Problem 1. Anderson 8.3

Calculate the wavelength of a 1 MeV neutron in free space. If a total E of 1 MeV is a constant of the motion and the neutron is in a region of a potential well depth of 10 MeV, what is the wavelength?

Solution

Part (a)

$$\begin{aligned}
\lambda_{free} &= \frac{h}{\sqrt{2m_n T}} \\
&= \frac{4.14 \times 10^{-15}\,\mathrm{eV\,s} \times \frac{1\,\mathrm{MeV}}{1 \times 10^{6}\,\mathrm{eV}}}{\sqrt{2 \times 939.6\,\mathrm{MeV}\,{c_0}^{-2} \times 1\,\mathrm{MeV}}} \\
&= 2.87 \times 10^{-14}\,\mathrm{m} \\
&= 28.7\,\mathrm{fm}
\end{aligned}$$

Part (b)

$$\begin{aligned}
\lambda_{well} &= \frac{h}{\sqrt{2m_n(T+V}} \\
&= \frac{4.14 \times 10^{-15}\,\mathrm{eV\,s} \times \frac{1\,\mathrm{MeV}}{1 \times 10^{6}\,\mathrm{eV}}}{\sqrt{2 \times 939.6\,\mathrm{MeV}\,{c_0}^{-2} \times 11\,\mathrm{MeV}}} \\
&= 8.64\,\mathrm{fm}
\end{aligned}$$

Problem 2.

Using the NNDC ENDF evaluations, find (and report) the elastic scattering cross sections for 0.5 MeV, 1 MeV, 5 MeV, and 10 MeV neutrons scattering in ^{207}Pb. Use those values to calculate the corresponding mean free paths for elastic scattering.

Solution

T (MeV)	Σ (cm^{-1})	Mean Free Path (cm)
0.5	5.810217	5.216310
1.0	4.876894	6.214590
5.0	4.896170	6.190124
10.0	2.483300	12.204686

Problem 3. Anderson 8.10, change deuterium to ^{7}Li and change uranium to ^{206}Pb

Find the number of collisions (nearest integer) necessary to thermalize a beam of 1 MeV neutrons with ^{7}Li, He, Be, C, and ^{206}Pb

Solution

A	Target	Average Collisions to Thermalize
7	Li-7	67
4	Helium	41
9	Beryllium	85
12	Carbon	111
206	Pb-206	1809

Problem 4.

A 14 MeV neutron scatters elastically off of a ^{12}C nucleus. The energy given to the ^{12}C nucleus is 1 MeV. What is the scattered angle of the neutron?

Solution

$$\theta' = \cot^{-1} \frac{1 - A\cos 2\theta'_A}{A \sin 2\theta'_A}$$

$$T' = T \left[\frac{\cos\theta' + \left(A^2 - \sin^2\theta'\right)^{1/2}}{A+1} \right]^2$$

Substituting in $T = 14\,\text{MeV}$ and $T' = 13\,\text{MeV}$ and using wolframalpha to solve, we get:

$$\theta' = \pm 56.22°$$