Ex. 1

a) $^{1}_{1}p + ^{84}_{36}Kr \longrightarrow ^{84}_{37}Rb + ^{1}_{0}n$

b) $^{1}_{0}n + ^{52}_{24}Cr \longrightarrow ^{52}_{23}V + ^{1}_{1}p$

c) $^{2}_{1}d + ^{74}_{32}Ge \longrightarrow ^{75}_{32}Ge + ^{1}_{1}p$

d) $^{4}_{2}\alpha + ^{32}_{16}S \longrightarrow ^{36}_{18}Ar + ^{0}_{0}\gamma$

Ex. 3

a) $T_1 = T_1' + T_2'$ .... (1)

$p_1 = p_1' + p_2'$ .... (2)

$p_1'^2 = (p_1 - p_2')^2 = p_1^2 + p_2'^2 - 2p_1p_2'$

$2m_1T_1' = 2m_1T_1 + 2m_2T_2' - 4\sqrt{m_1T_1m_2T_2'}$

$T_1' = \cancel{T_1} + \frac{m_2}{m_1}T_2' - \frac{2}{m_1}\sqrt{m_1m_2T_1T_2'}$

$= \cancel{T_1} - T_2'$

d'où : $T_2'\left(1 + \frac{m_2}{m_1}\right) = \frac{2}{m_1}\sqrt{m_1m_2T_1T_2'}$

$T_2'^2\left(\frac{m_1+m_2}{m_1}\right)^2 = \frac{4}{m_1^2}m_1m_2T_1T_2'$

d'où :

$$T_2' = \frac{4m_1m_2}{(m_1+m_2)^2}T_1$$

b) $m_1 = m_2$

$T_2' = \frac{4m_1^2}{4m_1^2}T_1 = T_1 \Rightarrow T_1' = 0$

$m_1 >> m_2$

$\frac{1}{2}m_2v_2'^2 = \frac{4m_1m_2}{(m_1+m_2)^2} \times \frac{1}{2}m_1v_1^2$

$v_2'^2 = \frac{4m_1^2}{(m_1+m_2)^2}v_1^2 \simeq \frac{4m_1^2}{m_1^2}v_1^2$

$\simeq 4v_1^2 \Rightarrow v_2' \simeq 2v_1$

$m_1 << m_2$

$v_2'^2 = \frac{4m_1^2}{(m_1+m_2)^2}v_1^2 \simeq 4\left(\frac{m_1}{m_2}\right)^2 v_1 \simeq 0$

Ex. 2

$T_1 = T_1' + T_2'$ .... (1)

$\vec{p_1} = \vec{p}_1' + \vec{p}_2'$ .... (2)

