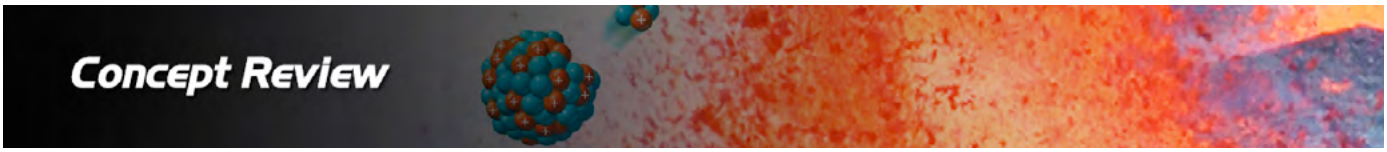

Chapter 5

Summary of Terms

Alpha Particle A subatomic particle consisting of the combination of two protons and two neutrons ejected by a radioactive nucleus. The composition of an alpha particle is the same as that of the nucleus of a helium atom.

Beta Particle An electron emitted during the radioactive decay of a radioactive nucleus.

Carbon-14 Dating The process of estimating the age of once-living material by measuring the amount of radioactive carbon-14 present in the material.

Chain Reaction A self-sustaining reaction in which the products of one reaction event initiate further reaction events.

Critical mass The minimum mass of fissionable material needed for a sustainable chain reaction.

Gamma Rays High-frequency electromagnetic radiation emitted by radioactive nuclei.

Half-Life The time required for half the atoms in a sample of a radioactive isotope to decay.

Nuclear Fission The splitting of the atomic nucleus into two smaller halves.

Nuclear Fusion The combining of nuclei of light atoms to form heavier nuclei.

Radioactive A descriptive term for a material that contains nuclei that emit energetic particles and radiation.

Radioactivity The phenomenon exhibited by the spontaneous emission of energetic particles and radiation by an atomic nucleus.

Rem A unit for measuring the ability of radiation to harm living tissue.

Strong Nuclear Force The attractive force between all nucleons, effective only at very short distances.

Thermonuclear Fusion Nuclear fusion brought about by high temperatures.

Transmutation The changing of an atomic nucleus of one element into an atomic nucleus of another element through a decrease or increase in the number of protons.

Review Questions

5.1 Unstable Nuclei

1. Which type of radiation—alpha, beta, or gamma—results in the greatest change in mass number? The greatest change in atomic number?

2. Which of the three rays—alpha, beta, or gamma— has the greatest penetrating power?

5.2 Radioactivity Is Natural

3. What is the origin of most of the natural radiation we encounter?

4. Which produces more radioactivity in the atmosphere, coal-fired power plants or nuclear power plants?

5. Is radioactivity on the Earth something relatively new? Defend your answer.

5.3 An Imbalance of Forces

6. Why doesn't the repulsive electric force of protons in the atomic nucleus cause the protons to fly apart?

7. Which have more neutrons than protons, large nuclei or small nuclei?

8. What role do neutrons play in the atomic nucleus?

5.4 Transmutation

9. In what form is most of the energy released by atomic transmutation?

10. What change in atomic number occurs when a nucleus emits an alpha particle? A beta particle?

11. What is the long-range fate of all the uranium that exists in the world today?

5.5 Radioactive Half-Life

12. What is meant by the half-life of a radioactive sample?

13. What is the half-life of uranium-238?

5.6 Isotopic Dating

14. What happens to a nitrogen atom in the atmosphere that captures a neutron?

15. Why is there more carbon-14 in living bones than in once-living ancient bones of the same mass?

16. Why is lead found in all deposits of uranium ores?

5.7 Nuclear Fission

17. What happens to the uranium-235 nucleus when it is stretched out?

18. Is a chain reaction more likely to occur in two separate pieces of uranium-235 or in the same pieces stuck together?

19. How is a nuclear reactor similar to a conventional fossil-fuel power plant? How is it different?

20. Nuclear power reactors that are relatively safe but have yet to be developed are those based upon the fission of what isotope?

5.8 Mass and Energy

21. Who discovered that energy and mass are two different forms of the same thing?

22. In which atomic nucleus do nucleons have the least mass?

23. How does the mass per nucleon in uranium compare with the mass per nucleon in the fission fragments of uranium?

5.9 Nuclear Fusion

24. How does the mass of a pair of atoms that have fused compare to the sum of their masses before fusion?

25. What kind of containers are used to contain plasmas at temperatures of millions of degrees?

26. What kind of nuclear power is responsible for sunshine?

Quantitative Questions

27. Radiation from a point source follows an inverse-square law where the amount of radiation received is proportional to $1/d^2$, where d is distance. If a Geiger counter that is 1 meter away from a small source reads 100 counts per minute, what will be its reading 2 meter from the source? 3 meters from it?

28. Consider a radioactive sample with a half-life of one week. How much of the original sample will be left at the end of the second week? The third week? The fourth week?

29. A radioisotope is placed near a radiation detector, which registers 80 counts per second. Eight hours later, the detector registers 5 counts per second. What is the half-life of the radioactive isotope?

30. Uranium-238 absorbs a neutron and then emits a beta particle. Show that the resulting nucleus is neptunium-239.

Solutions (Odd-Numbered)

1. Alpha radiation decreases the atomic number of the emitting element by 2 and the atomic mass number by 4. Beta radiation increases the atomic number of an element by 1 and does not affect the atomic mass number. Gamma radiation does not affect the atomic number or the atomic mass number. So alpha radiation results in the greatest change in atomic number, and hence charge, and mass number as well.

3. Most of the radiation we encounter is natural background radiation that originated in earth and in space.

5. No. It has been around longer than the human race and has been a part of the environment as long as the sun, rain and soil have been.

7. A large nucleus requires more neutrons to help overcome the repulsions among the many protons.

9. Most is kinetic energy of the ejected particle and some is the kinetic energy of the recoiling nucleus.

11. All uranium will eventually decay to lead.

13. 4.5 billion years.

15. Carbon-14 lost to decay is replenished with carbon-14 from the atmosphere. When a living thing dies, replenishment stops and the percentage of carbon-14 decreases at a constant rate.

17. An elongated uranium-235 nucleus splits in half because the strong nuclear force between distant nucleons quickly diminishes.

19. A nuclear reactor and a fossil fuel power plant both boil water to produce steam for turbines. The main difference between them is the amount of fuel involved. Nuclear reactors are much more efficient—one kilogram of uranium-235 yields more than 30 freight car loads of coal.

21. Albert Einstein.

23. Mass per nucleon is greater in uranium than the mass per nucleon of fission fragments of uranium.

25. Magnetic containers.

27. Intensity decreases with distance by the inverse-square law. Twice the distance is 1/4 the intensity and 1/4 the reading. Three times as far is 1/9 the intensity and 1/9 the reading.

29. Count: It's decreased to 40 cps (one half life), 20 cps (2 half-lives), 10 cps (3 half-lives), 5 cps, which takes 4 half lives. If 4 half-lives equals 8 hours, then a single half-life equals 8/4 = 2 hours.