

Answer on Question #75141-Physics-Other

Graphite (carbon with atomic mass of 12 atomic mass units (amu)) has some desirable properties as a neutron moderator in a nuclear reactor. The neutron (approximately 1 amu) needs to be slowed in order for the reaction to proceed. Assuming each collision is elastic, how many times must the neutron collide with a carbon atom (at rest) until its final speed is less than 25% of its initial speed?

Solution

1) From the conservation of momentum:

$$mV = -mV' + 12mv \rightarrow v = \frac{V + V'}{12}$$

The collision is elastic, so

$$\frac{mV^2}{2} = \frac{mV'^2}{2} + 12m \frac{v^2}{2}$$

$$\frac{V^2}{2} = \frac{V'^2}{2} + 12 \frac{1}{2} \left(\frac{V + V'}{12} \right)^2$$

$$V^2 = V'^2 + \frac{1}{12} (V^2 + 2VV' + V'^2)$$

$$\frac{13}{12} V'^2 + \frac{1}{6} VV' - \frac{11}{12} V^2 = 0$$

Two solutions:

$$V' = -V$$

$$V' = \frac{11}{13} V$$

First solution is impossible for magnitude of velocity.

2)

$$V^{(n)} = \left(\frac{11}{13} \right)^n V$$

$$KE \sim V^2.$$

Thus,

$$KE^{(n)} = \left(\frac{11}{13} \right)^{2n} KE < 0.25 KE$$

$$\left(\frac{11}{13} \right)^{2n} < 0.25$$

$$n > \frac{1 \ln 0.25}{2 \ln \left(\frac{11}{13}\right)} = 4.15.$$

Answer: 5 times.

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