$p_1^2 = p_1'^2 + p_2'^2 + 2p_1'p_2'\cos\theta$

$2mT_1 = 2mT_1' + 2mT_2' + 2\sqrt{4m^2T_1'T_2'}\cos\theta$

$T_1 = T_1' + T_2' + 2\sqrt{T_1'T_2'}\cos\theta$

Or d'après (1) : $T_1' + T_2' = T_1$

$T_1 = T_1 + 2\sqrt{T_1'T_2'}\cos\theta$

d'où $\cos\theta = 0$ et $\theta = \pi/2$

Ex. 4

a) $^{2}_{1}d + ^{7}_{3}Li \longrightarrow ^{8}_{4}Be + ^{1}_{0}n$

$Q = (m_d + m_{Li} - m_{Be} - m_n)c^2$

$= 15,03$ MeV

b) $Q = T_{Be} + T_n - T_d$

d'où : $T_{Be} = Q + T_d - T_n$

$\vec{p_d} = \vec{p_{Be}} + \vec{p_n}$ d'où

$\vec{p_{Be}} = \vec{p_d} - \vec{p_n}$

$p_{Be}^2 = p_d^2 + p_n^2 - \cancelto{0}{2\vec{p_d}\cdot\vec{p_n}}$

$\cancel{2}m_{Be}T_{Be} = \cancel{2}m_dT_d + \cancel{2}m_nT_n$

$T_{Be} = \frac{m_d}{m_{Be}}T_d + \frac{m_n}{m_{Be}}T_n$

$= Q + T_d - T_n$

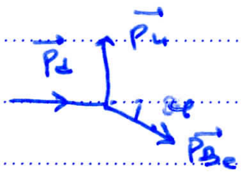
$T_n\left(\frac{m_n}{m_{Be}} + 1\right) = Q + T_d\left(1 - \frac{m_d}{m_{Be}}\right)$

$T_n = \frac{m_{Be}Q + T_d(m_{Be} - m_d)}{m_n + m_{Be}}$

$= 20$ MeV

c) $T_{Be} = Q + T_d - T_n$

$\simeq 5$ MeV



$$\begin{cases} p_d = p_{Be}\cos\varphi \\ 0 = p_n - p_{Be}\sin\varphi \end{cases}$$

d'où :

$\tan\varphi = \frac{p_n}{p_d} = \sqrt{\frac{2m_nT_n}{2m_dT_d}}$

$\simeq 1$ d'où $\varphi \simeq 45°$

Ex. 5

a) ${}^{4}_{2}\alpha + {}^{14}_{7}N \longrightarrow {}^{17}_{8}O + {}^{1}_{1}p$

$Q = (m_\alpha + m_N - m_O - m_p)c^2$

$= -1{,}19$ MeV

$E_{Th} = -\dfrac{M}{2m_N} Q = 1{,}53$ MeV

b) $Q = T_O + T_p - T_\alpha$

d'où : $T_O = Q + T_\alpha - T_p$ .... (1)

$\vec{p}_\alpha = \vec{p}_O + \vec{p}_p$ d'où : $\vec{p}_O = \vec{p}_\alpha - \vec{p}_p$

$p_O^2 = p_\alpha^2 + p_p^2 - 2p_\alpha p_p \cos 60$

$= p_\alpha^2 + p_p^2 - p_\alpha p_p$

$2m_O T_O = 2m_\alpha T_\alpha + 2m_p T_p - 2\sqrt{m_\alpha m_p T_\alpha T_p}$

$T_O = \dfrac{m_\alpha}{m_O} T_\alpha + \dfrac{m_p}{m_O} T_p - \dfrac{1}{m_O}\sqrt{m_\alpha m_p T_\alpha T_p}$

$= Q + T_\alpha - T_p$

$T_p\left(1 + \dfrac{m_p}{m_O}\right) - \dfrac{1}{m_O}\sqrt{m_\alpha m_p T_\alpha T_p}$

$+ T_\alpha\left(\dfrac{m_\alpha}{m_O} - 1\right) - Q = 0$

$T_p(m_O + m_p) - \sqrt{m_\alpha m_O T_\alpha}\sqrt{T_p}$

$+ T_\alpha(m_\alpha - m_O) - m_O Q = 0$

$T_p - \dfrac{\sqrt{m_\alpha m_O T_\alpha}}{m_O + m_p}\sqrt{T_p} + \dfrac{T_\alpha(m_\alpha - m_O)}{m_O + m_p}$

$- \dfrac{m_O Q}{m_O + m_p} = 0$

Soit : $(X = \sqrt{T_p})$

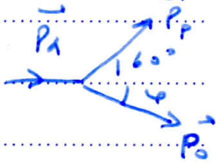
$X^2 - 0{,}28X - 2{,}9 = 0$

d'où : $X = \sqrt{T_p} = 1{,}85$ MeV

et $T_p = 3{,}42$ MeV

c) $T_O = Q + T_\alpha - T_p$

$= 1{,}13$ MeV



$$\begin{cases} p_\alpha = p_p \cos 60° + p_O \cos\varphi \\ 0 = p_p \sin 60° - p_O \sin\alpha \end{cases}$$

d'où

$\tan\alpha = \dfrac{p_p\sqrt{3}/2}{p_\alpha - p_p/2} = \dfrac{\sqrt{3}\,p_p}{2p_\alpha - p_p}$

