Chapter 21
Nuclear Chemistry: The Risks and Benefits
Learning Objectives

1.5.2022

To satisfy the minimum requirements for this course, you should be able to:

1. Recognize and use the symbols for protons, neutrons, electrons, positrons, alpha particles, beta particles, and gamma rays.

2. Write nuclide symbols given the number of protons, number or neutrons, and number of electrons.

3. Write balanced equations for nuclear reactions.

4. Recognize a band of stability plot and based on the n/p ratio of a nuclide and its position relative to the band of stability be able to:
   - predict if it decays.
   - if it decays, predict the type of decay (i.e. alpha decay, beta decay, positron emission, or electron capture) that the nuclide will undergo

5. Qualitatively interpret a decay series.

6. Use first-order kinetics to examine the rates of nuclear decay and be able to calculate
   - the half-life of a radioisotope
   - the age of an object (radiometric dating)
   - the remaining amount of a radioisotope, given the appropriate data

7. Perform energy calculations for nuclear reactions:
   - understand and calculate the mass defect for a nuclear reaction using isotopic atomic masses in Table A3.3 in Appendix 3, p. APP14-16)
   - use Einstein's relation, $E = (\Delta m)c^2$, to calculate energy changes in nuclear reactions
   - calculate nuclear binding energies
   - interpret the curve of binding energies per nucleon plots in terms of nuclear stability and the energy changes associated with fission and fusion reactions

8. Compare the penetrating power and biological effects of α, β, γ radiation.

9. Understand and be able to use the following units of activity and biological exposure:
   - activities: counts per minute (cpm), disintegrations per minute (dpm), curies and becquerel
   - curie (Ci): 1 Ci = 3.7×10^{10} disintegrations per second (dps); becquerel (Bq): 1 Bq = 1dps
   - roentgen equivalent for man (rem): rem = (# of rads) x (RBE)
     - radiation absorbed dose (rad): 1 rad = 0.01 J/kg of body tissue
     - relative biological effectiveness (RBE) ($\gamma \approx \beta \approx 1$; $\alpha \approx 20$)

   ***NOTE:** All constants and conversion factors shown here will be provided on an exam, but you must know how to use them.

10. NavApp: Nuclear Reactors/Weapons
    - explain how nuclear reactions can be used to produce energy for power generation and weapons.
    - define critical mass and describe the relationship between critical mass and chain reactions
    - explain the functions of the major components of a pressurized water nuclear reactor: fuel elements, control rods, moderator, cooling liquid, primary loop, and secondary loop
    - identify the primary and secondary loops in a boiler that is heated by a nuclear reactor