47. (a) The mass of a carbon atom is $(12.0\,\mathrm{u})(1.661\times10^{-27}\,\mathrm{kg/u}) = 1.99\times10^{-26}\,\mathrm{kg}$, so the number of carbon atoms in 1.00 kg of carbon is $(1.00\,\mathrm{kg})/(1.99\times10^{-26}\,\mathrm{kg}) = 5.02\times10^{25}$. The heat of combustion per atom is $(3.3\times10^{7}\,\mathrm{J/kg})/(5.02\times10^{25}\,\mathrm{atom/kg}) = 6.58\times10^{-19}\,\mathrm{J/atom}$. This is 4.11 eV/atom.

(b) In each combustion event, two oxygen atoms combine with one carbon atom, so the total mass involved is $2(16.0\,\mathrm{u}) + (12.0\,\mathrm{u}) = 44\,\mathrm{u}$. This is $(44\,\mathrm{u})(1.661\times10^{-27}\,\mathrm{kg/u}) = 7.31\times10^{-26}\,\mathrm{kg}$. Each combustion event produces $6.58\times10^{-19}\,\mathrm{J}$ so the energy produced per unit mass of reactants is $(6.58\times10^{-19}\,\mathrm{J})/(7.31\times10^{-26}\,\mathrm{kg}) = 9.00\times10^{6}\,\mathrm{J/kg}$.

(c) If the Sun were composed of the appropriate mixture of carbon and oxygen, the number of combustion events that could occur before the Sun burns out would be $(2.0\times10^{30}\,\mathrm{kg})/(7.31\times10^{-26}\,\mathrm{kg}) = 2.74\times10^{55}$. The total energy released would be $E = (2.74\times10^{55})(6.58\times10^{-19}\,\mathrm{J}) = 1.80\times10^{37}\,\mathrm{J}$. If P is the power output of the Sun, the burn time would be

$$t = \frac{E}{P} = \frac{1.80\times10^{37}\,\mathrm{J}}{3.9\times10^{26}\,\mathrm{W}} = 4.62\times10^{10}\,\mathrm{s} = 1460\,\mathrm{y}\ .$$