$= \dfrac{\sqrt{3}\sqrt{2m_p T_p}}{2\sqrt{2m_\alpha T_\alpha} - \sqrt{2m_p T_p}}$

$= \dfrac{\sqrt{3}}{2\sqrt{m_\alpha T_\alpha / m_p T_p} - 1} = 0{,}395$

d'où $\varphi \simeq 22°$

Ex. 6 :

$\dfrac{\Delta\phi}{\phi} = n\sigma\Delta x$

$n\Delta x = 1{,}3\times10^{19}$ cm^{-2}

$\Delta\phi = \dfrac{15\times4\pi}{2\times10^{-3}} = 3\pi\,10^4$ s^{-1}

$I = \dfrac{q}{t} = 2e\phi \Rightarrow \phi = \dfrac{I}{2e} =$

$\sigma = \dfrac{\Delta\phi}{\phi}\times\dfrac{1}{n\Delta x} = \dfrac{3\pi\,10^4\times2\times1{,}6\times10^{-19}}{10^{-9}\times1{,}3\times10^{19}}$

$= 23{,}2\times10^{-26}$ cm^2 $= 0{,}23$ b

Ex. 7 :

a) $\tan\dfrac{\theta}{2} = \dfrac{b_0}{b} \Rightarrow b = b_0/\tan(\theta/2)$

$b = b_0/\tan 45° = b_0 = \dfrac{q_1 q_2}{4\pi\varepsilon_0\,\mu\,v_0^2}$

$= \dfrac{Ze^2}{4\pi\varepsilon\, m_p(2E/m_p)} = \dfrac{Ze^2}{8\pi\varepsilon_0 E_k} = 1{,}8\times10^{-15}$ m

b) $\sigma(>90°) = \displaystyle\int_{\pi/2}^{\pi}\frac{b_0^2\times2\pi\sin\theta\,d\theta}{4\sin^4(\theta/2)}$

$= 2\pi b_0^2\displaystyle\int\frac{\sin\theta/2\cos\theta/2\;d\theta/2}{\sin^4\theta/2} = 2\pi b_0^2\int\frac{du}{u^3}$

$= 2\pi b_0^2\left[-\dfrac{1}{2u^2}\right] = \pi b_0^2\left[\dfrac{1}{\sin^2\theta/2}\right]_{\pi}^{\pi/2}$

$= \pi b_0^2 = 0{,}11$ b

Ex. 8 :

$E_n = \dfrac{E_{n-1}}{2} = \dfrac{E_{n-2}}{2^2} = \dots = \dfrac{E_0}{2^n}$

$2^n = \dfrac{E_0}{E_n} \Rightarrow n = \dfrac{\ln(E_0/E_n)}{\ln 2}$

$n = \dfrac{\ln(2\times10^6/0.04)}{\ln 2} \simeq 26$

Ex. 9 :

$Q = T_1 + T_2$; $2m_1T_1 = 2m_2T_2$

$\Rightarrow T_2 = \dfrac{m_1}{m_2}T_1$ / $Q = T_1\left(1 + \dfrac{m_1}{m_2}\right)$

$\Rightarrow T_1 = \dfrac{m_2}{m_1 + m_2}Q = 115{,}65$ MeV

$T_2 = Q - T_1 = 74{,}35$ MeV

Ex. 10

$\mathcal{P} = \dfrac{W}{t} \Rightarrow t = \dfrac{W}{\mathcal{P}}$

$t = \dfrac{185\times\cancel{10^6}\times1{,}6\times10^{-19}\times1000\times6{,}02\times10^{23}}{235\times100\times\cancel{10^6}}$

$= 7{,}59\times10^5$ s $= 8.77$ j