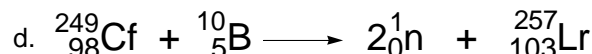
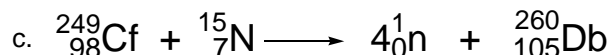
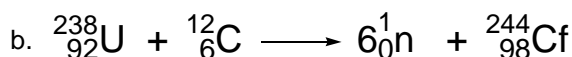
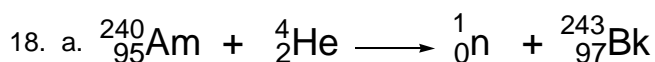
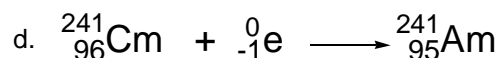
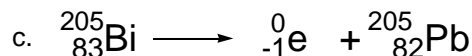
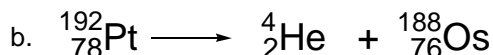
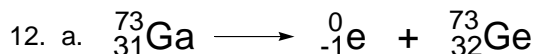
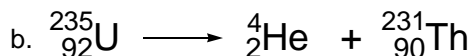
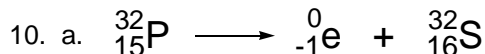


### Homework 10



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

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

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

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

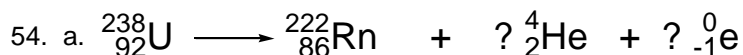
36. For  ${}^2_1\text{H}$ : mass defect =  $\Delta m = \text{mass of } {}^2_1\text{H nucleus} - \text{mass of proton} - \text{mass of neutron}$ . Let's determine the mass defect in a slightly different way than in Exercise 18.35. Instead of using the atomic mass of hydrogen-1, we will use the mass of the electron and the mass of the proton. The mass of the  ${}^2\text{H}$  nucleus will equal the atomic mass of  ${}^2\text{H}$  minus the mass of the electron in a  ${}^2\text{H}$  atom. From the back of the text, the pertinent masses are:  $m_e = 5.49 \cdot 10^{-4} \text{ amu}$ ,  $m_p = 1.00728 \text{ amu}$ ,  $m_n = 1.00866 \text{ amu}$ .

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

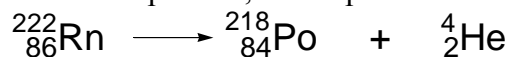
$$\Delta E = \Delta mc^2 = -2.39 \cdot 10^{-3} \text{ amu} \cdot 1.6605 \cdot 10^{-27} \text{ kg/amu} \cdot (2.998 \cdot 10^8 \text{ m/s})^2 = -3.57 \cdot 10^{-13} \text{ J}$$

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

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

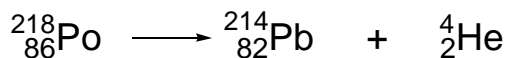
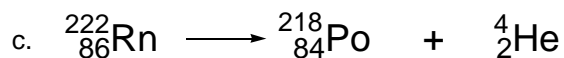


To account for the mass number change, 4 alpha particles are needed. To balance the number of protons, 2 beta particles are needed.



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

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



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

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

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

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

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