SECTION SUMMARY

Reviewing the Concepts

- **Certain large nuclei, upon bombardment with neutrons, split into two smaller nuclei and additional neutrons. This process is referred to as nuclear fission.**

1. Name three isotopes that can undergo neutron-induced fission.
2. Explain the difference between nuclear fission and nuclear fusion.
3. Write a balanced nuclear equation for the fission of U-235 by a neutron, producing Br-87, La-146, and several neutrons.

- **The strong force holds the nucleus of an atom together. Nuclear reactions result in a small loss of mass, which is converted into large quantities of energy.**

4. State Einstein's mass-energy relationship, and give the meaning of each symbol.
5. How are the conservation of mass and the conservation of energy related in nuclear reactions?
6. Name the force that holds subatomic particles together, and describe its characteristics.
7. If nuclear fusion is so effective for powering stars, why isn't it practical for generating electricity in power plants?

- **A critical mass of fissionable material is required to sustain a chain reaction.**

8. Describe the requirements needed to sustain a fission reaction.
9. Why is it impossible for a nuclear power plant to become a nuclear bomb?

- **The electricity produced by a nuclear power plant originates from the energy released by fission of U-235 in a controlled chain reaction.**

10. How can nuclear power plants release so much energy from so little fuel?
11. Explain why the word *chain* is a good descriptor of a chain reaction process.
12. Why is it necessary to have a critical mass of fissionable material before a chain reaction can begin?
13. Why is U-235 used in nuclear power plants instead of smaller, simpler radioisotopes?
14. Explain how it is possible for both of these statements to be regarded as true:

    a. Nuclear fusion has not been used as an energy source on Earth.
    b. Nuclear fusion is Earth's main energy source.

- **Nuclear fusion results from the combination of two relatively small nuclei into a new, more massive nucleus. This process, which powers the Sun and other stars, requires extremely high temperatures and pressures.**

15. Why are high pressures and temperatures needed to produce fusion reactions?
16. How does the process of nuclear fusion help to explain the origin of all chemical elements?
17. How does nuclear fusion compare to a reaction involving two hydrogen atoms combining to form a hydrogen molecule, H_2?

- **Permanent disposal of nuclear waste poses problems related to the volume, level of radioactivity, and half-lives of radioisotopes present in the waste.**

18. Why must nuclear waste be stored rather than just returning it to its place of origin?
19. What are current methods for disposing of high-level nuclear waste?
20. A simple way to minimize the need for long-term storage of radioactive waste might seem to be just to speed up all of radioactive decay rates involved. Why won't that plan work?
21. Burning is sometimes regarded as a good way to dispose of certain types of extremely toxic material. Why would burning be an unacceptable plan for destroying nuclear waste?

Connecting the Concepts

22. Fusion reactions that produce elements with atomic numbers up to iron ($^{56}_{26}Fe$) can take place in the core of an ordinary star. However, elements with higher atomic numbers generally result from violent stellar explosions. Explain the difference.
23. What are some factors that complicate the cleanup of nuclear waste that has been abandoned or improperly stored?

Extending the Concepts

24. Research two of the storage sites for high-level nuclear waste that have been proposed or used. List one advantage and one disadvantage of each site.
25. Explain the process that might be involved in reducing the existing volume of high-level nuclear wastes.
26. When confronted with the problems surrounding nuclear waste disposal, students sometimes propose putting the waste in a rocket and shooting it to the Sun. What are some problems with that plan?
27. Nuclear fusion is a potentially desirable technology. What would be some advantages of nuclear fusion over nuclear fission for producing electricity?
28. In the late twentieth century, a group of scientists announced they had discovered a new process termed "cold fusion." Their claim was later discredited, but the goal of producing sustained nuclear fusion at room temperature remains desirable. Why?