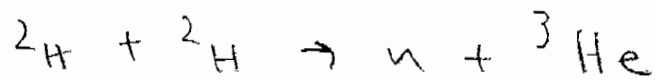


2.04

Phys 242 #3



$$m({}^2\text{H}) = 2.014102 \text{ u}$$

$$m(\text{n}) = 1.008665 \text{ u}$$

$$m({}^3\text{He}) = 3.016029 \text{ u}$$

$$\Delta m = 2 \cdot 2.014102 - 1.008665 - 3.016029$$

$$= 3.51 \times 10^{-3} \text{ u} \times \frac{931.494 \text{ MeV}}{c^2 \text{ u}}$$

$$= 3.27 \text{ MeV}/c^2$$

$$\boxed{\Delta E = 3.27 \text{ MeV}}$$

$$\text{rest energy initial} = 2 \cdot 2.014102^{\text{u}} \times 931.494 \frac{\text{MeV}}{\text{u}}$$

$$= 3752.25 \text{ MeV}$$

$$3.27 / 3752.25 = \boxed{8.7 \times 10^{-4} (\sim 0.099\%)}$$

2.93

$$\beta = 0.9c \quad \gamma = \frac{1}{\sqrt{1-\beta^2}} = 2.29$$

$$p_p = \gamma m v$$

$$= 2.29 \cdot 938.27 \cdot 0.9c$$

$$= 1937.28 \text{ MeV}/c$$

$$p_e = \gamma m v = 1937.28 \text{ MeV}/c$$

$$= \frac{1}{\sqrt{1-\beta^2}} \cdot 0.511 \text{ MeV} \cdot \beta = 1937.28 \text{ MeV}$$

$$\frac{\beta}{\sqrt{1-\beta^2}} = 3791.15$$

$$\frac{\beta^3}{1-\beta^2} = (3791.15)^2$$

$$\beta^2 + (3791.15)^2 \beta^2 = (3796.15)^2$$

$$\beta^2 = \frac{(3791.15)^2}{1 + (3791.15)^2}$$

$$\beta = 1 - 3.47 \times 10^{-8}$$

$$\gamma = 3790$$

$$T = \gamma mc^2 - mc^2$$

$$= 2.29938.27 - 938.27 = 1210.37 \text{ MeV}$$

$$T_c = 1210.37 = \gamma(0.511) - 0.511$$

$$\gamma = 2369.62$$

$$\Rightarrow \beta = 1 - 8.90 \times 10^{-8}$$

$$\frac{1}{\sqrt{1-\beta^2}} = \gamma$$

$$1-\beta^2 = \frac{1}{\gamma^2}$$

$$\beta^2 = 1 - \frac{1}{\gamma^2}$$

2.101

$$a) 498 - 135 - 135 = 228 \text{ MeV}$$

b) Momentum $\Sigma = 0$

$$T = 228/2 = 114 \text{ MeV}$$

$$E = T + mc^2 = 114 + 135 = \boxed{249 \text{ MeV}}$$

$$E^2 = p^2 c^2 + m^2 c^4$$

$$p^2 c^2 = E^2 - m^2 c^4$$

$$= (249)^2 - (135)^2 = 43776$$

$$\Rightarrow \boxed{p = 209.23 \text{ MeV}/c}$$

$$\beta = p/E = \frac{209}{249} = \boxed{0.84}$$

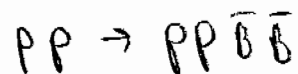
#4

$$20 \text{ MT} = 20 \times 10^6 \times 4.18 \times 10^9 \text{ J}$$

$$= 8.36 \times 10^{16} \text{ J} = mc^2$$

$$\Rightarrow m = \frac{8.36 \times 10^{17}}{(3 \times 10^8)^2} = \boxed{0.93 \text{ kg}}$$

#5



$$s^2 = (\sum E)^2 - c^2 (\sum \vec{P})^2 \quad \begin{array}{l} 0 \text{ for end products} \\ \text{at rest} \end{array}$$

$$= (m_p c^2 + m_p c^2 + m_b c^2 + m_b c^2)^2$$

$$= (938 + 938 + 5000 + 5000)^2 = (11876)^2$$

in center-of-momentum frame

$$s^2 = (P_1 + P_2)^2 = (E_1 + E_2)^2 - c^2 (\vec{P}_1 + \vec{P}_2)^2$$

$$= (2E_1)^2$$

$$= 4E_1^2$$

$$\Rightarrow 4E_1^2 = (11876)^2$$

$$E_1 = 5938$$

$$T_1 = E_1 - m_p c^2 = \boxed{5000 \text{ MeV}} \quad (\text{as expected})$$

in lab frame

$$s^2 = (P_1 + P_2)^2$$

$$= P_1^2 + P_2^2 + 2P_1 \cdot P_2$$

$$= m_1^2 c^4 + m_2^2 c^4 + 2(\bar{E}_1 \bar{E}_2 - \vec{p}_1 \cdot \vec{p}_2 c^2)$$

0 since "2" is at rest

$$= m_p^2 c^4 + m_p^2 c^4 + 2\bar{E}_1 m_p c^2 = (11876)^2$$

$$2 \cdot 938 \cdot \bar{E}_1 = (11876)^2 - (938)^2 - (938)^2$$

$$\bar{E}_1 = 74242.9 \text{ MeV}$$

$$T_1 = \bar{E}_1 - m_1 c^2 = 74242.9 - 938 = \boxed{73304.9 \text{ MeV}}$$