

## Reviewing the Concepts

1. Student diagrams should show evaporation, precipitation, runoff, streams, and aquifers.
2. Evaporation separates water from minerals and other dissolved substances. Bacterial action converts dissolved organic contaminants into simple compounds. Filtration removes suspended matter.
8. Even a clear mountain stream may contain disease-causing microorganisms.
11.  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Fe}^{3+}$
12. The precipitate ( $\text{CaCO}_3$ ) indicates the presence of  $\text{Ca}^{2+}$  ions.
13. Hard-water ions often give water a pleasant taste.

## Connecting the Concepts

16. Hard-water ions bind with soap molecules, preventing formation of suds. Soap sud formation is inversely related to water hardness.
17. Hard water causes buildup of scale in boiler pipes, reducing the flow of water and steam and thus reducing efficiency.
18. Precipitation and runoff would cease once all atmospheric moisture was released. Widespread drought would probably result.
20. Possible reasons include the need for extremely accurate measurement, the cost and difficulty associated with removing all THMs, the possible threat of a small

## Extending the Concepts

24. Hard-water ions are more soluble in hot than in cold water, so the hot-water faucet delivers water with a higher concentration of hard-water ions, especially stain-producing  $\text{Fe}^{3+}$ ; the ions are deposited when they contact the colder surface of the sink.

## Reviewing the Concepts

Water can be purified through the actions of the hydrologic cycle or through municipal treatment.

1. Make a diagram of the hydrologic cycle and label all processes.
2. List three major processes that occur in natural water purification and, for each, identify the contaminants that the process removes.
3. How are the properties of aluminum hydroxide related to the process of flocculation?
4. Why is calcium oxide ( $\text{CaO}$ ) sometimes added in the final steps of municipal water treatment?
5. Fluoride, an ingredient in many types of toothpaste, is sometimes added to municipal water supplies in the last stage of water treatment. How much fluoride is added and what is its purpose?

Chlorination is commonly used to treat and purify water for human consumption.

6. What are advantages of chlorinated drinking water compared to untreated water?
7. Is there a disadvantage to using chlorination in water treatment? Explain.
8. Water from a clear mountain stream may require chlorination to make it safe for drinking. Explain.
9. List two alternatives to the use of chlorination in municipal water treatment.

Hard water can be softened by removing hard-water ions as a precipitate or as large soluble ions.

10. What are two problems associated with the use of hard water?
11. Identify three common hard-water ions.
12. When a sample of well water was mixed with a few drops of sodium carbonate solution, a precipitate formed. What does the formation of a precipitate indicate about the water sample?
13. Hard water often tastes better than distilled water. Explain.
14. Which water source in a given locality would probably have harder water, a well or a river? Explain.
15. Sketch two molecular-level representations of an ion-exchange resin bead—one bead before and one bead after treatment of hard water.

## Connecting the Concepts

16. A simple test of water hardness is to add soap to the water sample and shake. Explain how you can measure the quantity of soap suds to assess the relative hardness of the water.
17. Explain why hard water can decrease the efficiency of a boiler in a steam-generated, electric power plant.
18. Explain what would happen to Earth's hydrologic cycle if water evaporation suddenly stopped.
19. One unique characteristic of water is that it is present in all three physical states (solid, liquid, and gas) in the range of temperatures found on Earth. How would the hydrologic cycle be different if this were not true?
20. Why does the EPA limit the concentration of THMs to 80 ppb instead of requiring their total elimination from municipal water supplies?
21. Compare how the various processes used in the foul-water investigation (page 10) are similar to steps in the natural purification of water.
22. Some physicians recommend consuming about 2 L of water daily. Municipal water supplies may contain up to 1 ppm fluoride. Assume that you drink 2 L of water per day. At 1 ppm fluoride, how many grams of fluoride ion would you consume in  
a. one day?    b. one week?    c. one year?

## Extending the Concepts

23. How much water would you need to drink to get your minimum daily requirement of calcium from water that contains 300 ppm  $\text{Ca}^{2+}$ ?
24. Explain why we find hard-water stains in old sinks around hot-water faucets more often than around cold-water faucets.
25. Research the sources and production of a brand of bottled water. Report on its origin and identify the substances that are removed and added before the water is bottled and sold.
26. Discuss the health effects associated with sodium-based ion-exchange resins used in home water softening systems.
27. Compare activated charcoal with reverse osmosis in home water filtration systems.
28. Describe and evaluate the practicality of two desalination processes for making seawater suitable for drinking.