HW4

1. a) $^{6}He \rightarrow {}^{6}Li + e^- + \bar{\nu}_e$

b) $^{66}Ga \rightarrow {}^{66}Zn + e^+ + \nu_e$

c) $e^- + {}^{8}B \rightarrow {}^{8}Be + \nu_e$

d) $\nu_e + {}^{37}Cl \rightarrow {}^{37}Ar + e^-$

e) $^{40}K \rightarrow \nu + e^+ + {}^{40}Ar$

f) $^{40}K \rightarrow \bar{\nu} + e^- + {}^{40}Ca$

2. For e^+ decay we would have

$^{7}Be \rightarrow {}^{7}Li + e^+ + \nu_e$

$Q = (m_i - m_f - 2m_e)c^2$ (atomic masses)

$= (\cancel{7m_u} + \Delta^7Be - \cancel{7m_u} - \Delta^7Li)c^2 - 2 \cdot .511\,MeV$

$= (16929\,\mu u - 16004\,\mu u)c^2 - 1.022\,MeV$

$= 925 \times 10^{-6}\,u \cdot \frac{931.494\,MeV/c^2}{u} - 1.022$

$= .861632 - 1.022 = -0.1603\,MeV \rightarrow$ no go

For K-capture

$e^- + {}^{7}Be \rightarrow {}^{7}Li + \nu_e$

$Q \approx (m_i - m_f)c^2 - B_K$ (atomic masses)

$= (0.861632 - 55 \times 10^{-6})\,MeV$

$= 0.861577\,MeV$ ✓ OK!

3. a) + b) $^{89}Sr(5/2^+) \rightarrow {}^{89}Y(1/2^-)$ $\Delta I = 2$ $\Delta\pi$ = yes GT 1^{ST}

$^{36}Cl(2^+) \rightarrow {}^{36}Ar(0^+)$ $\Delta I = 2$ $\Delta\pi$ = No GT 2^{ND}, F 2^{ND}

$^{26}Si(0+) \rightarrow {}^{26}Al^*(0^+)$ $\Delta I = 0$ $\Delta\pi$ = NO F allowed

$^{97}Zr(1/2+) \rightarrow {}^{97}Nb(1/2^-)$ $\Delta I = 0$ $\Delta\pi$ = yes GT 1^{ST} F 1^{st}

4a) ^{203}Hg β^- to ^{203}Tl

$T_0 = 0.213$ MeV $\rightarrow \log_{10} f = -0.3$ (fig. 3.8)

$t_{1/2} = 46.59$ days $= 4.0254 \times 10^6$ sec

$\log_{10} t_{1/2} = 6.605$

$\log_{10} ft = -0.3 + 6.605 = 6.30$

b) Table 3.3 shows first forbidden & allowed as possible for this ft.

$^{203}Hg(5/2^-) \rightarrow {}^{203}Tl^*(\frac{3}{2}+)$

$\Delta I = 1$

$\Delta \pi =$ yes

so 1st forbidden

5, a) $^{203}Tl \rightarrow {}^{199}Au + \alpha$

b) $Q = (m_i - m_f)c^2$

$= (\cancel{203u} + \Delta {}^{203}Tl - \cancel{199u} - \Delta {}^{199}Au - \cancel{4u} - \Delta {}^4He)c^2$

$= -27671\mu u - (-31252)\mu u - 2603\mu u)c^2$

$= 978 \mu u\, c^2$

$= 978 \times 10^{-6} \times 931.494 = 0.911$ MeV

c) $R = 1.2(A_1^{1/3} + A_2^{1/3})$ fm

$= 1.2(199^{1/3} + 4^{1/3}) = 1.2(5.838272 + 1.5874) = 8.9108$ fm

$T = 120$ MeV $+ Q \approx 121$ MeV

$v = \sqrt{\frac{2T}{mc^2}}\, c = \sqrt{\frac{2 \cdot 121}{3727}}\, c = .25482\, c$

$1/f = 1/\frac{R2}{v} = 1/\frac{8.9108 \text{ fm}}{.25482c} = 1/34.97 \frac{\text{fm}}{c} \times \frac{10^{-15} \text{m}}{10^8 \text{m/s}} = 2(2.86 \times 10^{21})$ $\quad f = 5.66 \times 10^{21}$

$B = \frac{2 \cdot 79 e^2}{4\pi\epsilon_0 R} = \frac{2 \cdot 79 \cdot 1.44 \text{ MeV} \cdot \text{fm}}{8.9108 \text{ fm}} = 25.533$ MeV

$Q/B = \frac{.911}{25.333} = 0.03568$

5.c) ctd.

