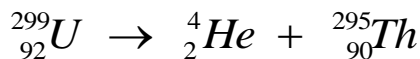


## TOPIC 10: NUCLEAR CHEMISTRY, EXTRA PRACTICE

CLEARLY SHOW THE METHOD USED AND THE STEPS INVOLVED IN ARRIVING AT YOUR ANSWERS

1. A certain radioactive isotope of uranium-299,  $U$ , has a half-life of 4500 days. A lab worker discovers that a sample of this substance has been sitting on a shelf for 722 days (exactly). What percent of the original nuclei is still present after 722 days? Also, write the nuclear equation if this substance was for a nuclei uranium-299, that undergoes alpha decay during this period of time.



$$(mass)_t = (mass)_0 \times 0.5^n$$

$$n = \frac{722 \text{ days}}{4500 \text{ days}} = 0.160\bar{4}$$

$$(mass)_t = 100 \text{ g} \times 0.5^{0.160\bar{4}} = 89.47 \text{ g}$$

$$\frac{89.47 \text{ g}}{100 \text{ g}} \times 100\% = 89.5\%$$

**OR**

$$\ln\left(\frac{[A]_t}{[A]_0}\right) = -kt \quad ; \quad \ln\left(\frac{50 \text{ g}}{100 \text{ g}}\right) = -k(4500 \text{ days})$$

$$\frac{\ln(0.5)}{-4500 \text{ days}} = k = 0.000154 \frac{1}{\text{days}} \quad ; \quad \left(\ln\frac{?}{100 \text{ g}}\right) = (-0.000154)(722 \text{ days})$$

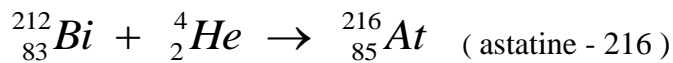
$$e^{\left(\ln\frac{?}{100 \text{ g}}\right)} = e^{((-0.000154)(722 \text{ days}))} = e^{(-0.1112116)}$$

$$\frac{?}{100 \text{ g}} = 0.895 \quad ; \quad \frac{?}{100 \text{ g}} = 0.895$$

$$? = (0.895)(100 \text{ g}) = 89.5 \text{ g}$$

$$\frac{89.47 \text{ g}}{100 \text{ g}} \times 100\% = 89.5\%$$

2. A 0.365 gram sample of **bismuth-212**,  $Bi$ , is decaying at a rate of  $3.18 \times 10^{15}$  disintegrations of nuclei per second (dis  $\text{sec}^{-1}$  OR nuclei  $\text{sec}^{-1}$ ). First, write the nuclear equation for **bismuth-212** when the nuclei undergo alpha capture. Then calculate the decay rate constant,  $k$ , of **bismuth-212** (in  $\text{sec}^{-1}$ ). Also, calculate the half-life period of time for this nuclear reaction.



$$\text{Rate} = k N_t$$

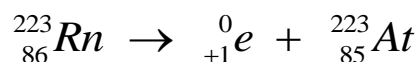
$$\frac{0.365 \text{ gram}}{212 \text{ grams}} \times \frac{1 \text{ mol}}{1 \text{ mol}} \times \frac{6.02 \times 10^{23} \text{ nuc}}{1 \text{ mol}} = 1.0365 \times 10^{21} \text{ nuc}$$

$$k = \frac{\text{Rate}}{N_t} = \frac{3.18 \times 10^{15} \text{ nuc sec}^{-1}}{1.0365 \times 10^{21} \text{ nuc}} = 3.068 \times 10^{-6} \frac{1}{\text{sec}}$$

$$t_{1/2} = \frac{\ln(0.5)}{-k} = \frac{\ln(0.5)(\text{sec})}{-3.068 \times 10^{-6}} = 2.26 \times 10^5 \text{ sec}$$

$$\text{IF curious... } \frac{2.26 \times 10^5 \text{ sec}}{3600 \text{ sec}} \times \frac{1 \text{ hour}}{3600 \text{ sec}} = 62.8 \text{ hours}$$

3. **Radon-223** undergoes positron decay with an initial mass of 469 grams. Currently the sample has a mass of 62.4 grams after 35.3 days. First, write the nuclear equation for this reaction, and then calculate the number of half-lives that have elapsed.



$$\ln\left(\frac{[A]_t}{[A]_0}\right) = -kt \quad ; \quad \ln\left(\frac{62.4 \text{ g}}{469 \text{ g}}\right) = -k(35.6 \text{ days})$$

$$\frac{\ln\left(\frac{62.4 \text{ g}}{469 \text{ g}}\right)}{-35.6 \text{ days}} = k = 0.0566584 \frac{1}{\text{days}}$$

$$t_{1/2} = \frac{\ln(0.5)(\text{days})}{-0.0566584} = 12.2 \text{ days}$$

$$\text{number of half-lives} = \frac{35.6 \text{ days}}{12.2 \text{ days}} = 2.91$$

**OR**

$$(\text{mass})_t = (\text{mass})_0 \times 0.5^n$$

$$62.4 \text{ g} = 469 \text{ g} \times 0.5^n$$

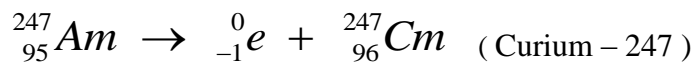
$$\frac{62.4 \text{ g}}{469 \text{ g}} = 0.5^n = 0.133049$$

$$\log_{0.5}(0.5^n) = \log_{0.5}(0.133049) \quad \dots \text{ Yep, that is logarithm base 0.5 } \odot$$

$$n = 2.90997$$

***n = number of half-lives***

4. A lab worker discovered that 39.5% of the original amount of **americium-247, Am**, remained (changed due to beta decay) in the original package that the material was shipped within. The original amount (on the shipping date) of **americium-247** HAD a mass of 2250 grams. The shipping date (and time) on the container (the moment it was packaged contained 100% of the sample which was **americium-247**) was EXACTLY 9.00 days ago (to the second – isn't that amazing?). First, write the nuclear equation for this reaction, and then calculate the decay rate constant,  $k$ , for **americium-247**. Finally, calculate the half-life period of time for this nuclear reaction.



$$39.5\% \text{ of } 2250 \text{ g} = (0.395)(2250 \text{ g}) = 888.75 \text{ g}$$

$$\ln\left(\frac{[A]_t}{[A]_0}\right) = -kt \quad ; \quad \ln\left(\frac{888.75 \text{ g}}{2250 \text{ g}}\right) = -k(9.00 \text{ days}) \quad ;$$

$$\frac{\ln\left(\frac{888.75 \text{ g}}{2250 \text{ g}}\right)}{-9.00 \text{ days}} = k = 0.103208 \frac{1}{\text{days}}$$

$$t_{1/2} = \frac{\ln(0.5)}{-k} = \frac{\ln(0.5)(\text{days})}{-0.103208} = 6.72 \text{ days}$$