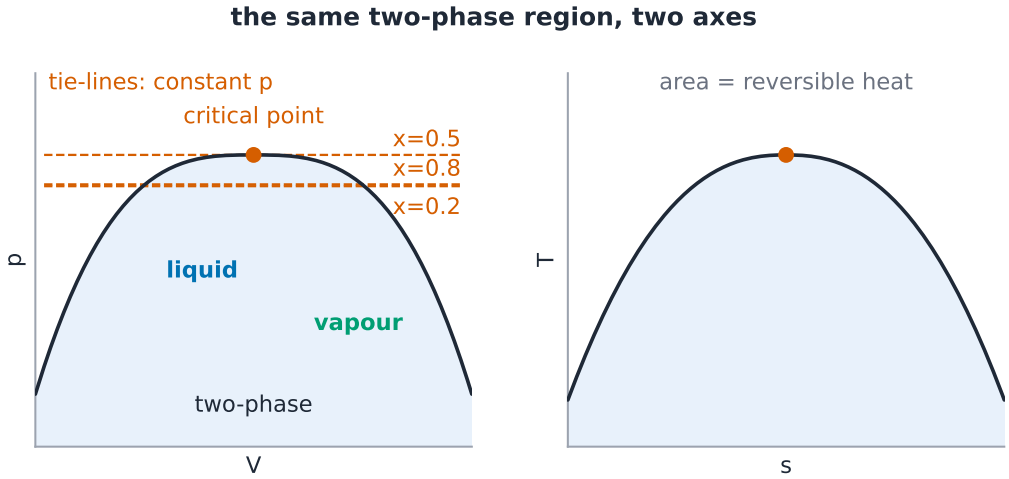
Exercise walk-through

5.1
Properties and state

University Mechanical Engineering

Properties and state: two numbers fix the fluid



Saturated water at $100°C$: at $x = 0.5$, $v = \mathbf{0.837}$ m^3/kg and $h = \mathbf{1547.5}$ kJ/kg - linear in x. Air outside the dome: $v = \mathbf{0.8497}$ m^3/kg at 300 K, halving at double pressure.

Exercises 2.1·2.2

2.1 For saturated water at 100 °C ($v_f = 0.001044$ and $v_g = 1.6729$ m^3/kg, $h_f = 419.04$ and $h_{fg} = 2257.0$ kJ/kg): at qualities $x = 0.3$ and $x = 0.8$, the specific volume and the enthalpy (three decimals for v, one for h). [4]

2.2 A sealed vessel holds 2 kg of this two-phase mixture at $x = 0.3$: the mass of vapour and the mass of liquid (kg, one decimal). [2]

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2.1

- $v(0.3) = 0.001044 + 0.3 \times 1.671856 = \mathbf{0.503}$ m^3/kg; $h(0.3) = 419.04 + 0.3 \times 2257.0 = \mathbf{1096.1}$ kJ/kg.
- $v(0.8) = 0.001044 + 0.8 \times 1.671856 = \mathbf{1.339}$ m^3/kg; $h(0.8) = 419.04 + 0.8 \times 2257.0 = \mathbf{2224.6}$ kJ/kg.

2.2 A sealed vessel holds 2 kg of this two-phase mixture at $x = 0.3$: the mass of vapour and the mass of liquid (kg, one decimal). [2]

2.2

- Vapour mass $= 2 \times 0.3 = \mathbf{0.6}$ kg.
- Liquid mass $= 2 - 0.6 = \mathbf{1.4}$ kg. ✓

Exercises 2.3·2.4

2.3 Air ($R = 0.287\ \text{kJ/(kg K)}$) at 400 K and 200 kPa: the specific volume (three decimals, m^3/kg), and the pressure at which $v = 1.000\ \text{m}^3/\text{kg}$ at the same temperature (one decimal, kPa). [4]

2.4 One sentence each: why must quality be a mass fraction rather than a volume fraction, and why does $pv = RT$ fail inside the dome? [4]

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2.3

- $v = RT/p = 0.287 \times 400/200 = \mathbf{0.574}$ m^3/kg.
- $p = RT/v = 0.287 \times 400/1.000 = \mathbf{114.8}$ kPa.

2.4 One sentence each: why must quality be a mass fraction rather than a volume fraction, and why does $pv = RT$ fail inside the dome? [4]

2.4

- Volume fractions weight the phases by v, which differs by three orders of magnitude across the dome; only the mass fraction makes $v = v_f + x(v_g - v_f)$ linear and additive.
- Inside the dome p and T are not independent (they lock on the saturation line) and molecules interact during phase change, so the two-variable ideal-gas equation of state does not apply.