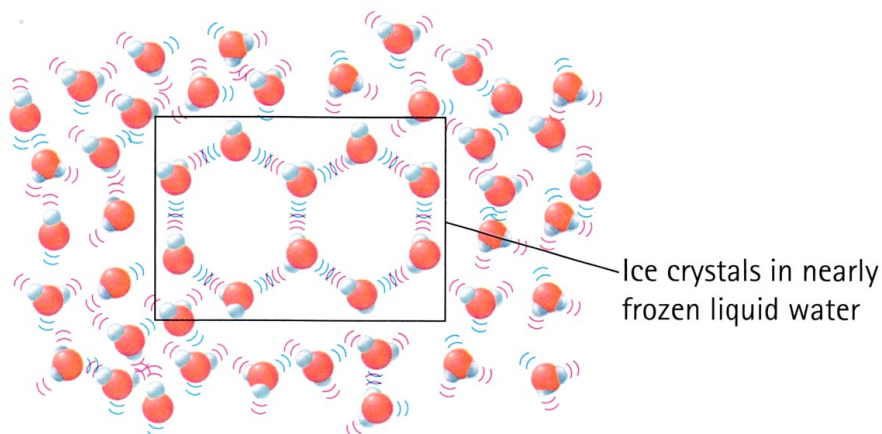


The expansion of water

At temperatures above 4 °C water expands like most other liquids. But below 4 °C, and when freezing, it shows a behavior which is different from other substances: It expands.

This is due to the fact that ice has a crystalline structure in which the molecules are farther apart than in the liquid state. The volume of water increases when it becomes solid ice, which means that its density decreases.



When ice melts, not all the open-structured crystals collapse. Some microscopic crystals remain in the ice-water mixture, making up a microscopic slush that slightly “bloats” the water, increasing its volume slightly (Figure 15.19). This results in ice water being less dense than slightly warmer water. As the temperature of water at 0°C is increased, more of the remaining ice crystals collapse. The melting of these crystals further decreases the volume of the water. The water undergoes two processes at the same time—expansion and contraction (Figure 15.20). Volume tends to increase due to greater molecular motion with increased temperature, while volume at and near 0°C decreases as ice crystals collapse upon melting. The collapsing effect dominates until the temperature reaches 4°C. After that, expansion overrides contraction because most of the microscopic ice crystals have melted by then (Figure 15.21).

When ice water freezes to become solid ice, its volume increases by nearly 10% and its density is lowered. That’s why ice floats on water. Like most other substances, solid ice contracts with further cooling. This behavior of water is very important in nature. If water were most dense at 0°C, it would settle to the bottom of a pond or lake. Water at 0°C, however, is less dense and “floats” at the surface. How nice that ice forms at the surface.

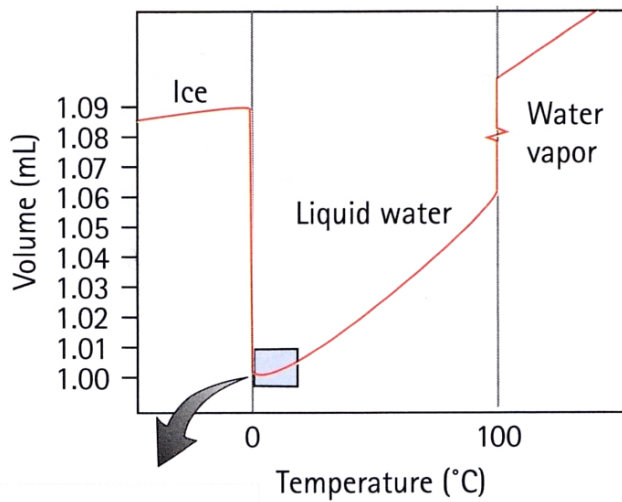
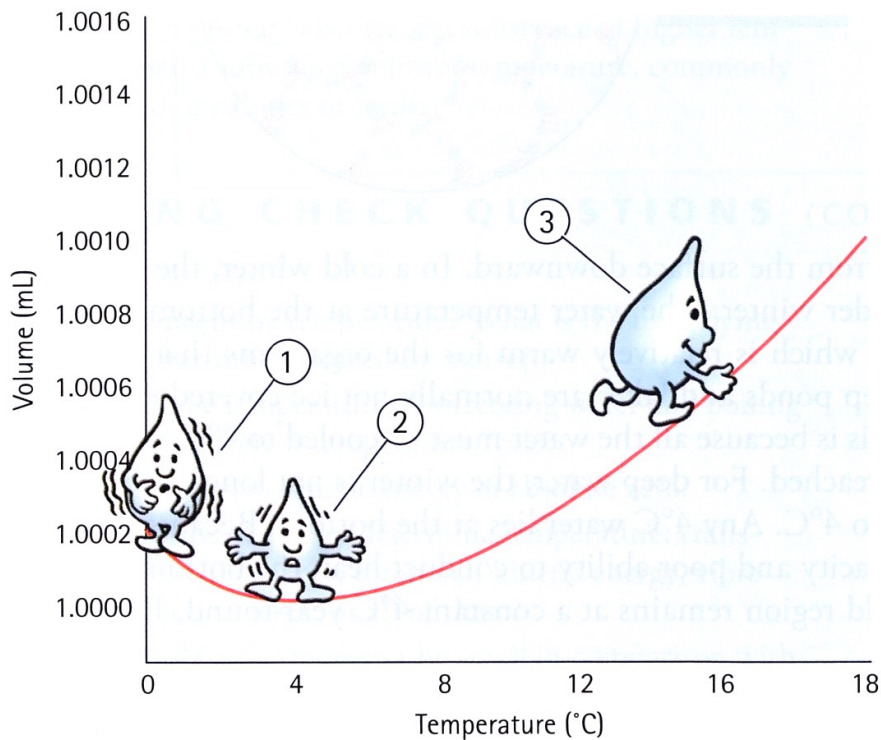


FIGURE 15.21

Between 0°C and 4°C, the volume of liquid water decreases as the temperature increases. Above 4°C, water behaves the way other substances do: Its volume increases as its temperature increases. The volumes shown here are for a 1-gram sample.



- ① Liquid water below 4°C is bloated with ice crystals.
- ② Upon warming, the crystals collapse, resulting in a smaller volume for the liquid water.
- ③ Above 4°C, liquid water expands as it is heated because of greater molecular motion.