Chapter 19.3-5 - Binding Energy, Fission and Fusion
Reading Sheet

1. In Einstein’s equation $\Delta E = c^2 \Delta m$, $c$ stands for the ____.  
   a. speed of light  
   b. nuclear constant  
   c. binding energy  
   d. carbon-12

2. In spontaneous nuclear reactions, the value of $\Delta m$ (from $\Delta E = c^2 \Delta m$) is _____.  
   a. enormously large  
   b. always negative  
   c. always positive  
   d. immeasurably small

3. A nucleus consists of protons and neutrons. The mass of a nucleus is always _____.  
   a. equal to the mass of the individual protons and neutrons from which it is composed  
   b. less than the mass of the individual protons and neutrons from which it is composed  
   c. greater than the mass of the individual protons and neutrons from which it is composed

4. A comparison is made on page 522 of the mass of a lithium-6 nucleus and the mass of the three protons and three neutrons of which it is composed. The difference between these two masses is referred to as _____.  
   a. dark matter  
   b. critical mass  
   c. the mass defect  
   d. the binding energy

5. The stabilities of nuclei can be compared to one another by comparing their binding energy per nucleon value. Based upon Figure 19.4, which one of the following is the most stable nucleus?  
   a. hydrogen-2  
   b. boron-10  
   c. iron-56  
   d. uranium-238

6. Study Figure 19.4. Approximately how many times greater is the binding energy/nucleon of the lithium-6 nucleus compared to the hydrogen-2 nucleus?  
   a. two times greater  
   b. three times greater  
   c. four times greater  
   d. five times greater

7. Which one of the following is the best definition of the word fission?  
   a. The splitting of a heavy nucleus into a lighter nucleus.  
   b. The generation of large amounts of radiation by bomb material.  
   c. The generation of large amounts of heat and smoke by bomb material.  
   d. The combining of two lighter nuclei to produce a single heavy nucleus.

8. Observe the balanced nuclear equations for the fission of uranium-235 as found near the bottom of page 524. Which one of the following characteristics of these reactions is responsible for the fact that neutron bombardment of uranium-235 can lead to a chain reaction?  
   a. The products of the process are two unstable nuclei that undergo a series of decays.  
   b. Neutrons are produced which can continue on to induce fission of other uranium atoms.  
   c. The products are nuclei of intermediate mass but still relatively unstable.

9. How does the energy released by the fission of 1-gram of uranium-235 compare to the energy released by the explosion of 1-gram of TNT and the combustion of 1-gram of coal?  
   a. The fission of U-235 releases a little more energy than the explosion of TNT and considerably more energy than the combustion of coal.  
   b. The fission of U-235 releases a little more energy than the combustion of coal and considerably more energy than the explosion of TNT.  
   c. The fission of U-235 releases an enormously greater energy than both the explosion of TNT and the combustion of coal.

Notes from Class Discussion:
Einstein: mass and energy are two equivalent and interchangeable forms of matter.  
$\Delta E = c^2 \Delta m$
$\Delta E = \Delta m \cdot c^2$  
Use information from Table 19.3 to determine $\Delta m$ values
Nuclear reactions (2 x $10^7$ kJ/g) vs. Combustion of fossil fuels (50 kJ/g)
Binding energy - a measure of stability

Figure 19.4 - binding energy / nucleon

http://ec.europa.eu/research/energy/fi/fi_bs/images/fig2_1473.gif
10. Study Figure 19.5 and the associated discussion in the text. Then consider the following four steps in the transformation of nuclear energy into electrical energy.

   A Water is circulated through the reactor to absorb heat and carry it to a heat exchanger.
   B A uranium-235 atom is bombarded; control rods are adjusted to control the fission rate.
   C Water is heated to steam and passes through a steam turbine to generate electricity.
   D Uranium oxide pellets are enriched with fissionable uranium-235.

   Place these four steps in sequential order. ______________

11. Which one of the following is NOT a reason why nuclear power generation of electricity in the United States has failed to fulfill its promise?
   a. Public opinion regarding nuclear power has been affected by the Chernobyl accident.
   b. The public is concerned about the safe and equitable disposal of nuclear waste.
   c. The concern that nuclear power could contribute to global warming is a serious roadblock.
   d. The public is concerned about the safe and equitable disposal of nuclear waste.

12. Which one of the following is the best definition of the word fission?
   a. The burning of fuels such as hydrogen at very high temperatures.
   b. The movement of combustible fluids to a energy-productive environment.
   c. The joining together of uranium atoms to produce a super enriched nuclear fuel.
   d. The combining of two lighter nuclei to produce a heavier nucleus.

13. Which one of the following would produce a greater amount of energy?
   a. The fission of 1 gram of a heavy element such as uranium-235.
   b. The fusion of 1 gram of two lighter nuclei.

14. Which one of the following describes the main drawback of the use of nuclear fusion to generate electricity?
   a. The raw materials needed for nuclear fusion are not abundantly available.
   b. The amount of energy released by nuclear fusion is not much greater than alternatives.
   c. Fusion reactions have high activation energies, requiring abnormally high temperatures.
   d. Nuclear fusion reactions contribute to global warming by the emission of greenhouse gases.

15. Which of the following best describes the current status of development of fusion-generated electrical power?
   a. The technology has been developed and proven effective; legal issues and pressure from environmentalists are preventing the implementation of the technology.
   b. The technology is nearly developed; it’s only a matter of a few years before it is scaled up for use on a large-scale commercial basis.
   c. The technology is several decades from being developed; it is difficult to achieve methods by which the energy produced exceeds the energy expended to achieve fusion.