

Chapter 21  
**Nuclear Chemistry: The Risks and Benefits**  
 Learning Objectives

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 balanced equations for nuclear reactions.
3. Recognize a band of stability plot and based on its position of a nuclide relative to the band of stability be able:
  - to predict if it decays,
  - if it does decay, predict the type of decay (i.e. alpha decay, beta decay, positron emission, or electron capture) that the nuclide will undergo
4. Qualitatively interpret a decay series.
5. 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
6. 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 binding energy per nucleon plots in terms of nuclear stability and the energy changes associated with fission and fusion reactions
7. NavApp: Nuclear Reactors
  - explain how nuclear reactions can be used to produce energy
  - 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
8. Compare the penetrating power of  $\alpha$ ,  $\beta$ ,  $\gamma$  radiation.
9. Understand the factors that determine the biological effects of radiation:
  - absorbed dose
  - penetrating ability
  - ionizing ability
10. Understand and be able to use the following that are related to biological effects:
  - activities: counts per minute (cpm), disintegrations per minute (dpm), curies and becquerel
  - curie (Ci):  $1 \text{ Ci} = 3.7 \times 10^{10}$  disintegrations per second (dps); becquerel (Bq):  $1 \text{ Bq} = 1 \text{ dps}$
  - roentgen equivalent for man (rem):  $\text{rem} = (\# \text{ of rads}) \times (\text{RBE})$ 
    - radiation absorbed dose (rad):  $1 \text{ rad} = 0.01 \text{ J/kg}$  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.