

## Problem Set 4, PS4 due Wednesday May 26

**PS4-1** A 15 ft<sup>3</sup> rigid tank contains a saturated mixture of liquid and vapor R-134a at 30 psi. If the saturated liquid occupies 10% of the volume, determine the quality and total mass of the refrigerant in the tank.

**PS4-2** Compare the specific volume, internal energy and enthalpy of compressed liquid water at 100 C and 15 MPa using the saturated liquid approximation, the steam tables and the EES program.

**PS4-3** Determine the specific volume of superheated steam at 10 MPa and 400 C using, a) the ideal gas equation, b) the general compressibility chart and c) the steam table. Calculate the error in a) and b).

PS4-1  $V_f = 1.5 \text{ ft}^3$ ,  $V_g = 13.5 \text{ ft}^3$

@ 30 psia Pressure Table A-12

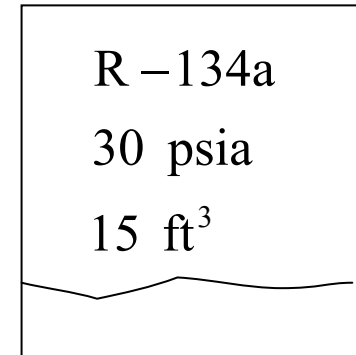
$$v_f = \frac{V_f}{m_f} = .01209 \text{ ft}^3/\text{lb}$$

$$m_f = \frac{V_f}{v_f} = 124.07 \text{ lbs}$$

$$v_g = \frac{V_g}{m_g} = 1.5408 \text{ ft}^3/\text{lb}$$

$$m_g = \frac{V_g}{v_g} = \frac{13.5}{1.5408} = 8.76 \text{ lbs}$$

$$x = \frac{m_g}{m_f + m_g} = \frac{8.76 \text{ lb}}{8.76 \text{ lb} + 124.07 \text{ lb}} = .066(6.6\%)$$



PS4-2 Water @ 100C, 15MPa  
approximation Table A-7 EES

$v$ , m <sup>3</sup> /kg	.001044	.001036	.001036
$u$ , kJ/kg	418.94	414.74	414.749
$h$ , kJ/kg	419.04	430.28	430.289

Approximation for  $h$ :  $h @ (T = 100 \text{ C}, p = 15 \text{ MPa}) = h_f @ 100 \text{ C}$

EES Statements:  $v = \text{volume}(\text{water}, T = 100, p = 15)$

$u = \text{intenergy}(\text{water}, T = 100, p = 15)$

$h = \text{enthaply}(\text{water}, T = 100, p = 15)$

PS4-3

$$\text{a) } v = \frac{RT}{p} = \frac{.4615 \times (273.15 + 400) \text{ K}}{10,000} = .03107 \text{ m}^3$$

$$\text{b) } T_R = \frac{673.15 \text{ K}}{647.3 \text{ K}} = 1.04, \quad p_R = \frac{10,000 \text{ kPa}}{22,090 \text{ kPa}} = .453, \quad Z = .85$$

$$v = Z \left( \frac{RT}{p} \right) = .85 \times .03107 \text{ m}^3 = .0264 \text{ m}^3$$

c) Table A-6, Superheat Table

$$v = .02641 \text{ m}^3$$