{2^2} - \frac{1}{k^2}\right) \qquad \text{für } k = 3, 4, \ldots \text{ (Balmer-Serie)}$$

10) Klausuraufgabe 2004



$$r = \frac{R}{2}$$

$$E_{ges} = E_{kin} + E_{pot} = 2\,\frac{m}{2}\,v^2 - \frac{e^2}{4\pi\varepsilon_0 R} = m\omega^2\left(\frac{R}{2}\right)^2 - \frac{e^2}{4\pi\varepsilon_0 R} \qquad (1)$$

$$v = \omega r = \omega\,\frac{R}{2}$$

$$L = 2\,m\left(\frac{R}{2}\right)^2\omega = \hbar$$

$$\hookrightarrow \omega^2 = \frac{4\hbar^2}{m^2 R^4}$$

$$m\omega^2 r = m\omega^2\left(\frac{R}{2}\right) \overset{!}{=} \frac{e^2}{4\pi\varepsilon_0 R^2}$$

$$R = \frac{8\hbar^2\pi\varepsilon_0}{m e^2} = \frac{2\varepsilon_0 h^2}{\pi m e^2} \quad (= 2a_0) = 1{,}05\,\text{Å}$$

in (1): $$E = -\frac{1}{16}\,\frac{m e^4}{\varepsilon_0^2 h^2} \quad \left(= -\frac{1}{2}\,R_y\right) = -6{,}8\,eV$$

$$v = \frac{\omega R}{2} = \frac{L}{mR} = \frac{\hbar}{mR} = 1{,}096 \cdot 10^6\,\frac{m}{s}$$

11) Aus Vorlesung: $\Delta x \cdot \Delta p \geq \hbar$

hier: $\frac{\Delta p}{p} = 10^{-3}$

Tischtennisball:

$$\Delta x \geq \frac{\hbar}{\Delta p} = \frac{\hbar}{10^{-3} p} = \frac{\hbar}{10^{-3}\,m \cdot v} = 1{,}054 \cdot 10^{-29}\,m$$

Elektron (relativistisch, da $\beta = \frac{v}{c} = 0{,}6$)

$$p = m \cdot v = m_0\,\frac{\beta}{\sqrt{1-\beta^2}}\,c$$

$$\Delta x = \frac{\hbar}{10^{-3} \cdot p} = 5{,}15 \cdot 10^{-10}\,m$$

12)

A) a) $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mE_{kin}}}$

$$2m\,E_{kin} = \frac{h^2}{\lambda^2}$$

$$U = \frac{h^2}{2me\lambda^2} = 150{,}6\ V$$

typisch für LEED (Low Energy Electron Diffraction) für Oberflächenuntersuchungen

b) $U = 15{,}06\ keV$

relativistisch:

$$\frac{h}{\lambda} = \sqrt{2m_0 E_{kin}}\sqrt{1+\frac{E_{kin}}{2m_0c^2}}$$

$$E_{kin}^2 + 2m_0c^2 E_{kin} - \frac{h^2c^2}{\lambda^2} = 0$$

$$E_{kin} = -m_0c^2 + \sqrt{m_0^2c^4 + \frac{h^2c^2}{\lambda^2}} = 150{,}6\ eV \quad \text{für } \lambda = 1\,Å$$

$$14{,}85\ keV \quad \text{für } \lambda = 0{,}1\,Å$$

B) $E_{kin} = \frac{h^2}{2m\lambda^2} = \begin{cases} a)\ 82\ meV \\ b)\ 8{,}2\ eV \end{cases} \ll 950\ MeV$

$$v = \frac{h}{m\lambda} = \begin{cases} a)\ 3956\ \frac{m}{s} \\ b)\ 39558\ \frac{m}{s} \end{cases}$$

$$E_{kin} = \frac{3}{2}k_B T$$

$$T = \frac{2}{3}\frac{E_{kin}}{k_B} = \begin{cases} a)\ 633\,K \\ b)\ 63300\,K \end{cases}$$

~ thermische Neutronen