Homework 10

10. a. $^{32}_{15}P \longrightarrow ^{0}_{-1}e + ^{32}_{16}S$

b. $^{235}_{92}U \longrightarrow ^{4}_{2}He + ^{231}_{90}Th$

12. a. $^{73}_{31}Ga \longrightarrow ^{0}_{-1}e + ^{73}_{32}Ge$

b. $^{192}_{78}Pt \longrightarrow ^{4}_{2}He + ^{188}_{76}Os$

c. $^{205}_{83}Bi \longrightarrow ^{0}_{-1}e + ^{205}_{82}Pb$

d. $^{241}_{96}Cm + ^{0}_{-1}e \longrightarrow ^{241}_{95}Am$

18. a. $^{240}_{95}Am + ^{4}_{2}He \longrightarrow ^{1}_{0}n + ^{243}_{97}Bk$

b. $^{238}_{92}U + ^{12}_{6}C \longrightarrow 6\,^{1}_{0}n + ^{244}_{98}Cf$

c. $^{249}_{98}Cf + ^{15}_{7}N \longrightarrow 4\,^{1}_{0}n + ^{260}_{105}Db$

d. $^{249}_{98}Cf + ^{10}_{5}B \longrightarrow 2\,^{1}_{0}n + ^{257}_{103}Lr$

20. $k = \ln 2/t_{1/2} = 0.69315/432.2$ yr • 1 yr/365 d • 1 d/24 h • 1 hr/3600 s = $5.086 \cdot 10^{-11}$ s^{-1}
Rate = kN = $5.086 \cdot 10^{-11}$ s^{-1} • 5.00 g • 1 mol/241 g • $6.022 \cdot 10^{23}$ nuclei/mol = $6.35 \cdot 10^{11}$ decays/s

$6.35 \cdot 10^{11}$ alpha particles are emitted each second from a 5.00 g ^{241} Am sample.

26. $\ln(N/N_0 = -kt$; $N = 0.010\ N_0$; $t_{1/2} = (\ln 2)/k$
$\ln(0.010) = -(\ln 2)t/t_{1/2} = -0.6931\ t/t_{1/2}$, t = 54 days

32. $1.8 \cdot 10^{14}$ kJ/s • 1000 J/kJ • 3600 s/h • 24 h/day = $1.6 \cdot 10^{22}$ J/day
$\Delta E = \Delta mc^2$, $\Delta m = \Delta E/c^2 = 1.6 \cdot 10^{22}$ J/$(3.00 \cdot 10^8$ m/s$)^2 = 1.8 \cdot 10^5$ kg of solar material provides 1 day of solar energy to the earth.
$1.6 \cdot 10^{22}$ J • 1 kJ/1000 J • 1 g/32 kJ • 1 kg/1000 g = $5.0 \cdot 10^{14}$ kg of coal is needed to provide the same amount of energy.

36. For $^{2}_{1}H$: mass defect = Δm = mass of $^{2}_{1}H$ nucleus – mass of proton – mass of neutron. Let's determine the mass defect in a slightly different way than in Exercise 18.35. Instead of using the atomic mass of hydrogen-1, we will use the mass of the electron and the mass of the proton. The mass of the ^{2}H nucleus will equal the atomic mass of ^{2}H minus the mass of the electron in a ^{2}H atom. From the back of the text, the pertinent masses are: $m_e = 5.49 \cdot 10^{-4}$ amu, $m_p = 1.00728$ amu, $m_n = 1.00866$ amu.

$\Delta m = 2.01410$ amu – 0.000549 amu – [1.00728 amu + 1.00866 amu] = $-2.39 \cdot 10^{-3}$ amu

$\Delta E = \Delta mc^2 = -2.39 \cdot 10^{-3}$ amu • $1.6605 \cdot 10^{-27}$ kg/amu • $(2.998 \cdot 10^{8}\ m/s)^2 = -3.57 \cdot 10^{-13}$ J

BE/nucleon = $3.57 \cdot 10^{-13}$ J/2 nucleons = $1.79 \cdot 10^{-13}$ J/nucleon.

44. i) and ii) mean that Pu is not a significant threat outside the body. Our skin is sufficient to keep out the α particles. If Pu gets inside the body, it is easily oxidized to Pu^{4+}(iv), which is chemically similar to Fe^{3+}(iii). Thus, Pu^{4+} will concentrate in tissues where Fe^{3+} is found. One of these is the bone marrow where red blood cells are produced. Once inside the body, α particles cause considerable damage.

54. a. $^{238}_{92}U \longrightarrow ^{222}_{86}Rn \quad + \quad ?\ ^{4}_{2}He \quad + \ ?\ ^{0}_{-1}e$

To account for the mass number change, 4 alpha particles are needed. To balance the number of protons, 2 beta particles are needed.

$^{222}_{86}Rn \longrightarrow ^{218}_{84}Po \quad + \quad ^{4}_{2}He$

Polonium-84 is produced when ^{222}Rn decays.

b. Alpha particles cause significant ionization damage inside a living organism. Since the half-life of ^{222}Rn is relatively short, a significant number of alpha particles will be produced when ^{222}Rn is present (even for a short period of time) in the lungs.

c. $^{222}_{86}Rn \longrightarrow ^{218}_{84}Po \quad + \quad ^{4}_{2}He$

$^{218}_{86}Po \longrightarrow ^{214}_{82}Pb \quad + \quad ^{4}_{2}He$

Polonium-218 is produced when radon-222 decays. ^{218}Po is a more potent alpha particle producer since it has a much shorter half-life than ^{222}Rn. In addition, ^{218}Po is a solid, so it can get trapped in the lung tissue once it is produced. Once trapped, the alpha particle produced form polonium-218 (with its very short half-life) can cause significant ionization damage.

d. Rate = kN; rate = 4.0 pCi/L x $1 \cdot 10^{-12}$ Ci/pCi x $3.7 \cdot 10^{10}$ decays/sec/Ci = 0.15 decays/sec•L

k = ln2/$t_{1/2}$ = 0.6931/3.82 d x 1 d.24 h x 1 hr/3600 s = $2.10 \cdot 10^{-6}\ s^{-1}$

N = rate/k x (0.15 decay/sec•L)/$2.10 \cdot 10^{6}\ s^{-1}$ = $7.1 \cdot 10^{4}$ ^{222}Rn atoms/L

$7.1 \cdot 10^{4}$ ^{222} Rn atoms/L x 1 mol ^{222}Rn/$6.022 \cdot 10^{23}$ atoms = $1.2 \cdot 10^{-19}$ mol ^{222}Rn/L