

# HW 6

13.18, 13.25, 15.8, 15.10

18) calculate  $Q$   $(7.016004_u - 3.016029_u - 4.002603_u) \times 931.5 \frac{\text{MeV}}{u}$   
 $= -2.45 \text{ MeV}$  need a. 2.45 MeV to break this apart

$\gamma \rightarrow e^+ e^- ?$

$E_i = E_f$

$E_\gamma = E_1 + E_2$

$\vec{p}_i = \vec{p}_f$

$\vec{p}_\gamma = \vec{p}_1 + \vec{p}_2$

$$0 = E_\gamma^2 - p_\gamma^2 c^2 = (E_1 + E_2)^2 - (p_1 + p_2)^2 \quad (\text{let } c=1)$$

$$= E_1^2 + 2E_1 E_2 + E_2^2 - p_1^2 - 2\vec{p}_1 \cdot \vec{p}_2 - p_2^2$$

$$= m_1^2 + m_2^2 + 2E_1 E_2 - 2\vec{p}_1 \cdot \vec{p}_2$$

For massive particles  $E_1 E_2 > p_1 p_2$

massless  $|E_1 E_2| = |p_1 p_2|$

25) calculate  $Q$

answers  
in back  
of book

- = ①  $Q_1 = m(^{12}\text{C}) + m(^1\text{H}) - m(^{13}\text{N})$
- = ②  $Q_2 = m(^{13}\text{N}) - m(^{13}\text{C}) - m(e^+)$
- = ③  $Q_3 = m(^{13}\text{C}) + m(^1\text{H}) - m(^{14}\text{N})$
- = ④  $Q_4 = m(^{14}\text{N}) + m(^1\text{H}) - m(^{15}\text{O})$
- = ⑤  $Q_5 = m(^{15}\text{O}) - m(^{14}\text{N}) - m(e^+)$
- = ⑥  $Q_6 = m(^{15}\text{N}) + m(^1\text{H}) - m(^{12}\text{C}) - m(^4\text{He})$

$Q_1 + Q_2 + Q_3 + Q_4 + Q_5 + Q_6 = 4m(^1\text{H}) - 2m(e^+) - m(^4\text{He})$

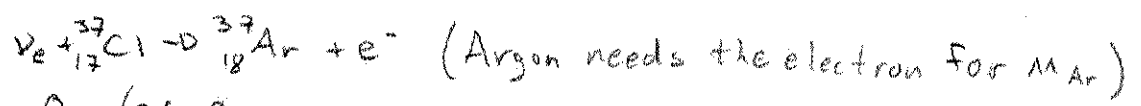
so must be same

15.8

$${}^7\text{Be} + e^- \rightarrow {}^7\text{Li} + \nu_e \text{ (electron capture)}$$

$$Q = (7.016929 \text{ u} - 7.016004 \text{ u}) \frac{931.5 \text{ MeV}}{\text{u}}$$

$$= 0.862 \text{ MeV}$$

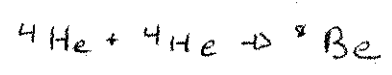


$$Q = (36.965903 \text{ u} - 36.966776 \text{ u}) \frac{931.5 \text{ MeV}}{\text{u}}$$

$$= -0.813 \text{ MeV}$$

so the  $\nu_e$  has barely enough energy

15.10



$$Q = (2(4.002603 \text{ u}) - 8.005305 \text{ u}) \frac{931.5 \text{ MeV}}{\text{u}}$$

$$= -92.2 \text{ keV}$$

If we assume a 2 state system

treat 2 states as  $4\text{He} + 4\text{He}$  and  ${}^8\text{Be}$

with  $\Delta E = 92.2 \text{ keV}$

$$\frac{P(\text{Be})}{P(\text{He} + \text{He})} = \frac{e^{-\Delta E/k_B T}}{g(\text{He} + \text{He})} \quad \text{assuming } g(\text{He} + \text{He}) = 1 = g(\text{Be})$$

$$\text{For 1 Be atom, } \# \text{He} = e^{\Delta E/k_B T} = N = (2.25 \times 10^{-5})^{-1}$$

The number of ways we can form 2 He atoms is  $\frac{N(N-1)}{2} = g(\text{He})$

( even though the Be state is unstable, the He are moving fast and colliding so often, the Be has a chance to stick around a while.  
 $t_{\text{collision}} \sim 10^{-21} \text{ s}$      $t_{\text{Be}} \sim 10^{-16} \text{ s}$  )

estimate for the relative amount

$$\frac{\# \text{Be}}{\# \text{He}} = \frac{e^{-\Delta E/k_B T}}{(e^{\Delta E/k_B T})^2 / 2} = 2 \left( e^{-2(92.2 \times 10^3 \text{ eV}) / (8.617 \times 10^{-5} \text{ eV/K} \times 10^8 \text{ K})} \right)$$

$$= 1.14 \times 10^{-14} \quad \left( \begin{array}{l} \# \text{ I saw in a book was} \\ \sim 10^{-10} \end{array} \right)$$

We could say the  $\frac{dN_{Be}}{dt} = 0 = R - \lambda N$   
Rate of creation

and from our discussion of the sun, we know

$$\frac{R}{V} = \frac{n_{He}^2}{2} \nu \sigma$$

so we end up with

$$\frac{n_{He}^2}{2} \nu \sigma = \lambda N_{Be}$$

$$\frac{n_{He}^2}{n_{Be}} = 2 \left( \frac{\lambda}{\nu \sigma} \right)$$

$$\frac{N_{He}^2}{N_{Be}} = V 2 \left( \frac{\lambda}{\nu \sigma} \right)$$

$$\frac{N_{Be}}{N_{He}^2} = \frac{1}{V} \left( \frac{\nu \sigma}{2\lambda} \right)$$

$$= ? e^{-\Delta E/k_B T} ? ?$$

so, actually, we're stuck!

We need to know  $\langle \nu \sigma \rangle$ , Volume ...

As it is, we've cheated by saying there was 1 Be atom at equilibrium!