$$G = \frac{2}{137} \cdot 79 \sqrt{\frac{2 \cdot 3727}{0.911}} \left[\cos^{-1}\sqrt{.03568} - \sqrt{.03568(1-0.03568)} \right]$$

$$= (1.1533)(90.4556)\left[1.3807 - .18549\right]$$

your calc probably says zero → wrong!

$$G = 124.3 \quad : \quad t_{1/2} = \frac{0.69}{(2.86\times10^{21}/s)\exp(-2\cdot124.3)}$$

note: $e^x = 10^{x \log_{10} e}$

$$t_{1/2} = \frac{0.69}{(5.66\times10^{21}/s)(10^{-2\cdot124.3\cdot\log_{10} e})} = \frac{0.69}{(5.66\times10^{21})(10^{-107.96})} = \frac{0.69}{6.127\times10^{-87}}$$

$$\boxed{\approx 1.13\times10^{86}\, s}$$

d) longer than current estimate of life of universe.

e) $^{294}118 \rightarrow {}^{290}116 + \alpha$

$Q \approx 11.65\ MeV \qquad T = Q + 120\,MeV = 131.65\,MeV$

$R = 1.2(290^{1/3} + 4^{1/3})\,fm = 9.8478\ fm$

$v = \sqrt{\frac{2\cdot131.65}{3727}} = .2658\ c$

$$f \approx \frac{v}{2R} = \frac{.2658c}{29.8478\,fm} = \frac{.02699}{2}\frac{c}{fm} \times \frac{3\times10^8\,m/s}{c} \times \frac{1\,fm}{10^{-15}} = 4.05 \times 10^{21}/s$$

$$B = \frac{2\cdot116\cdot1.44}{9.8478}\frac{MeV\,fm}{fm} = 33.924\ MeV$$

$$Q/B = \frac{11.65}{33.924} = 0.34341$$

$\cos^{-1}\sqrt{.34341} = 0.94467 \qquad \sqrt{.34341(1-.34341)} = .47485$

$[\quad] = .46982$

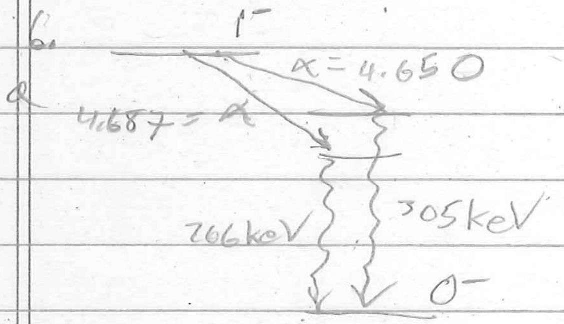
$$G = \frac{2\cdot116}{137}\sqrt{\frac{2\cdot3727}{11.65}}\left[\quad\right] = 42.835\cdot(.46982)$$

$$= 20.124$$

$$t_{1/2} = \frac{0.69}{(4.05\times10^{21}/s)(\exp(-2\cdot20.124))} = \frac{0.69}{4.05\times10^{(21-2\cdot20.124\cdot\log_{10}e)}} = 5.16\times10^{-5}\,sec$$

$$= .05\ ms$$

6.



b) $|I_i - I_f| \le L \le |I_i + I_f|$

$$1 \le L \le 1$$

so only $L = 1$ would be possible.
Since $I(\alpha) = 0$, this would have to be orbital ang. mom. of 1, but that goes with change of parity. Since $\Delta\pi = $ No for g.s. to g.s. transition here, it can't happen.

7. Lilley 4.1

$$\sigma = \pi R^2 \left(1 - \frac{B}{E}\right)$$

$E = 2B$

$$\sigma = \pi R^2 \left(1 - \frac{B}{2B}\right)$$

$$1\,b = \frac{\pi R^2}{2}$$

$$R = \sqrt{\frac{2(1b)}{\pi}} = \sqrt{\frac{2\,10^{-28}\,m^2}{\pi}} = 7.98 \times 10^{-15}\,m$$

$$= 7.98\ fm.$$

$\frac{p^2}{2m} = E$

8. Lilley 4.2 $\quad R = 1.2\,(125)^{1/3} = 6\,fm$

$$0 \le l \le R\,ƛ$$

$$l \lesssim 6\,fm \cdot .659\,fm^{-1}$$

$$l \le 4$$

so 5 partial waves: $l = 0, 1, 2, 3, 4$.

(neutrons $z = 0$ so $E = E'$)

$$ƛ = \frac{\lambda}{2\pi} = \frac{1}{k} = \frac{p}{\hbar} = \frac{\sqrt{2mE}}{\hbar c}$$

$$= \frac{\sqrt{2(939.565)(9\,MeV)}}{197.3} = 0.659\,fm^{-1}$$