50. (a) From $E = NQ = (M_{\text{sam}}/4m_p)Q$ we get the energy per kilogram of hydrogen consumed:

$$\frac{E}{M_{\text{sam}}} = \frac{Q}{4m_p} = \frac{(26.2\,\text{MeV})(1.60 \times 10^{-13}\,\text{J/MeV})}{4(1.67 \times 10^{-27}\,\text{kg})} = 6.3 \times 10^{14}\ \text{J/kg}\ .$$

(b) Keeping in mind that a Watt is a Joule per second, the rate is

$$\frac{dm}{dt} = \frac{3.9 \times 10^{26}\,\text{W}}{6.3 \times 10^{14}\,\text{J/kg}} = 6.2 \times 10^{11}\ \text{kg/s}\ .$$

This agrees with the computation shown in Sample Problem 44-5.

(c) From the Einstein relation $E = Mc^2$ we get $P = dE/dt = c^2 dM/dt$, or

$$\frac{dM}{dt} = \frac{P}{c^2} = \frac{3.9 \times 10^{26}\,\text{W}}{(3.0 \times 10^{8}\,\text{m/s})^2} = 4.3 \times 10^{9}\ \text{kg/s}\ .$$

This finding, that $\frac{dm}{dt} > \frac{dM}{dt}$, is in large part due to the fact that, as the protons are consumed, their mass is mostly turned into alpha particles (helium), which remain in the Sun.

(d) The time to lose 0.10% of its total mass is

$$t = \frac{0.0010M}{dM/dt} = \frac{(0.0010)(2.0 \times 10^{30}\,\text{kg})}{(4.3 \times 10^{9}\,\text{kg/s})(3.15 \times 10^{7}\,\text{s/y})} = 1.5 \times 10^{10}\ \text{y}\ .$$