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HW 1

1.) a) $^{56}Ni \xrightarrow{EC} {}^{56}Co$ $\quad Q_{EC} = \Sigma M_{react} - \Sigma M_{prod}$

~~$Q_{EC} = (-56040.5 - (-53907.6))$ keV =~~

$Q_{^{56}Ni,\,EC} = (-53907.6 - (-56040.5))$ keV

$= 2132.9$ keV

b) $^{44}Ti \xrightarrow{EC} {}^{44}Sc \quad \therefore Q = (-37548.6 - (-37816.0))$ keV

$= 267.4$ keV

c) $^{177}Lu \xrightarrow{\beta^-} {}^{177}Hf \quad \therefore$

$Q = -52383.9 - (-52886.7)$

$= 496.8$ keV

d) $^{99}Mo \xrightarrow{\beta^-} {}^{99}Tc$ $\quad Q = -85970.11 - (-87327.9)$

$= 1357.79$ keV

e) $^{22}Na \xrightarrow{\beta^+} {}^{22}Ne$ $\quad Q = \Sigma M_{react} - \Sigma M_{prod} - 2M_{e^-}$

$Q = -5181.39 - (-8024.716) - 2(511)$

$= 1821.326$ keV

f) $^{89}Zr \xrightarrow{\beta^+} {}^{89}Y$ $\quad Q = -84878 - (-87711.2) - 2(511)$

$= 1811.2$ keV

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2) $E_{\beta^- max} = Q - E_{level}$

a) $E_{max} = 0.4971 - 0.32132 = 0.17578$ MeV

b) $E_{max} = 0.4971 - 0.24967 = 0.4971$ MeV

c) $E_{max} = 0.4971 - 0.11295 = 0.38415$ MeV

d) $E_{max} = 0.4971 - 0 = 0.4971$ MeV

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3) β decay results in a spectrum because the energy is shared between the β particle and antineutrino so if the energy for the antineutrino is higher then the energy for the β particle would be lower and vice versa

HW1

4) a) $^{22}Na\ (\beta^+)$: $^{22}Na \longrightarrow {}^{22}Ne + e^+ + \nu$

$^{22}Na\ (\beta^-)$: $^{22}Na \longrightarrow {}^{22}Mg + e^- + \bar{\nu}$

b) $^{60}Co\ (EC)$: $^{60}Co + e^- \longrightarrow {}^{60}Fe + \gamma + \nu$

c) $^{127}Cs\ (\beta^+)$: $^{127}Cs \longrightarrow {}^{127}Xe + e^+ + \nu$

$^{127}Cs\ (\beta^-)$: $^{127}Cs \longrightarrow {}^{127}Ba + e^- + \bar{\nu}$

d) $^{241}Am\ (\alpha)$: $^{241}Am \longrightarrow {}^{237}Np + {}^{4}He$

e) $^{252}Cf\ (\alpha)$: $^{252}Cf \longrightarrow {}^{248}Cm + {}^{4}He$

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5) $A = 150\ MBq$

$A_0 = 200\ MBq$

$t = 5\ days$

$A = A_0 e^{-\lambda t}$

$\lambda = -\dfrac{\ln\left(\frac{A}{A_0}\right)}{t}$

$\lambda = -\dfrac{\ln\left(\frac{150\ MBq}{200\ MBq}\right)}{5\ days}$

$\lambda = 0.057536414\ \frac{1}{days}$

$\lambda = 12.047\,1042\ \frac{1}{days}$

$t_{1/2} = \dfrac{\ln(2)}{\lambda}$

$t_{1/2} = \dfrac{\ln(2)}{\lambda} = 12.047\,1042\ days$

HW 1

6) a) $^{239}Pu \longrightarrow {}^{235}U + {}^{4}He$

$\therefore Q_\alpha = \Sigma M_{react} - \Sigma M_{prod}$

$= \underbrace{48588.2}_{Pu} - \underbrace{40918.8}_{U} - \underbrace{2424.91587}_{He}$

$= 5244.484$ KeV

$T_\alpha = (Q - E_{level})\left(\frac{A_{D_1}}{A_{D_1} + A_{D_2}}\right) = (5244.484 - 0)\left(\frac{235}{235+4}\right)$

$= 5156.710337$ KeV

b) $^{243}Am \longrightarrow {}^{239}Np + {}^{4}He$

used values from iaea for b

$Q = 57175 - 49311 - 2424.916 = 5439.084$ KeV

$T_\alpha = 5439.084\left(\frac{239}{243}\right) = 5349.552$ KeV

c) $^{214}Bi \longrightarrow {}^{210}Tl + {}^{4}He$

$Q = -1201 - (-9247) - 2424.916 = 5621.084$ KeV

$T_\alpha = 5621.084\left(\frac{214}{214}\right) = 5516.017$ KeV

HW 1

7) ^{187}Pb can undergo both α and β decay.

It can undergo α decay because it is heavy and unstable and it can undergo β decay because $A \gg Z$.

And the Chart of nuclides says 88% β and 12% α

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8) $N_0 = 2.5$ mol

$t_{1/2} = 43$ days

$\lambda = \frac{\ln(2)}{t_{1/2}} = 0.01612 \frac{1}{\text{days}}$

$N = N_0 \exp(-\lambda t)$

$N_{43} = 2.5 \exp(-0.01612 \cdot 43) = 1.25$ mol

$N_{6m} = 2.5 \exp(-0.01612 \cdot 6 \cdot 30.5) = 0.130861638$ mol

$N_{1y} = 2.5 \exp(-0.01612 \cdot 1 \cdot 12 \cdot 30.5) = 6.849907 \times 10^{-3}$ mol

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a) $A_0 = 47$ Bq $\qquad A = A_0 \exp(-\lambda \cdot t)$

$t_{1/2} = 4$ days

$\lambda = \frac{\ln(2)}{t_{1/2}} = 0.173286795 \frac{1}{\text{days}}$

b) 2 days before: $t = -2$

$\therefore$ ~~$A = A_0$~~ $\qquad A = 47 \exp(-0.173286795 \cdot -2)$

$= 66.46803743$ Bq

c) 2 days after: $t = +2$

$\therefore A = 47 \exp(-0.173286795 \cdot 2)$

$= 33.23401872$ Bq

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10) $A = 3.5\ \mu Ci = 3.5 \times 10^{-6}\ Ci = 3.5 \times 10^{-6}\ Ci \cdot \frac{3.7 \times 10^{10}\ Bq}{1\ Ci}$

$A = 129500\ Bq = 129500\ dps$

$\lambda = \frac{\ln(2)}{t_{1/2}} = \frac{\ln(2)}{1.41352 \times 10^{17}\ sec} = 4.90369 \times 10^{-18}\ \frac{1}{sec}$

using $A = \lambda N \rightarrow N = \frac{A}{\lambda}$

$= \frac{129500\ \frac{atom}{sec}}{4.90369 \times 10^{-18}\ \frac{1}{sec}} = 2.64087 \times 10^{22}\ atom$

$\Rightarrow 2.64087 \times 10^{22}\ atom \cdot \frac{1\ mol}{6.022 \times 10^{23}}$

$= 0.043853666\ mol\ ^{235}U$