

Chapter 38 Problem 45 †

Given

$$m = 55.9206 \text{ u}$$

$$m_p = 1.007276 \text{ u}$$

$$m_n = 1.008665 \text{ u}$$

$$1 \text{ u} = 1.661 \times 10^{-27} \text{ kg}$$

Solution

Find the binding energy per nucleon for Iron-56.

Iron-56 has 26 protons and 30 neutrons. As free nucleons the total mass is

$$m_{free} = 26m_p + 30m_n = 26(1.007276 \text{ u}) + 30(1.008665 \text{ u}) = 56.4491 \text{ u}$$

The mass difference between the free and bound nucleons is

$$\Delta m = m_{free} - m_{bound} = 56.4491 \text{ u} - 55.9206 \text{ u} = 0.5285 \text{ u}$$

Converting this to kilograms gives

$$\Delta m = (0.5285 \text{ u}) \left(\frac{1.661 \times 10^{-27} \text{ kg}}{1 \text{ u}} \right) = 8.778 \times 10^{-28} \text{ kg}$$

The rest mass energy from special relativity is

$$E = mc^2$$

$$E = (8.778 \times 10^{-28} \text{ kg})(3.00 \times 10^8 \text{ m/s})^2 = 7.90 \times 10^{-11} \text{ J}$$

Convert the energy to *MeV* where $1 \text{ MeV} = 1.6 \times 10^{-13} \text{ J}$

$$E = (7.90 \times 10^{-11} \text{ J}) \left(\frac{1 \text{ MeV}}{1.6 \times 10^{-13} \text{ J}} \right) = 494 \text{ MeV}$$

Since there are 56 nucleons, then binding energy per nucleon is

$$\frac{494 \text{ MeV}}{56 \text{ nucleon}} = 8.82 \text{ MeV/nucleon}$$

†Problem from Essential University Physics, Wolfson