39.7 In a refrigeration cycle, R-134a leaves the evaporator at $20psia$ with $20°F$ of superheat. What is the entropy of the refrigerant entering the compressor?

A. $0.03\frac{Btu}{lb°F}$

B. $0.22\frac{Btu}{lb°F}$

C. $0.24\frac{Btu}{lb°F}$

D. $106\frac{Btu}{lb°F}$

In the Reference Handbook, search for Properties of Refrigerants and use the phrase: Pressure Versus Enthalpy. Find the chart for Refrigerant 134a.

Following a horizontal line at a pressure of $20psia$ to the rightmost edge of the saturation curve, corresponding to a saturated vapor condition. Continue horizontally to the right to account for the additional $20°F$ of superheat. Note that to the right of the saturation curve, lines of constant temperature are curved downward (nearly vertical). This is the compressor entering condition, typically noted as State 1 of the refrigeration cycle.

Once the state point has been identified, read off the entropy from the chart. Note that lines of constant entropy run roughly southwest/northeast on the diagram.

$$s \approx 0.235\frac{Btu}{lb°F}$$

Answer C

39.8 A chiller plant producing a low chilled water supply temperature of $40°F$ uses a glycol/water mixture of 30% glycol by volume. At $40°F$, glycol has a specific heat capacity of $0.56\frac{Btu}{lb_m°F}$ and a specific gravity of 1.15. What is the specific heat capacity of the mixture?

A. $0.86\frac{Btu}{lb_m°F}$

B. $0.87\frac{Btu}{lb_m°F}$

C. $0.88\frac{Btu}{lb_m°F}$

D. $0.89\frac{Btu}{lb_m°F}$

The glycol/water mixture is defined as being 30% glycol by volume, but the specific heat capacity of the mixture will be a function of the relative *mass* of glycol and water, not the volume.

Assume an arbitrary volume of $100ft^3$ of the mixture, comprised of $30ft^3$ of glycol and $70ft^3$ of water.

Find the mass of water:

$$m_{water} = \rho_{water}V_{water} = \left(62.4\frac{lb_m}{ft^3}\right)(70ft^3) = 4368lb_m$$

Find the mass of glycol, by first determining the density of glycol using the specific gravity.

$$SG = \frac{\rho}{\rho_{water}} \rightarrow \rho_{glycol} = \rho_{water} SG_{glycol} = \left(62.4\frac{lb_m}{ft^3}\right)(1.15) = 71.76\frac{lb_m}{ft^3}$$

$$m_{glycol} = \rho_{glycol} V_{glycol} = \left(71.76\frac{lb_m}{ft^3}\right)(30ft^3) = 2153lb_m$$

Perform a mixing calculation for the specific heat capacity as a function of the relative mass of glycol and water:

$$c_{p,mixture} = \frac{c_{p,glycol} m_{glycol} + c_{p,water} m_{water}}{m_{glycol} + m_{water}}$$

$$c_{p,mixture} = \frac{\left(.56\frac{Btu}{lb_m \cdot^\circ F}\right)(2153lb_m) + \left(1\frac{Btu}{lb_m \cdot^\circ F}\right)(4368lb_m)}{2153lb_m + 4368lb_m} = .855\frac{Btu}{lb_m \cdot^\circ F}$$

Answer A

39.9 Atmospheric air at $77°F$ undergoes isentropic compression to $100psia$ and $470°F$. How much work is done to the system during the process?

A. $0.5\frac{Btu}{lb}$

B. $70\frac{Btu}{lb}$

C. $90\frac{Btu}{lb}$

D. $50,000\frac{Btu}{lb}$

For an Isentropic Process, there are (at least) two formulas that may be used to find the work done from one state to another, which can be shown to be equivalent:

$$w = \frac{P_2 v_2 - P_1 v_1}{1-k}$$

$$w = \frac{R(T_2 - T_1)}{1-k}$$

Using the ideal gas law and solving for specific volume:

$$PV = mRT \rightarrow Pv = RT \rightarrow v = \frac{RT}{P}$$

Substitute for specific volume in the first formula and cancel pressure:

$$w = \frac{P_2\left(\frac{RT_2}{P_2}\right) - P_1\left(\frac{RT_1}{P_1}\right)}{1-k} = \frac{R(T_2 - T_1)}{1-k}$$

For convenience, use the second equation which is a function of temperature only: