CHAPTER 21 Review

REFLECTING ON CHAPTER 21

- Nuclear fission is the process in which a very large nucleus splits into two smaller nuclei and two or three neutrons with the release of a large amount of energy.
- A few large nuclei can be induced to fission by the absorption of a thermal neutron.
- Nuclear fusion is the process in which two very small nuclei combine to form one larger nucleus and in some cases, other elementary particles. Large amounts of energy are released.
- Fission and fusion products have a larger binding energy than the reactants. The mass defect accounts for the energy that is released.
- In order for two small nuclei to fuse, they must be highly energetic. Temperatures of nearly 100 million degrees Celsius are needed to achieve a high enough energy.
- In a nuclear fission reactor, a chain reaction is sustained and controlled so that one neutron emitted in each fission reaction stimulates another reaction.
- A moderator is required in fission reactors to slow the fast neutrons that are emitted in fission reactions. Only slow or thermal neutrons can stimulate fission of uranium-235 and plutonium-239.
- The coolant in a reactor carries the thermal energy from the reactor core to a boiler where water is converted into steam. The steam drives a turbine which, in turn, drives a electric generator.
- Fission products are highly radioactive because they have a neutron to proton ratio that is too high for their size.
- To date, no fusion reaction has been sustained for more than approximately half a second.

Knowledge and Understanding

1. What is the source of the energy that is released in a nuclear fission reaction?
2. Use the curve of binding energy per nucleon versus nucleon number to explain why fusion reactions release energy.
3. How are fusion reactions sustained in the Sun?
4. Describe a nuclear chain reaction.
5. What is the function of a moderator in a fission reactor?
6. What property is necessary for an element to be used in control rods? Explain your answer.
7. Why is it important that a reactor coolant not absorb neutrons?
8. Explain the difference between primary and secondary coolants in a nuclear reactor.
9. Why are high temperatures necessary to initiate fusion reactions?
10. What is the purpose of the magnetic field in the experimental Tokamak fusion reactor?

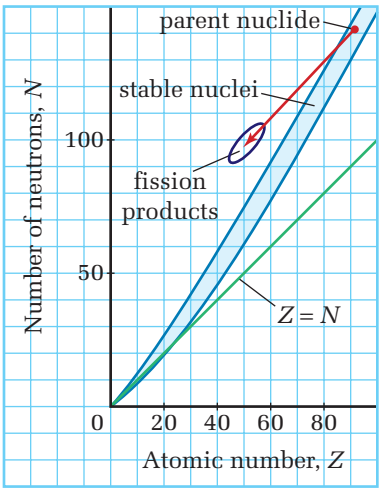
Inquiry

11. Media reports will often refer to plutonium as "one of the most toxic substances known." Some people in the nuclear industry strongly object to such statements. They contend that, although plutonium, as an alpha emitter, is harmful if it is inhaled, it is harmless externally and it is not nearly as toxic as news reports state. Do research about the toxicity of plutonium and find out why there are such great differences of opinion on the subject.
12. Some people say that exposure to any amount of radiation is dangerous while others explain that humans have always been exposed to radioactivity that occurs naturally in the environment. Do research to learn about naturally occurring sources of radiation and the degree of exposure that is unavoidable due to these naturally occurring sources.
13. Do research to find out about the levels of containment and the backup safety systems that are designed into the CANDU reactor.

Communication

14. Only an average of 18 collisions are required to slow down a fast neutron by ordinary water whereas 25 collisions are required if the moderator is heavy water. Nevertheless, heavy water is a "better" moderator. Explain why.

15. Use the curve of stability, reproduced below, to explain why fission products are very radioactive.



16. It is necessary to use enriched uranium in many reactors. Why is enriched uranium not necessary in the CANDU reactor?

17. Prepare a presentation that you could give to a grade six class to explain nuclear fusion reactors.

Making Connections

18. Locate the nuclear power reactor that is nearest to where you live. Find out if there have been any problems or accidents at that nuclear plant. Write an article to submit to your school newspaper to report about the potential risks and benefits of having the nuclear power reactor operating at its current location.

19. Invite a person who works in the nuclear industry to come and make a presentation to your class about their career.

Problems for Understanding

20. Determine the energy change involved in the fusion of two hydrogen nuclei as indicated by the following equation. Assume that a neutrino has no mass. This reaction is one of the many fusion reactions that take place in the Sun.

$${}_1^1\mathrm{H} + {}_1^1\mathrm{H} \rightarrow {}_1^2\mathrm{H} + {}_1^0\mathrm{e} + \nu_e$$

Particle	Mass (u)
${}_1^1\mathrm{H}$	1.007 276
${}_1^2\mathrm{H}$	2.013 553
${}_1^0\mathrm{e}$	0.000 549

21. One possible fission of uranium-235 produces one atom of rubidium-90, another nuclide, and two neutrons. The fission is initiated when one neutron collides with the atom of uranium-235. Identify the second nuclide and write an equation to represent the reaction.