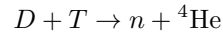


NPRE 321 HW 1

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Due: Sep 25 Edit: October 22, 2024

1. a) i.

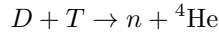


ii. By searching online, $E_{{}^4\text{He}} = 28.3$ MeV, $E_D = 2.2$ MeV, $E_T = 8.482$ MeV. Then

$$28.3 - (2.2 + 8.482) = 17.618 \text{ MeV}$$

iii. It will be around 17.6 MeV

b)



$$\begin{aligned} m_b &= m_D + m_T = (2.014 + 3.016) \times 1.66 \times 10^{-27} \\ &= 8.35 \times 10^{-27} \text{ kg} \end{aligned}$$

$$\begin{aligned} E_b &= m_b \times c^2 \\ &= 8.35 \times 10^{-27} \times (2.998 \times 10^8)^2 \\ &= 7.505 \times 10^{-10} \text{ J} \end{aligned}$$

$$\begin{aligned} m_a &= m_{{}^4\text{He}} + m_n = (4.0026 + 1.0087) \times 1.66 \times 10^{-27} \\ &= 8.3187 \times 10^{-27} \text{ kg} \end{aligned}$$

$$\begin{aligned} E_a &= m_a \times c^2 \\ &= 7.47685 \times 10^{-10} \text{ J} \end{aligned}$$

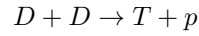
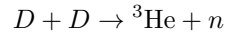
$$\begin{aligned} \Delta E &= E_a - E_b = (7.47685 - 7.505) \times 10^{-10} \\ &= -2.8142 \times 10^{-12} \text{ J} \\ &= -2.8142 \times 10^{-12} \times 6.242 \times 10^{12} \\ &= 17.5683 \text{ MeV} \end{aligned}$$

c)

$$\begin{aligned}
 E &= K \frac{Q_1 Q_2}{r} \\
 &= 9 \times 10^9 \times \frac{(1.602 \times 10^{-19})^2}{(1.80 + 2.13) \times 0.5 \times 10^{-15}} \\
 &= 1.17545 \times 10^{-13} \text{ J} \\
 &= 6.242 \times 10^{18} \times 1.17545 \times 10^{-13} \\
 &= 733715.89 \text{ eV} \\
 &= 733715.89 \times 11604 \\
 &= 8.514 \times 10^9 \text{ K}
 \end{aligned}$$

I believe this temperature does make some sense, as we do need high temperature for fusion and it is not so hot making it impossible to reach.

d)



$$\begin{aligned}
 m_b &= (2.014 \times 2) \\
 &= 4.0282 \text{ u} \\
 m_{a1} &= (3.016 + 1.00866) \\
 &= 4.024 \text{ u} \\
 m_{a2} &= (3.016 + 1.0072) \\
 &= 4.0222 \text{ u} \\
 \Delta m &= 4.02397 - 4.0282 \\
 &= -0.004231 \\
 \Delta E &= \Delta mc^2 \\
 &= 0.004231 \times 1.66 \times 10^{-27} \times (2.998 \times 10^8)^2 \\
 &= 6.31269 \times 10^{-13} \text{ J} \\
 &= 3.94038 \text{ MeV}
 \end{aligned}$$

2. a)

$$\begin{aligned}\sigma_i &= \pi \times (r_{Ar,i} + r_{Ar})^2 \\ &= \pi((285 + 97) \times 10^{-12})^2 \\ &= 4.58434 \times 10^{-19} \text{ m}^2\end{aligned}$$

$$\begin{aligned}n &= \frac{p}{k_b T} \\ &= \frac{133.322 \times 5 \times 10^{-3}}{1.38 \times 10^{-23} \times (25 + 273)} \\ &= 1.62098 \times 10^{20} \text{ m}^{-3}\end{aligned}$$

$$\begin{aligned}\lambda_{0e} &= \frac{1}{\sigma_e n} \\ &= \frac{1}{5 \times 10^{-19} \times 1.62098 \times 10^{20}} \\ &= 0.012338 \text{ m}\end{aligned}$$

$$\begin{aligned}\lambda_{0i} &= \frac{1}{\sigma n} \\ &= \frac{1}{4.58434 \times 10^{-19} \times 1.62098 \times 10^{20}} \\ &= 0.013457 \text{ m}\end{aligned}$$

Does seems like, there will be average less than 4 collisions in the container which is not so sufficient for a plasma to form.

b)

$$\begin{aligned}\omega_c &= \frac{qB}{m} \\ &= \frac{1.602 \times 10^{-19} \times 50 \times 10^{-3}}{2\pi \times 9.11 \times 10^{-31}} \\ &= 1.39928 \times 10^9 \text{ Hz}\end{aligned}$$

$$\begin{aligned}v_{\perp} &= \sqrt{\frac{2E}{m}} \\ &= \sqrt{\frac{2k_b T}{m}} \\ &= 1.027 \times 10^6 \text{ m/s}\end{aligned}$$

$$\begin{aligned}r_L &= \frac{v_{\perp}}{\omega_c} \\ &= \frac{1.027 \times 10^6}{1.39928 \times 10^9} \\ &= 7.339 \times 10^{-4} \text{ m}\end{aligned}$$

Yes, there will be average over 60 collisions per electron in the chamber.

c)

$$\begin{aligned}E &= qdV \\&= 1.602 \times 10^{-19} \times 0.005 \times 500 \\&= 4.005 \times 10^{-19} \text{ J} \\&= 4.005 \times 10^{-19} \times 6.242 \times 10^{18} \\&= 2.49992 \text{ eV}\end{aligned}$$