One way to rearrange this equation is $\Delta m = (Zm_p + Zm_e) + Nm_n -$ (atomic mass). Because a hydrogen atom contains one proton and one electron, the first term is equal to Z(atomic mass of H). Thus, the equation for mass defect can be rewritten as follows:

$$\Delta m = Z(\text{atomic mass of H}) + Nm_n - \text{atomic mass}$$

Use this equation and the atomic masses given in Appendix H to calculate mass defect when solving problems involving binding energy. (In this discussion, we have disregarded the binding energies of the electrons. This is reasonable because nuclear binding energies are many tens of thousands of times greater than electronic binding energies.)

The binding energy per nucleon for light nuclei ($A < 20$) is much smaller than the binding energy per nucleon for heavier nuclei. In other words, particles in lighter nuclei are less tightly bound on average than particles in heavier nuclei. Except for the lighter nuclei, the average binding energy per nucleon is about 8 MeV. Of all nuclei, iron-58 has the greatest binding energy per nucleon.

SAMPLE PROBLEM A

Binding Energy

PROBLEM

The nucleus of the deuterium atom, called the *deuteron,* consists of a proton and a neutron. Given that the atomic mass of deuterium is 2.014 102 u, calculate the deuteron's binding energy in MeV.

SOLUTION

1. DEFINE

Given: $Z = 1$ atomic mass of deuterium = 2.014 102 u

$N = 1$ atomic mass of H = 1.007 825 u

$m_n = 1.008\ 665$ u

Unknown: $E_{bind} = ?$

2. PLAN

Choose an equation or situation:

First, find the mass defect with the following relationship:

$$\Delta m = Z\,(\text{atomic mass of H}) + Nm_n - \text{atomic mass}$$

Then, find the binding energy by converting the mass defect to rest energy.

3. CALCULATE

Substitute the values into the equation and solve:

$$\Delta m = 1(1.007\ 825\ \text{u}) + 1(1.008\ 665\ \text{u}) - 2.014\ 102\ \text{u}$$

$$\Delta m = 0.002\ 388\ \text{u}$$

$$E_{bind} = (0.002\ 388\ \text{u})\ (931.49\ \text{MeV/u})$$

$$\boxed{E_{bind} = 2.224\ \text{MeV}}$$

4. EVALUATE

In order for a deuteron to be separated into its constituents—a proton and a neutron—2.224 MeV of energy must be added.