NPRE200 HW 3

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1. a) The Not desirable ones are $II.$ and $III.$
   b) $II.$ or 1 Mev
   c) $I.$ Red
   d) $II.$ Heavy water
   e) $I.$ water.

2.

100 K Red
200 K Blue
500 K Black

3. a)

$$\begin{aligned}\sigma IN\mathcal{A}X &= 2.6\times10^{-24}\times5\times10^{8}\times0.080\times10^{24}\times0.1\times0.05\\ &= 5.2\times10^{5}\text{ intertactions/s}\end{aligned}$$

b)

$$\begin{aligned}\frac{N_{coll}}{N} &= \frac{5.2\times10^{5}\times0.1}{5\times10^{8}}\\ &= 0.0104 = 1.04\%\end{aligned}$$

c)

$$\begin{aligned}\Sigma = \sigma N &= 2.6\times10^{-24}\times0.080\times10^{24}\\ &= 0.208\text{ cm}^{-1}\end{aligned}$$

d)

$$\begin{aligned}\sigma IN &= 2.6\times10^{-24}\times0.080\times10^{24}\\ &= 1.04\times10^{8}\text{ intertactions}/cm^{3}\cdot\text{s}\end{aligned}$$

4.

$$P = \frac{\sigma_f}{\sigma_f + \sigma_c} = \frac{582}{99 + 582}$$
$$= 85.46\%$$

5. a)

$$\Sigma = \sigma N = 4.5 \times 10^{-24} \times 0.048 \times 10^{24}$$
$$= 0.216 \text{ cm}^{-1}$$

b)

$$\sigma IN\mathcal{A}X = 4.5 \times 10^{-24} \times 4 \times 10^{10} \times 0.048 \times 10^{24} \times 1 \times 0.1$$
$$= 8.64 \times 10^8 \text{ intertactions/s}$$

c)

$$\sigma IN = 4.5 \times 10^{-24} \times 4 \times 10^{10} \times 0.048 \times 10^{24}$$
$$= 8.64 \times 10^9 \text{ intertactions/}cm^3\text{·s}$$

6. a)

$$I = nv$$
$$n = I/v$$
$$v = \sqrt{2\frac{KE}{m_n}} = \sqrt{2 \cdot \frac{0.0253 \times 1.602 \times 10^{-19}}{1.674 \times 10^{-27}}}$$
$$= 2200.54\text{m/s} = 2.2 \times 10^5\text{cm/s}$$
$$n = \frac{I}{v}$$
$$= \frac{3 \times 10^8}{2.2 \times 10^5}$$
$$= 1363.3 \text{ neutron/cm}^3$$

b)

$$R = \phi \sigma N$$
$$= 3 \times 10^8 \times 0.23 \times 10^{-24} \times \frac{6.023 \times 10^{23} \times 0.01}{27}$$
$$= 1.53 \times 10^4 \text{ atom/s}$$

7. a)

$$\Sigma = N(\sigma_D + 2 \times \sigma_O)$$
$$= 0.03323 \times 10^{24} \cdot (2.6 + 1.6 \times 2) \times 10^{-24}$$
$$= 0.182765 \text{ cm}^{-1}$$

b)

$$\begin{aligned} 0.1I &= I\exp(-\Sigma x) \\ 0.1 &= \exp(-0.182765x) \\ x &= 12.598 \text{ cm} \end{aligned}$$

c)

$$\begin{aligned} P &= \frac{\sigma_D}{\sigma_D + 2 \cdot \sigma_O} \\ &= \frac{2.6}{2.6 + 3.2} \\ &= 44.82\% \end{aligned}$$

8.

$$\begin{aligned} \frac{E_2}{E_1} &= \left(\frac{A-1}{A+1}\right)^2 \\ &= \left(\frac{16-1}{16+1}\right)^2 \\ &= \left(\frac{15}{17}\right)^2 = 0.7788 \end{aligned}$$

Therefore, after collison, the energy of neutron would be:$E_n = 0.7788 \times 2 = 1.557$ Mev, and energy of ^16O would be $2 - 1.557 = 0.443$ Mev

9.

$$\begin{aligned} E' &= \frac{E}{(A+1)^2}\left(\cos(\vartheta) + \sqrt{A^2 - \sin^2(\vartheta)}\right)^2 \\ &= \frac{1}{(12+1)^2}\left(\cos(90) + \sqrt{12^2 - \sin^2(90)}\right)^2 \\ &= \frac{1}{169}\left(0 + \sqrt{12^2 - 1}\right)^2 \\ &= 0.846154\text{MeV} \end{aligned}$$

Thus, the energy of recoilling nucleus is $1 - 0.846154 = 0.1538$ MeV

10.

$$\begin{aligned} \sigma(E) &= \sigma(E_0)\sqrt{\frac{E_0}{E}} \\ &= 0.23 \times \sqrt{\frac{0.0253}{100}} \\ &= 0.003658 \text{ barn} \end{aligned}$$

11.

$$\begin{aligned} F_a &= g_a(T)\Sigma(E_0)\phi_0 \\ &= 1.15 \times 7.419 \times 5 \times 10^{12} \\ &= 4.27 \times 10^{13} \end{aligned}$$

12.

$$\begin{aligned} \int_0^\infty M(E)\mathrm{d}E &= \frac{2\pi}{(\pi kT)^{3/2}} \int_0^\infty E^{1/2} \exp(-E/kT)\mathrm{d}E \\ \text{let} x^2 = E/kT, \text{ then: } E = kTx^2,\ \mathrm{d}E &= 2kTx\mathrm{d}x \text{and} \sqrt{E} = \sqrt{kT}x \\ &= \frac{2\pi}{(\pi kT)^{3/2}} \cdot 2(kT)^{3/2} \int_0^\infty x^2 \cdot \exp(-x^2)\mathrm{d}x \\ &= \frac{4\pi}{\pi\sqrt{\pi}} \cdot \frac{\sqrt{\pi}}{4} = 1 \end{aligned}$$