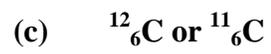


Nuclear Chemistry Worksheet

- 1) The decay constant for I-131 is $3.59 \times 10^{-3} \text{ h}^{-1}$. 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 $^{55}_{25}\text{Mn}$. ($^1_0\text{n} = 1.00867 \text{ u}$, $^1_1\text{H} = 1.00782 \text{ u}$, $^{55}_{25}\text{Mn} = 54.9381 \text{ u}$)
- 4) Balance the following nuclear equations.
 - (a) $^{218}_{84}\text{Po} \rightarrow ? + ^{214}_{82}\text{Pb}$
 - (b) $^{212}_{83}\text{Bi} \rightarrow ^0_{-1}\beta + ?$
 - (c) $? \rightarrow ^4_2\alpha + ^{207}_{81}\text{Tl}$
 - (d) $^9_4\text{Be} + ^4_2\text{He} \rightarrow ? + ^1_0\text{n}$
 - (e) $? + ^4_2\text{He} \rightarrow ^{12}_6\text{C} + ^6_3\text{Li}$
 - (f) $^{12}_6\text{C} + ? \rightarrow ^1_1\text{H} + ^{13}_6\text{C}$
- 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.



Solutions

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

$$m_0 = 15.0 \text{ g}$$

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

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

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

$$m_t = \mathbf{8.21 \text{ g}}$$

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

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

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

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

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

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

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

$$3) \quad m_{\text{Mn}} = 54.9381 \text{ u} \quad {}^1_1\text{H} = 1.00782 \text{ u}$$

$${}^1_0\text{n} = 1.00867 \text{ u} \quad c = 3.00 \times 10^8 \text{ m/s}$$

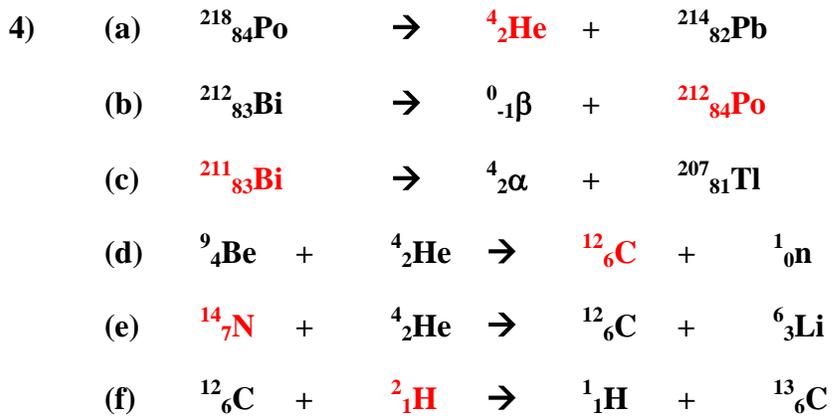
$$m_{\text{T}} = 25 \times 1.00782 \text{ u} + 30 \times 1.00867 \text{ u} = 55.4556 \text{ u}$$

$$\Delta m = m_{\text{T}} - m_{\text{Mn}} = 54.9381 \text{ u} - 55.4556 \text{ u} = -0.5175 \text{ u}$$

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

$$\Delta E = -0.5175 \text{ g} \times 1 \text{ kg}/10^3 \text{ g} \times (3.00 \times 10^8 \text{ m/s})^2 = -4.66 \times 10^{13} \text{ J}$$

$$\Delta E = -4.66 \times 10^{13} \text{ J or } 4.66 \times 10^{13} \text{ J released per mole}$$



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

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

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

Rate = $k \times N$

$10 \text{ C-14 atoms/min} = 2.30 \times 10^{-10} \text{ min}^{-1} \times N$

$N = 10 \text{ C-14 atoms} / (2.30 \times 10^{-10}) = 4.35 \times 10^{10} \text{ C-14 atoms}$

(b) $m = 4.35 \times 10^{10} \text{ C-14 atoms} \times 1 \text{ mol C-14} / (6.02 \times 10^{23} \text{ C-14 atoms}) \times$

$14.00 \text{ g C-14} / 1 \text{ mol C-14} = 1.01 \times 10^{-12} \text{ g C-14}$

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

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

(c) $^{12}_6\text{C}$ or $^{11}_6\text{C}$ because C-12 has an even number of protons and neutrons.

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

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