Chem 1062

Note Title 8/6/2008

* Final Exam tomorrow – please be here on time so we may begin @ 8:00 am
* Exams Returned

Types of Radioactive Decay

* make predictions of decay type by its location with respect to the band of stability
* links to isotable tables may also be used

Nuclear Bombardment Reactions

* nucleus bombarded by another nucleus or particle
* also called transmutation
* carried out with large instruments called cyclotrons (particle accelerators)
* Rutherford conducted first documented transmutation – this lead to discovery of proton ~1919

$$^{14}_{7}N + ^{4}_{2}He \rightarrow ^{17}_{8}O + ^{1}_{1}H$$

abbreviated notation → $^{14}_{7}N(\alpha, p)^{17}_{8}O$

α = alpha
β = beta
γ = gamma
p = proton
d = deuteron $^{2}_{1}H$
t = triton $^{3}_{1}H$
n = neutron

James Chadwick – discovered the neutron in 1932

Write an equation that shows the

bombardment of Be-9 with alpha particles to produce a neutron.

$$^{9}_{4}Be(\alpha, n)^{12}_{6}C$$

$$^{9}_{4}Be + ^{4}_{2}He \rightarrow ^{12}_{6}C + ^{1}_{0}n$$

Ch. 21, # 61, 67, 71, 77, 79

Rate $\propto N_t$ — rate = activity

$$\text{Rate} = K N_t \qquad t_{1/2} = \frac{0.693}{K} \qquad \ln\frac{N_t}{N_0} = -Kt$$

$$\text{Rate} = K[A]$$

decay constant — rate constant

Radioactive Decay is a 1st-order rate process

N_t = nuclei present at time = t

$$1\ Ci = 1\ \text{curie} = 3.700 \times 10^{10}\ \frac{\text{disintegrations}}{s}$$

$$E = mc^2$$
$$\Delta E = \Delta m c^2$$

(21.61) Au-198 $t_{1/2} = 2.69\ d$ What is the activity of 0.86 mg of this isotope in Curies?

$$2.69\ d \times \frac{24\ h}{1\ d} \times \frac{60\ min}{1\ h} \times \frac{60\ s}{1\ min} = 2.324 \times 10^5\ s$$

$$0.86\ mg\ ^{198}Au \times \frac{1\ g}{1000\ mg} \times \frac{1\ mol}{198\ g} \times \frac{6.022 \times 10^{23}\ \text{nuclei}}{1\ mol} = 2.616 \times 10^{18}\ \text{nuclei}$$

$$\text{Rate} = K N_t = \frac{0.693}{t_{1/2}} N_t = \left(\frac{0.693}{2.324 \times 10^5\ s}\right) 2.616 \times 10^{18}\ \text{nuclei}$$

$$t_{1/2} = \frac{0.693}{K} \Rightarrow K = \frac{0.693}{t_{1/2}} = 7.801 \times 10^{12} \frac{\text{nuclei}}{s}$$

$$7.801 \times 10^{12} \frac{\text{disintegrations}}{s} \times \frac{1\ Ci}{3.700 \times 10^{10} \frac{\text{disint}}{s}} = \boxed{2.1 \times 10^{2}\ Ci}$$

21.67 If 28.0% of a sample of N-17 decays in 1.97 s, what is the half-life?

72.0% remains $\quad N_t = 0.720 N_0$

$$\ln \frac{N_t}{N_0} = -Kt$$

$$\ln \frac{0.720 N_0}{N_0} = -K(1.97s)$$

$$\frac{-0.3285}{-1.97s} = \frac{-K(1.97s)}{-1.97s} = 0.1668\ s^{-1}$$

$$t_{1/2} = \frac{0.693}{K} = \frac{0.693}{0.1668 s^{-1}} = \boxed{4.16 s}$$

21.71 $Rate_t = 8.1 \frac{\text{disint}}{\text{min} \cdot g}$ $\quad$ ^{14}C has a $t_{1/2} = 5730\ yr$

$Rate_0 = 15.3 \frac{\text{disint}}{\text{min} \cdot g}$

$$^{14}_{7}N + ^{1}_{0}n \rightarrow ^{14}_{6}C + ^{1}_{1}p$$

$$t_{1/2} = \frac{0.693}{K} \Rightarrow K = \frac{0.693}{t_{1/2}} = \frac{0.693}{5730 yr} = 1.209 \times 10^{-4}\ yr^{-1}$$

$$\ln \frac{Rate_t}{Rate_0} = -Kt = \ln \frac{8.1 \frac{\text{dis}}{\text{min} \cdot g}}{15.3 \frac{\text{dis}}{\text{min} \cdot g}} = -(1.209 \times 10^{-4} yr^{-1})t$$

$$\frac{N_t}{N_0} = \frac{Rate_t}{Rate_0}$$

$$\frac{+0.636}{+1.209\times10^{-4}\,yr^{-1}} = \frac{+(1.209\times10^{-4}\,yr^{-1})\,t}{+1.209\times10^{-4}\,yr^{-1}}$$

$= 5260\ yr = \boxed{5.3\times10^{3}\ yr}$

21.77

$${}^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n$$

mass (amu)	2.01400	3.01605	4.00260	1.008665
	reactants		products	

Find energy change in $\frac{MeV}{{}^{2}_{1}H \text{ nucleus}}$

$\Delta E = (\Delta m)c^2$ 1 amu $= 1.6605402\times10^{-27}$ kg

$$\Delta m = -0.018785\ amu \times \frac{1.6605402\times10^{-27}\,kg}{1\ amu} = -3.1193\times10^{-29}\,kg$$

$$\Delta E = (-3.1193\times10^{-29}\,kg)\times\left(2.998\times10^{8}\,\frac{m}{s}\right)^2$$

$$= -2.804\times10^{-12}\,\frac{J}{\text{nucleus } {}^{2}_{1}H} \times \frac{1\ MeV}{1.602\times10^{-13}\,J} = \boxed{-17.50\,\frac{MeV}{\text{nucleus } {}^{2}_{1}H}}$$

$$-2.804\times10^{-12}\,\frac{J}{\text{nucleus}} \times \frac{1\ kJ}{1000\ J} \times \frac{6.022\times10^{23}\ \text{nuclei}}{1\ mol} \qquad \frac{kJ}{mol}$$

$$= -1.69\times10^{12}\,\frac{kJ}{mol}$$

$H_2 + O_2 \rightarrow H_2O$

$-241\ \frac{kJ}{mol}$

(21.79) mass defect for $^{6}_{3}Li$ in amu

find nuclear binding energy in MeV per $^{6}_{3}Li$

$$3\,^{1}_{1}p + 3\,^{1}_{0}n \rightarrow \,^{6}_{3}Li$$

mass (amu) $3(1.00728) + 3(1.008665)$ 6.01512

6.047835 amu vs 6.01512 amu

Δm = mass defect

$$\Delta E = \Delta m c^2$$