Fys2140 oblig 2 Eirik Lund Flatland

3.3 a) $E = E_1 - E_2 \nearrow \gamma$ en del av energien overføres til atomet som E_K (rekyl).

Antar ikke-relativistisk: $E_K = \frac{p^2}{2m} = \left(\frac{h\nu}{c}\right)^2 \frac{1}{2m}$

$P_\gamma = \frac{h\nu}{c}$

$E = h\nu + \frac{h^2\nu^2}{c^2}\frac{1}{2m} = E_1 - E_2$

$$\Delta E = \frac{(m_i^2 - m_j^2)c^4}{2E} = \frac{(h\nu)^2}{2Mc^2}$$

b) $0P_c + P_\gamma \rightarrow P_c'$

$0 + \frac{h\nu}{c} \rightarrow mv$ gir $V = \frac{h\nu}{mc}$ (*)

$k_E = \frac{1}{2}mv^2$ innsatt (*) : $\Delta E = \frac{(h\nu)^2}{2Mc^2}$

c) Regn ut $\frac{\Delta E}{h\nu}$ for overgang $E_2 - E_1 = 4.86\,eV$ i et kvikksølv atom $m_{Hg} = 200\,m_p$

$4.86\,eV = h\nu$ $\nu = 1.175 \cdot 10^{15}$

$\left(\frac{4.86\,eV}{2Mc^2}\right) = \frac{(h\nu)^2}{2Mc^2} = 1.295 \cdot 10^{-11}$

3.5 oppgitt potensiale:

$V(r) = V_0 \left(\frac{r}{a}\right)^k$, kvantifiseres bet. $L = n\hbar$

$L = mvr = n\hbar \qquad r = \frac{n\hbar}{mv}$

$F = -\frac{dV(r)}{dt} = -\frac{V_0 k r^{k-1}}{a^k}$

Bruker sentripetal akselerasjon. Sirkulær bevegelse $\frac{mv^2}{r}$

$\frac{mv^2}{r} = \frac{V_0 k r^{k-1}}{a^k} \qquad v^2 = \frac{V_0 k r^k}{m a^k}, \quad v^2 = \frac{V_0 k}{m}\left(\frac{r}{a}\right)^k$

$E = \frac{1}{2}mv^2 + V(r) = \frac{1}{2}\cancel{m}\frac{V_0 k}{\cancel{m}}\left(\frac{r}{a}\right)^k + V_0\left(\frac{r}{a}\right)^k$

$E = \frac{V_0}{2}\left(\frac{r}{a}\right)^k (k+2)$

Vi har at $r = \frac{n\hbar}{mv}$, $v^2 = \frac{V_0 k}{m}\left(\frac{r}{a}\right)^k$

$r^k = \frac{v^2 a^k m}{V_0 k} \qquad r^k = \left(\frac{n^2\hbar^2 a^k m}{m^2 V_0 k}\right)^{\frac{1}{k+2}}$

$r(k,n) = \left(\frac{\hbar^2 a^k}{m V_0 k} n^2\right)^{\frac{1}{k+2}}$

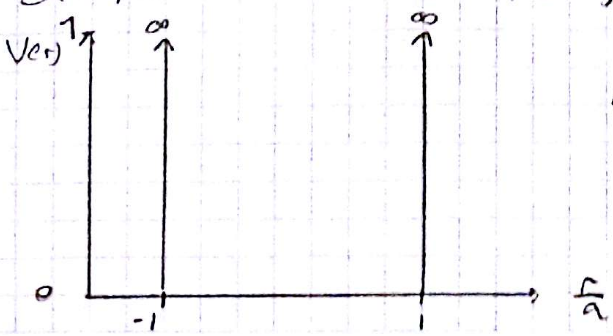
$E(n,k) = \frac{V_0(k+2)}{2a^k}\left(\frac{\hbar^2 a^k n^2}{m V_0 k}\right)^{\frac{k}{k+2}}$

- kontroller n-avhengighet med $k = -1$

$E(n,-1) = \frac{V_0(-1+2)}{2a^{-1}}\left(\frac{\hbar^2 a^{-1} n^2}{m V_0 \cdot -1}\right)^{\frac{-1}{-1+2}} = -\frac{V_0 a}{2}\left(\frac{n^2\hbar^2 a^{-1}}{m V_0}\right)^{-1}$

$E(n,-1) = -(V_0 a)^2 \frac{m}{2n^2\hbar^2}$ hvis $(V_0 a)^2 = k_e^2 e^4$

Så får vi at $E(n, k=-1) = -13.6\ \text{eV}\frac{1}{n^2}$ Bohr



dette kalles et brønnpotensial.

