Quiz 20.2 – Radiometric Dating, Fission, and Fusion

Name: Key

Question 1

A geological sample contains $24.5\ g$ of ^{238}U and $7.35\ g$ of ^{206}Pb. What is the radiometric age of the sample?

↳ $N = 0.103$ moles ↳ 0.0357 moles → $N_0 = 0.139$ moles

$\ln\left(\frac{N_0}{N}\right) = \left(\frac{\ln 2}{t_{1/2}}\right) \cdot t$ $\ln\left(\frac{0.139\ \text{moles}}{0.103\ \text{moles}}\right) = \frac{\ln 2}{4.5 \cdot 10^9\ y} \cdot t \rightarrow t = 1.95 \cdot 10^9$ years

Question 2

An archaeological sample contains carbon which decays at a rate of $13.8\ \frac{d}{min\ g}$. Living biological material decays at a rate of $15.3\ \frac{d}{min\ g}$. What is the carbon-dating age of the sample?

$\ln\left(\frac{A_0}{A}\right) = \left(\frac{\ln 2}{t_{1/2}}\right) t$ $\ln\left(\frac{15.3\ d/min\cdot g}{13.8\ d/min\cdot g}\right) = \left(\frac{\ln 2}{5730\ y}\right) \cdot t \rightarrow t = 853$ years

Question 3

$^{235}_{92}U$ will undergo fusion when it absorbs a single extra neutron. The products of this reaction include 3 neutrons, $^{141}_{56}Ba$, and one more daughter nucleus. Write a complete balanced equation for this fission reaction

$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\,{}^{1}_{0}n$

Question 4

The "Farnsworth Fusor" is a popular nuclear fusion reactor design among hobbyists (I kid you not). This apparatus will fuse together 2 deuterons ($^{2}_{1}H$) to produce a single product nucleus and a gamma ray. Write a balanced equation for this fusion reaction

${}^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{4}_{2}He + {}^{0}_{0}\gamma$

Question 5

Assume that all of the energy released in a reaction in a Farnsworth Fusor is carried away by the gamma ray. What is the energy and wavelength of that gamma ray? ^{2}H has a precise mass of $2.01355\ u$, and ^{4}He has a precise mass of $4.00151\ u$

Reactant mass: $2 \cdot 2.01355\ u = 4.02710\ u$

$\Delta m = -0.02559\ u \left(\frac{1\ g}{6.022 \cdot 10^{23}\ u}\right)\left(\frac{1\ kg}{1000\ g}\right)$

Product mass: $4.00151\ u$

$\Delta m = -4.249 \cdot 10^{-29}\ kg$

$\lambda = \frac{hc}{E} = 5.202 \cdot 10^{-14}\ m = 0.5202\ fm = 520.2\ pm$ $\Delta E = \Delta m c^2 = -4.249 \cdot 10^{-29}\ kg\ (2.998 \cdot 10^8\ m/s)^2 = 3.819 \cdot 10^{-12}\ J$!