Boiling

Equilibrium vapor pressures can be used to explain and define the concept of boiling, which you read about in Section 3. **Boiling** *is the conversion of a liquid to a vapor within the liquid as well as at its surface.*

If the temperature of the liquid is increased, the equilibrium vapor pressure also increases. *The* **boiling point** *of a liquid is the temperature at which the equilibrium vapor pressure of the liquid equals the atmospheric pressure.* The lower the atmospheric pressure is, the lower the boiling point is.

Vapor Pressures of Diethyl Ether, Ethanol, and Water at Various Temperatures

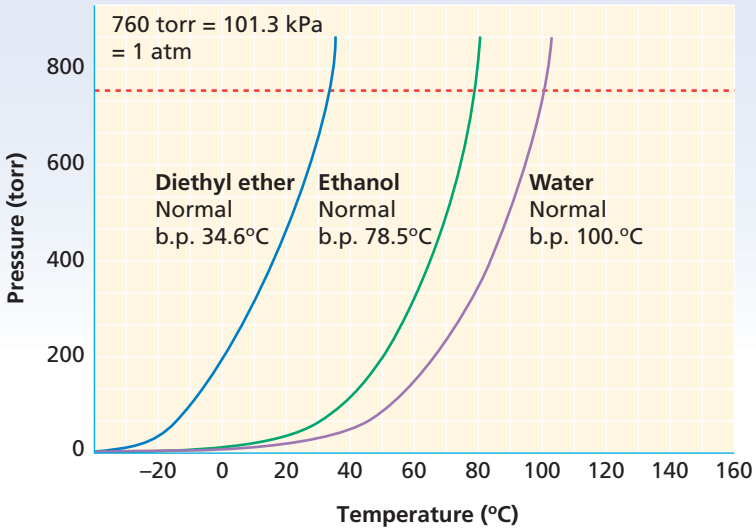

FIGURE 14 The vapor pressure of any liquid increases as its temperature increases. A liquid boils when its vapor pressure equals the pressure of the atmosphere.

At the boiling point, all of the energy absorbed is used to evaporate the liquid, and the temperature remains constant as long as the pressure does not change. If the pressure above the liquid being heated is increased, the temperature of the liquid will rise until the vapor pressure equals the new pressure and the liquid boils once again. This is the principle behind the operation of a pressure cooker. The cooker is sealed so that steam pressure builds up over the surface of the boiling water inside. The pressure increases the boiling temperature of the water, resulting in shorter cooking times. Conversely, a device called a *vacuum evaporator* causes boiling at lower-than-normal temperatures. Vacuum evaporators are used to remove water from milk and sugar solutions. Under reduced pressure, the water boils away at a temperature low enough to avoid scorching the milk or sugar. This process is used to prepare evaporated milk and sweetened condensed milk.

At normal atmospheric pressure (1 atm, 760 torr, or 101.3 kPa), the boiling point of water is exactly 100°C. This temperature is known as the *normal* boiling point of water. **Figure 14** shows that the normal boiling point of each liquid is the temperature at which the liquid's equilibrium vapor pressure equals 760 torr.

Energy and Boiling

Energy must be added continuously in order to keep a liquid boiling. A pot of boiling water stops boiling almost immediately after it is removed from the stove. If you were to carefully measure the temperature of a boiling liquid and its vapor you would find that they are at the same constant temperature. The temperature at the boiling point remains constant despite the continuous addition of energy. The added energy is used to overcome the attractive forces between molecules of the liquid during the liquid-to-gas change and is stored in the vapor as potential energy.