Nuclear Chemistry Worksheet

1) **The decay constant for I-131 is 3.59 x 10^{-3} h^{-1}. How much I-131 remains after a week if the initial mass was 15.0 g?**

2) **The decay constant for Sr-90 is 1237 min^{-1}. If after one year k is found to be 937 min^{-1}, what is the half-life of Sr-90?**

3) **Calculate the binding energy of $^{55}_{25}Mn$. ($^{1}_{0}n$ = 1.00867 u, $^{1}_{1}H$ = 1.00782 u, $^{55}_{25}Mn$ = 54.9381 u)**

4) **Balance the following nuclear equations.**

(a)	$^{218}_{84}Po$			→	?	+	$^{214}_{82}Pb$		
(b)	$^{212}_{83}Bi$			→	$^{0}_{-1}\beta$	+	?		
(c)	?			→	$^{4}_{2}\alpha$	+	$^{207}_{81}Tl$		
(d)	$^{9}_{4}Be$	+	$^{4}_{2}He$	→	?	+	$^{1}_{0}n$		
(e)	?	+	$^{4}_{2}He$	→	$^{12}_{6}C$	+	$^{6}_{3}Li$		
(f)	$^{12}_{6}C$	+	?	→	$^{1}_{1}H$	+	$^{13}_{6}C$		

5) **A sample of C-14 has an activity of 10 disintegrations per minute and a half-life of 5730 yr.**

(a) How many C-14 atoms are there in this sample?

(b) How many grams are there?

6) For each pair of isotopes, tell which isotope is more stable and why.

(a) $^{23}_{11}Na$ **or** $^{22}_{11}Na$

(b) $^{58}_{27}Co$ **or** $^{59}_{27}Co$

(c) $^{12}_{6}C$ **or** $^{11}_{6}C$

(d) $^{45}_{20}Ca$ **or** $^{44}_{20}Ca$

(e) $^{96}_{42}Mo$ **or** $^{96}_{43}Tc$

Solutions

1) $k = 3.59 \times 10^{-3}\ h^{-1}$ $t = 7$ days

$m_0 = 15.0$ g

$\ln(m_t/m_0) = -k \times t$

$\ln(m_t/15.0\ g) = -3.59 \times 10^{-3}/\cancel{h} \times 24\ \cancel{h}/1\ \cancel{day} \times 7\ \cancel{days} = -0.603$

$m_t/15.0\ g = e^{-0.603}$

$m_t =$ **8.21 g**

2) $k_0 = 1237\ min^{-1}$ $t = 1$ yr

$k_t = 937\ min^{-1}$ $t_{1/2} = ?$

$\ln(k_t/k_0) = -k \times t$

$\ln(937\ \cancel{min^{-1}}/1237\ \cancel{min^{-1}}) = -k \times 1\ yr$

$k = 0.277\ yr^{-1}$

$k = 0.693/t_{1/2}$

$t_{1/2} = 0.693/k = 0.693/0.277\ yr^{-1} =$ **2.50 yr**

3) m_{Mn} = 54.9381 u $\quad$ ${}^{1}_{1}H$ = 1.00782 u

${}^{1}_{0}n$ = 1.00867 u $\quad$ c = 3.00 x 10^8 m/s

m_T = 25 x 1.00782 u + 30 x 1.00867 u = 55.4556 u

$\Delta m = m_T - m_{Mn}$ = 54.9381 u – 55.4556 u = -0.5175 u

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

ΔE = -0.5175 $\cancel{g}$ x 1 kg/10^3 $\cancel{g}$ x (3.00 x 10^8 m/s)^2 = -4.66 x 10^{13} J

ΔE = -4.66 x 10^{13} J or 4.66 x 10^{13} J released per mole

4)

(a) ${}^{218}_{84}Po \rightarrow {}^{4}_{2}He + {}^{214}_{82}Pb$

(b) ${}^{212}_{83}Bi \rightarrow {}^{0}_{-1}\beta + {}^{212}_{84}Po$

(c) ${}^{211}_{83}Bi \rightarrow {}^{4}_{2}\alpha + {}^{207}_{81}Tl$

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

(e) ${}^{14}_{7}N + {}^{4}_{2}He \rightarrow {}^{12}_{6}C + {}^{6}_{3}Li$

(f) ${}^{12}_{6}C + {}^{2}_{1}H \rightarrow {}^{1}_{1}H + {}^{13}_{6}C$

5) k = 10 dis/min $t_{1/2}$ = 5730 yr

(a) $t_{1/2}$ = 5730 ~~yr~~ x 365 ~~days/yr~~ x 24 ~~h~~/1 ~~day~~ x 60 min/1 ~~h~~ = 3.01 x 10^9 min

k = 0.693/ $t_{1/2}$ = 0.693/(3.01 x 10^9 min) = 2.30 x 10^{-10} min^{-1}

Rate = k x N

10 C-14 atoms/~~min~~ = 2.30 x 10^{-10} ~~min^{-1}~~ x N

N = 10 C-14 atoms/(2.30 x 10^{-10}) = 4.35 x 10^{10} C-14 atoms

(b) m = 4.35 x 10^{10} ~~C-14 atoms~~ x 1 ~~mol C-14~~/(6.02 x 10^{23} ~~C-14 atoms~~) x

14.00 g C-14/1 ~~mol C-14~~ = 1.01 x 10^{-12} g C-14

6) (a) $^{23}_{11}Na$ or $^{22}_{11}Na$ because Na-23 has an even number of neutrons. Odd numbers of both protons and neutrons usually produce unstable nuclei.

(b) $^{58}_{27}Co$ or $^{59}_{27}Co$ because Co-59 has an even number of neutrons.

(c) $^{12}_{6}C$ or $^{11}_{6}C$ because C-12 has an even number of protons and neutrons.

(d) $^{45}_{20}Ca$ or $^{44}_{20}Ca$ because Ca-44 has an even number of protons and neutrons.

(e) $^{96}_{42}Mo$ or $^{96}_{43}Tc$ because Mo-96 has an even number of protons and neutrons.