

# Chapter: Nuclear Chemistry

## Section 1: The Nucleus

*Nuclear chemistry:* the study of nuclear reactions and their uses in chemistry

**Nucleons:** protons and neutrons in the atomic nuclei

**Nuclide:** in nuclear chemistry, what an atom is referred to as

- Identified by the number of protons and neutrons in the nucleus
- Written two ways (ex. Radium)
  - ${}^{228}_{88}\text{Ra}$ 
    - 228 is the mass number (protons + neutrons)
    - 88 is the atomic number (protons)
  - Radium – 228

**Mass defect:** the difference between the mass of an atom and the sum of the masses of its protons, neutrons, and electrons

- Helium – 4
  - 2 protons, 2 neutrons, and 2 electrons = 4.032979 amu
  - Measured atomic mass of helium = 4.00260 amu
    - Average atomic mass: weighted average of all natural occurring isotopes of an element
- Mass defect of helium = 4.032979 amu – 4.00260 amu = 0.03038 amu

What causes the loss in mass?

- Albert Einstein stated that mass is converted to energy and energy to mass
  - $E = mc^2$  ( $c$  = speed of light =  $3.00 \times 10^8$  m/s)
  - 1 amu =  $1.6605 \times 10^{-27}$  kg

**Nuclear binding energy:** energy released when a nucleus is formed from nucleons

- Measure of the stability of a nucleus (break apart the nucleus)

**Binding energy per nucleon:** the binding energy of the nucleus divided by the number of nucleons it contains

- Higher the binding energy per nucleon, the more tightly the nucleons are held together

*Strong nuclear force:* force of attraction that exists between nucleons

- The most stable nuclei (atomic # below 20) have the same number of neutrons and protons (1:1 ratio)
- As atomic # increases, stable neutrons – proton ratio increases to 1.5:1
- **Band of stability:** the stable nuclei cluster over a range of neutron – proton ratios
  - Figure 22-2 page 703
  - Stable nuclei land between those red lines
  - For this reason, all nuclei with 84 or more protons are radioactive
  - Stable nuclei also tend to have even numbers of nucleons
    - Just like electrons that are paired

**Nuclear shell model:** nucleons, just like electrons, exist in different energy levels (shells) in the nucleus

- **Magic numbers:** 2, 8, 20, 28, 50, 82, and 126
  - Compare with electrons (2, 8, 18, 36, 54, and 86)

Unstable nuclei undergo spontaneous changes to change the number of protons and neutrons:

- **Nuclear reaction:** a reaction that occurs with changes in matter that affects the nucleus of an atom
- **Transmutation:** change in the identity of a nucleus as a result of a change in the number of protons
  - Changing one element into another
  - Add or subtract particles
  - Work with isotopes