NOTE

Properties of Compressed Liquid

At temperatures well below the critical, enthalpy (and internal energy) is approximately independent of pressure. Under this approximation, eq. (3.21) can be used to calculate the enthalpy difference between two states in the compressed liquid region, not necessarily at the same pressure. Alternatively, the enthalpy of compressed liquid may be approximated by the enthalpy of the saturated liquid at the same temperature.

3.7 Heat of Vaporization

To convert the saturated liquid into vapor of the same pressure and temperature, we must provide the energy required to free molecules from the attractive forces that hold the liquid together. This energy is called *heat of vaporization* and since this process is at constant pressure, it is equal to the difference of the enthalpy of the saturated liquid and saturated vapor:

$$\Delta H_{\mathrm{vap}} = H_V - H_L. \tag{3.23}$$

This amount of energy is also called *latent* heat of vaporization, to indicate that it is not accompanied by any temperature change. Writing $H = U + PV$ for the enthalpy, the enthalpy of vaporization can also be expressed as

V_L (change subscript to L)

$$\Delta H_{\mathrm{vap}} = U_V - U_L + P^{\mathrm{sat}}(V_V - V_V) = \Delta U_{\mathrm{vap}} + P^{\mathrm{sat}}\Delta V_{\mathrm{vap}}. \tag{3.24}$$

Here, ΔU_{vap} is the internal energy of vaporization, ΔV_{vap} is the change in volume from the saturated liquid to the saturated vapor, and P^{sat} is the saturation pressure. The heat of vaporization can be calculated from tabulated properties of the saturated liquid and saturated vapor.

A state that lies in the vapor-liquid region (point C in Figure 3-10) consists of a mixture of saturated vapor and saturated liquid. If the mass fraction of liquid is x_L and the mass fraction of vapor is x_V, the specific enthalpy of the two-phase system is

$$H = x_L H_L + x_V H_V. \tag{3.25}$$

Using $x_L + x_V = 1$, the above relationship can be solved for the mass fractions:

$$x_L = \frac{H_V - H}{H_V - H_L}, \quad x_V = \frac{H - H_L}{H_V - H_L}. \tag{3.26}$$

Equations (3.25) and (3.26) are expressions of the lever rule for enthalpy. It will be left as an exercise to show that internal energy also satisfies the lever rule. An