Nuclear Chemistry Notes Examples

Set 1

#1 Rubidium-90 decays through beta emission since a mass of 90 is greater than the periodic table average of 85.4678.

#2 For Z (atomic number) > 83 decay is generally through the α process.

#3 $^{216}_{84}Po \longrightarrow {}^{212}_{82}Pb + {}^{4}_{2}He$ (remember Z & A MUST be conserved)

#4 $^{42}_{21}Sc$ is unstable primarily because it has an <u>odd</u> number of protons (21) & neutrons (21)

#5 $^{26}_{13}Al \longrightarrow {}^{0}_{1}\beta + {}^{26}_{12}Mg$ positron emission

Set 2

#1 mass defect = $236.9970 - (232.9901 + 4.0015) = .0054u$

.0054 amu

$.0054 \text{ amu} \times 1.66\times10^{-24} \text{ g/amu} = 8.964\times10^{-27} \text{ g} = 8.964\times10^{-30} \text{ kg}$

1 mole = # of atoms in 12.0g of Carbon-12

6.022×10^{23} atoms in 12.0g $= 1.99\times10^{-23}$ g/atom

12 protons/neutrons per atom $1.99\times10^{-23} \text{ g/atom} / 12 \text{ nucleons/atom}$

$= 1.66\times10^{-24}$ g/nucleon

$E = mc^2 \quad E = (8.964\times10^{-30} \text{ kg})(3.00\times10^{8} \text{ m/s})^2 = 8.068\times10^{-13} \text{ J}$

$8.068\times10^{-13} \text{ J} \times \frac{1 \text{ eV}}{1.6022\times10^{-19} \text{ J}} \times \frac{\text{MeV}}{1\times10^{6} \text{ eV}} = \underline{5.03 \text{ MeV}}$

#2 mass defect $= .0029u = 1.68\times10^{-30} \text{ kg}$

$E = (1.68\times10^{-30})(9\times10^{16}) = 4.33\times10^{-13} \text{ J} = \underline{2.70 \text{ MeV}}$ (Note: we get the same answer whether atomic masses or nuclear masses (atomic masses - electrons) are used.)

#3 $t_{\frac{1}{2}} = 0.693/k \qquad 5.3 = 0.693/k \qquad k = .131$

$N = N_0 e^{-kt} = (10.0 \text{ mg}) e^{-(.131)(21.2)} = \underline{.622 \text{ mg}}$

another way to solve this is 21.2 years is 4 half lives so

$10.0 \text{ mg} \left(\frac{1}{2}\right)^4 = .625 \text{ mg}$

Nuclear Chemistry Notes Examples 2

#4 $R = R_0 e^{-kt}$ $\quad 1600 = 6400\, e^{-k(6.00)}$

$.25 = e^{-k(6.00)}$ $\quad \ln .25 = -k(6.00)$

$-1.386 = -k(6.00)$

$t_{\frac{1}{2}} = \frac{0.693}{k} = \frac{0.693}{.231} = \underline{3.00 \text{ hours}}$ $\quad \leftarrow k = .231$

#5 Carbon-14 decays to nitrogen-14 w/ $t_{\frac{1}{2}} = 5{,}730$ years

Carbon-12 is a stable isotope that doesn't decay

If the ratio of C-14/C-12 is .72 (and C-12 is fixed) then the number of C-14 atoms is only .72 of what it originally was. Therefore $\frac{N}{N_0} = .72$ $\quad k = .693/5730 = 1.209 \times 10^{-4}$

$N = N_0 e^{-kt}$ $\quad \ln \frac{N}{N_0} = -kt$ $\quad \ln\left(\frac{.72}{1}\right) = -(1.209 \times 10^{-4})t$

$t \approx \underline{2700 \text{ years}}$