4.2

De Broglie, relasjoner:

$\lambda = \frac{h}{p}$ vi har $E_e' = \sqrt{p^2c^2 + m_0^2c^4}$

$p^2 = E2m_0$ $p = \sqrt{E2m_0}$ $= \sqrt{\left(\frac{E}{c}\right)^2 - m_0c^2}$

a) $E_{tot} = E_k + E_p$ $E_{tot} = E_k + m_0c^2$

$E_k = eV$ pga potensialet til e-feltet

$E_{tot} = eV + m_0c^2$ tilbake til $p = \sqrt{\left(\frac{eV + m_0c^2}{c}\right)^2 - m_0c^2}$

$p = \sqrt{\frac{eV^2 + 2eVm_0c^2 + m_0^2c^4}{c^2} - m_0c^2}$

$\sqrt{2eV_0m_0}\left(1 + \frac{eV}{2m_0c^2}\right)^{\frac{1}{2}}$

$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2eV_0m_0}}\left(1 + \frac{eV}{2m_0c^2}\right)^{-\frac{1}{2}}$

b) ikke-relativistisk: $E_{tot} = E_k + E_p$

$eV = \frac{1}{2}mv^2$ $p = \sqrt{2meV}$

$\lambda = \frac{h}{\sqrt{m_0^2v^2}}\left(1 + \frac{\cancel{m_0}v^2}{4\cancel{m_0}c^2}\right)^{-\frac{1}{2}}$ $v \lll c$ så $\frac{v}{c} \simeq 0$

$\lambda = \frac{h}{\sqrt{m^2v^2}}(1 + 0) = \frac{h}{m_0v}$

4.2

c) $p = \gamma m_0 v$ der $\gamma = \frac{1}{\sqrt{1-\frac{v}{c}}}$

$$\lambda = \frac{h}{\gamma m_0 v} = \frac{h}{m_0 v}\sqrt{1-\frac{v}{c}}$$ oppgitt $\beta = \frac{v}{c}$

$$\lambda = \frac{h}{m_0 v}\sqrt{1-\beta}$$ E_0 oppgitt hvileenergi $m_0 c^2$

Så vi ganger inn $\frac{c^2}{c^2}$

$$\Rightarrow \frac{hc^2}{m_0 c^2 v}\sqrt{1-\beta} \Rightarrow \frac{hc^2}{E_0 v}\sqrt{1-\beta}$$

$$\Rightarrow \frac{hc\sqrt{1-\beta}}{E_0 \frac{v}{c}}$$

$$\lambda = \frac{1.24\cdot 10^{-12+10}}{E_0 (MeV)}\frac{\sqrt{1-\beta}}{\beta}$$ Som vi skulle vise.

$$\lambda = \frac{1.24\cdot 10^{-2}}{E_0 (MeV)}\frac{\sqrt{1-\beta}}{\beta}$$

4.3 Relasjoner : $p = \frac{h}{\lambda} = \frac{h\nu_{min}}{c}$, $E = h\nu$

a) $\nu_{min} = \frac{c}{\lambda} = 5\cdot 10^{17}$ Hz

b) $E = h\nu_{min} = 2.069$ keV

c) $E_\gamma = \sqrt{(pc)^2 + m_0^2 c^4} = \sqrt{\frac{h^2 c^2}{\lambda^2} + m_0^2 c^4} = 510$ keV

$$E_{ikke\,rel} = \frac{p^2}{2m} = \frac{h^2}{2m\lambda^2} = 4.18 \text{ eV}$$

Det mest vanlige er elektronmikroskop for å observere nanonivå