Chapter 43

6. We note that the sum of superscripts (mass numbers A) must balance, as well as the sum of Z values (where reference to Appendix F or G is helpful). A neutron has $Z = 0$ and $A = 1$. Uranium has $Z = 92$.

(a) Since xenon has $Z = 54$, then “Y” must have $Z = 92 – 54 = 38$, which indicates the element strontium. The mass number of “Y” is 235 + 1 – 140 – 1 = 95, so “Y” is ^{95}Sr.

(b) Iodine has $Z = 53$, so “Y” has $Z = 92 – 53 = 39$, corresponding to the element yttrium (the symbol for which, coincidentally, is Y). Since 235 + 1 – 139 – 2 = 95, then the unknown isotope is ^{95}Y.

(c) The atomic number of zirconium is $Z = 40$. Thus, 92 – 40 – 2 = 52, which means that “X” has $Z = 52$ (tellurium). The mass number of “X” is 235 + 1 – 100 – 2 = 134, so we obtain ^{134}Te.

(d) Examining the mass numbers, we find $b = 235 + 1 – 141 – 92 = 3$.

7. If R is the fission rate, then the power output is $P = RQ$, where Q is the energy released in each fission event. Hence,

$$R = P/Q = (1.0\text{ W})/(200 \times 10^6\text{ eV})(1.60 \times 10^{-19}\text{ J/eV}) = 3.1 \times 10^{10}\text{ fissions/s}.$$

30. We are given the energy release per fusion ($Q = 3.27$ MeV $= 5.24 \times 10^{-13}$ J) and that a pair of deuterium atoms is consumed in each fusion event. To find how many pairs of deuterium atoms are in the sample, we adapt Eq. 42-21:

$$N_{d\text{ pairs}} = \frac{M_{\text{sam}}}{2M_d}N_{\text{A}} = \left(\frac{1000\text{ g}}{2(2.0\text{ g/mol})}\right)(6.02\times10^{23}\text{ / mol}) = 1.5\times10^{26}.$$

Multiplying this by Q gives the total energy released: 7.9×10^{13} J. Keeping in mind that a watt is a joule per second, we have

$$t = \frac{7.9\times10^{13}\text{ J}}{100\text{ W}} = 7.9\times10^{11}\text{ s} = 2.5\times10^{4}\text{ y}.$$

36. The energy released is

$$Q = -\Delta mc^2 = -(m_{\text{He}} - m_{\text{H2}} - m_{\text{H1}})c^2$$
$$= -(3.016029 \text{ u} - 2.014102 \text{ u} - 1.007825 \text{ u})(931.5 \text{ MeV/u})$$
$$= 5.49 \text{ MeV}.$$

37. (a) Let *M* be the mass of the Sun at time *t* and *E* be the energy radiated to that time. Then, the power output is

$$P = dE/dt = (dM/dt)c^2,$$

where $E = Mc^2$ is used. At the present time,

$$\frac{dM}{dt} = \frac{P}{c^2} = \frac{3.9\times10^{26}\text{ W}}{\left(2.998\times10^8 \text{ m/s}\right)^2} = 4.3\times10^9 \text{ kg/s}.$$

(b) We assume the rate of mass loss remained constant. Then, the total mass loss is

$$\Delta M = (dM/dt)\,\Delta t = (4.33 \times 10^9 \text{ kg/s})\,(4.5 \times 10^9 \text{ y})\,(3.156 \times 10^7 \text{ s/y})$$
$$= 6.15 \times 10^{26} \text{ kg}.$$

The fraction lost is

$$\frac{\Delta M}{M + \Delta M} = \frac{6.15\times10^{26}\text{ kg}}{2.0\times10^{30}\text{ kg} + 6.15\times10^{26}\text{ kg}} = 3.1\times10^{-4}.$$

51. Since plutonium has $Z = 94$ and uranium has $Z = 92$, we see that (to conserve charge) two electrons must be emitted so that the nucleus can gain a $+2e$ charge. In the beta decay processes described in Chapter 42, electrons and neutrinos are emitted. The reaction series is as follows:

$$^{238}\text{U} + \text{n} \rightarrow {}^{239}\text{Np} + {}^{239}\text{U} + e + \nu$$
$$^{239}\text{Np} \rightarrow {}^{239}\text{Pu} + e + \nu$$