# Exercise 1.81

Water has a density of 0.997 g/cm$^3$ at 25 °C; ice has a density of 0.917 g/cm$^3$ at −10 °C. (**a**) If a soft-drink bottle whose volume is 1.50 L is completely filled with water and then frozen to −10 °C, what volume does the ice occupy? (**b**) Can the ice be contained within the bottle?

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**Solution**

By the law of conservation of mass, the mass of water in the bottle is equal to the mass of ice formed when frozen.

$$m_{\text{ice}} = m_{\text{water}}$$

Use the fact that mass is equal to density $\rho$ times volume $V$.

$$\rho_{\text{ice}} V_{\text{ice}} = \rho_{\text{water}} V_{\text{water}}$$

The question is asking for the volume that the ice occupies, so solve this equation for $V_{\text{ice}}$.

$$\begin{aligned} V_{\text{ice}} &= \frac{\rho_{\text{water}} V_{\text{water}}}{\rho_{\text{ice}}} \\ &= \frac{\left(0.997 \ \frac{\text{g}}{\text{cm}^3}\right)(1.50 \text{ L})}{0.917 \ \frac{\text{g}}{\text{cm}^3}} \\ &\approx 1.63 \text{ L} \end{aligned}$$

This is too much for the 1.50-L bottle to contain, so the bottle will burst.