Problem Solutions For Introductory Nuclear Physics By Kenneth S. Krane

Tut 2

4. $E_k = 1\,keV \ll m_e c^2 = 511\,keV \Rightarrow$ non-relativistic

$\Delta p \Delta x \sim h \Rightarrow \Delta p \sim h/\Delta x$, $pc = \sqrt{2mc^2E}$

$\Delta p c = \frac{hc}{\Delta x}$ $= \sqrt{2 \times 511\,keV \times 1}$

$= 2\pi \frac{\hbar c}{\Delta x}$ $= 32\,keV$

$= \frac{6.28 \times 197\,MeV.fm}{0.1 \times 10^6\,fm}$

$= 12.4\,keV$

$\therefore \frac{\Delta p}{p} = 38\%$ $\quad (\Delta p \Delta x \sim \hbar \Rightarrow \frac{\Delta p}{p} \sim 6\%)$

5. $m = 0.05kg$, $v = 300m/s$, $p = mv = 15\,kg\,ms^{-1}$ (non-relativistic $v \ll c$)

$\frac{\Delta p}{p} = 0.01\% \Rightarrow \Delta p = 15 \times \frac{0.01}{100} = 1.5 \times 10^{-3}\,kg\,ms^{-1}$

$\Delta x \sim \frac{\hbar}{\Delta p} \sim \frac{1 \times 10^{-34}}{1.5 \times 10^{-31}} = 0.66 \times 10^{-3}\,m \ll$ atomic dimensions

6. SWE $E = \frac{\pi^2\hbar^2}{2mL^2} = \frac{p^2}{2m}$ (non-rel.) $\quad \therefore p^2L^2 = \pi^2\hbar^2$

$pL = n\hbar$

HUP $pL \sim \hbar$

7. $E = \frac{n^2\pi^2\hbar^2}{2mL^2} \quad \therefore L = \frac{n\pi\hbar}{\sqrt{2mE}}$

$= \frac{n\pi\hbar c}{\sqrt{2mc^2E}}$ $= \frac{n\pi 197 \times 10^6\,eV.fm}{\sqrt{2 \times 511 \times 10^3 \times 0.03\,eV^2}}$

$= 3.5n\,nm$

$\hbar c = 197\,MeV.fm$

8. $E = \frac{n^2\pi^2\hbar^2}{2mL^2} = \frac{n^2\pi^2\hbar^2c^2}{2mc^2L^2} = \frac{n^2\pi^2(197 \times 10^6\,eV.10^{-5}\,\text{Å})^2}{2 \times 511 \times 10^3\,eV \times 1\,\text{Å}^2} = n^2\,37.5\,eV$

$E'_{marble} = \frac{m_e}{m_{marble}} \times \frac{38\,eV}{(10^9)^2} = \frac{9.11 \times 10^{-31}}{10^{-2}} \times 38\,eV = 3.45 \times 10^{-45}\,eV.$

$v = 10^{-2}\,m/yr \Rightarrow \frac{10^{-2}m}{3.2 \times 10^7 s} = 3 \times 10^{-9}\,m/s$ $\quad E = \frac{1}{2}mv^2 = \frac{1}{2} \times 10^{-2} \times (3 \times 10^{-9})^2$

$= 4.5 \times 10^{-22}\,J$

$E^n/E^1 = n^2 \Rightarrow n^2 = 10^{21}.$

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