Practice Problems Week 10

1. Write balanced nuclear equations for the following:

(a) ^{214}Pb undergoes β decay : $^{214}Pb \rightarrow {}^{214}Bi + {}^{0}b$

(b) ^{231}Pa undergoes α decay : $^{231}Pa \rightarrow {}^{227}Ac + {}^{4}a$

(c) $^{14}_{7}N + {}^{4}_{2}He \longrightarrow {}^{1}_{1}H + {}^{17}_{8}O$

(d) $^{40}_{19}K \longrightarrow {}^{40}_{18}Ar + {}^{0}_{+1}\beta$

(e) $^{16}_{8}O + {}^{12}_{6}C \longrightarrow {}^{28}_{14}Si$

(f) $^{253}_{99}Es + {}^{4}_{2}He \longrightarrow {}^{256}_{101}Md + {}^{1}_{0}n$

(g) $^{235}_{92}U + {}^{1}_{0}n \longrightarrow {}^{137}_{52}Te + {}^{97}_{40}Zr + 2{}^{1}_{0}n$

2. Iodine-134 has a half-life of 52.0 minutes. If you begin with 1.28 mg of the isotope, how much is left after 0.289 days?

Well, the half-life is given in minutes, so let's convert 0.289 days into minutes:

$$0.289 \text{ da} \times \frac{24 \text{ hr}}{1 \text{ da}} \times \frac{60 \text{ min}}{1 \text{ hr}} = 416 \text{ min}$$

Now! How many times will 52.0 minutes/half-life go into 416 minutes?

$$\frac{416 \text{ min}}{52.0 \ \frac{\text{min}}{\text{half-life}}} = 8.00 \text{ half-lives}$$

So, we know that

$$m \equiv m_0 \left(\frac{1}{2}\right)^n \quad \text{(mass} \equiv \text{initial mass times 1/2 to the power of half-lives)}$$

$$m \equiv 1.28 \text{ mg} \left(\frac{1}{2}\right)^8 \equiv 1.28 \text{ mg} \left(\frac{1}{256}\right) \equiv 0.00500 \text{ mg} \equiv 5.00 \text{ μg}$$

3. A 64.0 mg sample of ^{235}Pu decays to 2.00 mg in 130 minutes. What is the half-life of this isotope?

So, what fraction of the initial mass 64.0 mg is 2.00 mg? It's 2.00/64.0

or 1.00/32.0. But 1.00/32.0 is 1.00/(2.00)5. So it has been divided by two, five times, meaning the time span of five half-lives has passed. So, if 130 minutes is five half-lives, then one half-life is

$$\frac{130 \text{ minutes}}{5.00 \text{ half-lives}} = 26.0 \frac{\text{minutes}}{\text{half-life}}.$$

4. How many weeks have passed if a 32.0 mg sample of a radioactive nuclide has decayed to 2.00 mg? ($t_{½}$ = 6.5 days)

The basic question here is: "How many times has the mass been divided by two?" That would be the number of half-lives. Then we multiply that number by 6.5 days and convert to weeks:

$$32.0 \text{ mg} \times \left(\frac{1}{2}\right)^n \equiv 2.0 \text{ mg}$$

So $\left(\frac{1}{2}\right)^n$ must equal $\frac{1}{16}$. Well, $\frac{1}{16} \equiv \left(\frac{1}{2}\right)^4$

So we have four half-lives each at 6.5 days making 26 days or 3.7 weeks.