Chapter 38 Problem 39 [†]

Given
$m = 55.9206\ u$
$m_p = 1.007276\ u$
$m_n = 1.008665\ u$
$1\ u = 1.661 \times 10^{-27}\ kg$

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

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

The mass difference between the free and bound nucleons is

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

Converting this to kilograms gives

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

The rest mass energy from special relativity is

$$E = mc^2$$

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

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

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

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

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

[†]Problem from Essential University Physics, Wolfson