

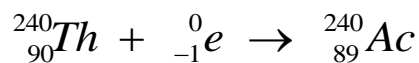
AP CHEMISTRY

TOPIC 10: NUCLEAR CHEMISTRY, REVIEW – PART II

Day 119

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

1. A certain radioactive isotope of thorium-240, Th , has a half-life of 8.87 hours. A lab worker discovers that a sample of this substance has been sitting on a shelf for 1.50 days (exactly). What percent of the original nuclei is still present after 1.50 days? Also, write the nuclear equation if this substance was for a nuclei thorium-240 that undergoes electron capture during this period of time.



$$\ln\left(\frac{[A]_t}{[A]_0}\right) = -kt \quad ; \quad \ln\left(\frac{0.5}{1.0}\right) = -kt_{1/2} \quad ; \quad k = \frac{\ln(0.5)}{-t_{1/2}} = \frac{\ln(0.5)}{-8.87 \text{ hrs}} = 0.078145 \text{ hrs}^{-1}$$

$$\frac{1.50 \text{ days}}{1 \text{ day}} \times \frac{24 \text{ hrs}}{1 \text{ day}} = 36.0 \text{ hrs}$$

$$\ln\left(\frac{[A]_t}{100 \text{ g}}\right) = -(0.078145 \text{ hrs}^{-1})(36.0 \text{ hrs}) \quad ; \quad \ln\left(\frac{[A]_t}{100 \text{ g}}\right) = -2.813224 \quad ;$$

$$e^{\left(\ln\left(\frac{[A]_t}{100 \text{ g}}\right)\right)} = e^{-2.813224}$$

$$\frac{[A]_t}{100 \text{ g}} = \cancel{0.0600} \quad ; \quad [A]_t = (0.0600)(100 \text{ g}) = 6.00 \text{ g}$$

$$\frac{6.00 \text{ g}}{100 \text{ g}} \times 100\% = 6.00\%$$

OR

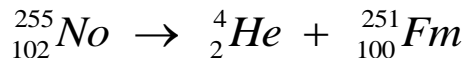
$$(\text{mass})_t = (\text{mass})_0 \times 0.5^n$$

$$n = \frac{36 \text{ hrs}}{8.87 \text{ hrs}} = 4.0586246$$

$$(\text{mass})_t = (100.0 \text{ grams}) (0.5^{4.0586246}) = 6.00 \text{ grams}$$

$$\frac{6.00 \text{ g}}{100 \text{ g}} \times 100\% = 6.00\%$$

2. A 1.77×10^{-4} gram sample of nobelium-255, No , is decaying at a rate of 4.0108×10^{15} disintegrations of nuclei per second (dis sec^{-1} OR nuclei sec^{-1}). First, write the nuclear equation for nobelium-255 when the nuclei undergo alpha emission. Then calculate the decay rate constant, k , of nobelium-255 (in sec^{-1}). Also, calculate the half-life period of time for this nuclear reaction (**in hours**).



$$Rate = k N_t$$

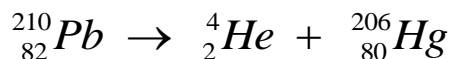
$$\frac{1.77 \times 10^{-4} \text{ gram } {}_{102}^{255}No}{255 \text{ grams}} \times \frac{1 \text{ mol } {}_{102}^{255}No}{1 \text{ mol } {}_{102}^{255}No} \times \frac{6.02 \times 10^{23} \text{ nuc}}{1 \text{ mol } {}_{102}^{255}No} = 4.1786 \times 10^{17} \text{ } {}_{102}^{255}No \text{ nuc}$$

$$k = \frac{Rate}{N_t} = \frac{4.0108 \times 10^{15} \text{ nuc sec}^{-1}}{4.1786 \times 10^{17} \text{ nuc}} = 9.59848 \times 10^{-3} \text{ sec}^{-1}$$

$$t_{1/2} = \frac{\ln(0.5)}{-k} = \frac{\ln(0.5)}{-9.59848 \times 10^{-3} \text{ sec}^{-1}} = 72.2 \text{ sec}$$

$$\frac{72.2 \text{ sec}}{60 \text{ sec}} \times \frac{1 \text{ min}}{60 \text{ min}} \times \frac{1 \text{ hour}}{60 \text{ min}} = 0.0201 \text{ hour}$$

3. Lead-210 undergoes alpha decay with an initial mass of 445.3 grams. Currently the sample has a mass of 24.2 grams after 789.5 hours. First, write the nuclear equation for this reaction and then calculate the number of half-lives that have elapsed.



$$\ln\left(\frac{[A]_t}{[A]_0}\right) = -kt$$

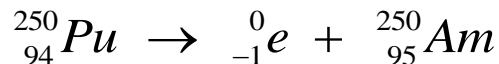
$$\ln\left(\frac{24.2 \text{ g}}{445.3 \text{ g}}\right) = -k(789.5 \text{ hrs})$$

$$\frac{\ln\left(\frac{24.2 \text{ g}}{445.3 \text{ g}}\right)}{-789.5 \text{ hrs}} = k = 0.003688911 \text{ hrs}^{-1}$$

$$t_{1/2} = \frac{\ln(0.5)}{-k} = \frac{\ln(0.5)}{-0.003688911 \text{ hrs}^{-1}} = 187.86 \text{ hrs}$$

$$\text{number of half-lives} = \frac{789.5 \text{ hrs}}{187.86 \text{ hrs}} = 4.20$$

4. A lab worker discovered that 7.55% of the original amount of plutonium-250, Pu , remained (changed due to beta decay) in the original package that the material was shipped within. The original amount (on the shipping date) of plutonium-250 HAD a mass of 973 grams. The shipping date (and time) on the container (the moment it was packaged contained 100% of the sample which was plutonium-250) was EXACTLY 24 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 plutonium-250. Finally, calculate the half-life period of time for this nuclear reaction.



$$7.55\% \text{ of } 973 \text{ g} = (0.0755)(973 \text{ g}) = 73.4615 \text{ g}$$

$$\ln\left(\frac{[A]_t}{[A]_0}\right) = -kt$$

$$\ln\left(\frac{73.4615 \text{ g}}{973 \text{ g}}\right) = -k(24 \text{ days})$$

$$\frac{\ln(0.0755)}{-24 \text{ days}} = k = 0.107651 \text{ days}^{-1}$$

$$t_{1/2} = \frac{\ln(0.5)}{-k} = \frac{\ln(0.5)}{-0.107651 \text{ days}^{-1}} = 6.44 \text{ days}$$