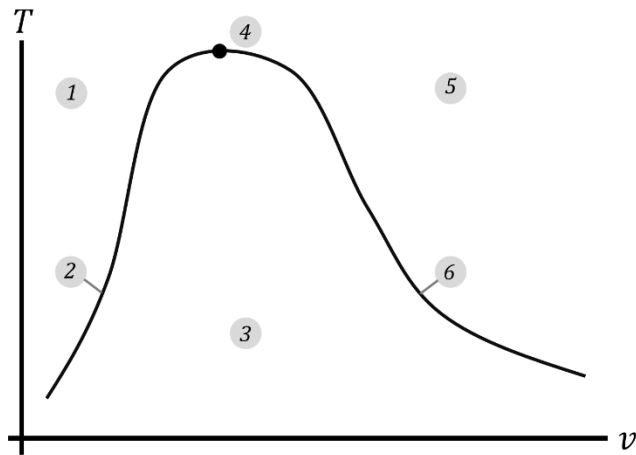


Thermodynamics 1: Phases & Compressibility

Phases:



1. Compressed (sub-cooled) liquid
2. Saturated liquid line
3. Two-phase mixture
4. Critical point
5. Superheated vapor
6. Saturated vapor line

- Quality of a two-phase mixture is the ratio of vapor to total mass, with $0 \leq x \leq 1$ such that $x=0$ indicates the mixture is 0% vapor and $x=1$ indicates 100% vapor

$$x = \frac{m_{\text{vapor}}}{m_{\text{vapor}} + m_{\text{liquid}}} = \frac{m_{\text{vapor}}}{m_{\text{total}}}$$

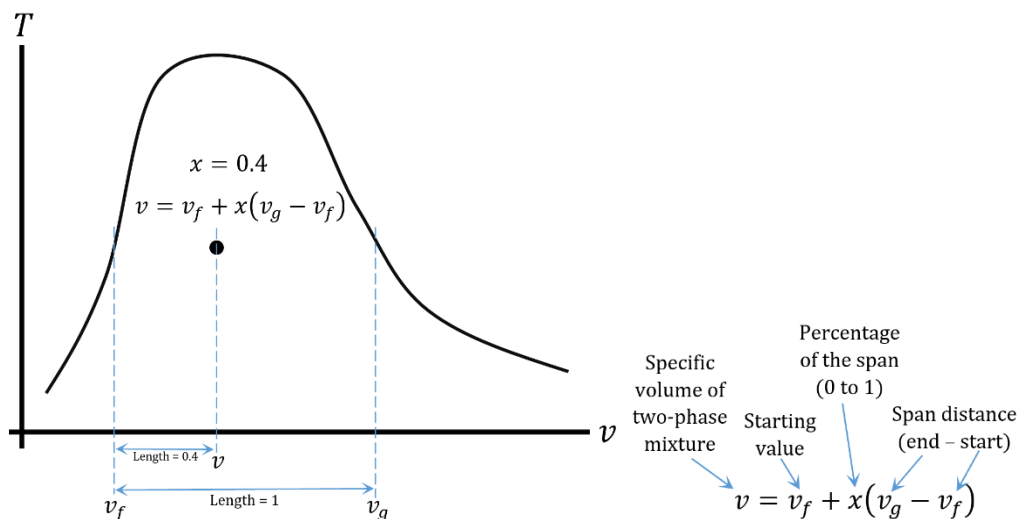
- Specific volume of a two-phase mixture is dependent on the quality. The higher the quality at a given temperature or pressure, the higher the specific volume:

$$v = \frac{v_{\text{sat. liquid}} + v_{\text{sat. vapor}}}{m_{\text{liquid}} + m_{\text{vapor}}} = \frac{m_{\text{liquid}}}{m_{\text{total}}} \cdot v_{\text{liquid}} + \frac{m_{\text{vapor}}}{m_{\text{total}}} \cdot v_{\text{vapor}}$$

Substituting subscript "g" for vapor (gas) and "f" for liquid (fluid) and rearranging:

$$v = (1 - x)v_f + xv_g = v_f + x(v_g - v_f)$$

From this formula, the meaning of quality can be seen on T-v and P-v diagrams:



This formula can be repeated for internal energy, entropy, and enthalpy of a two-phase:

Table 1

Property	Formula
Specific volume	$v = v_f + x(v_g - v_f)$
Internal energy	$u = u_f + x(u_g - u_f)$
Entropy	$s = s_f + x(s_g - s_f)$
Enthalpy	$h = h_f + x(h_g - h_f)$

Compressibility:

- Ideal gases follow the formula $PV=mRT$, but other gases fall on a spectrum of compressibility, denoted by z , which measures deviation from the ideal gas:

$$z = \frac{Pv}{RT} = \frac{PV}{mRT}$$

- Where...

- $P_R = \frac{P}{P_c} = \text{reduced pressure}$
- $T_R = \frac{T}{T_c} = \text{reduced temperature}$
- $v_r = \frac{v}{R} = \text{pseudo - reduced specific volume}$

For more information on Thermodynamics phases and compressibility, make an appointment with a [content tutor](#). Appointments are available in person at the [Student Success Center](#) or online.