$$R_{brick} = \frac{(4ft)\left(\frac{12in}{1ft}\right)}{0.42\frac{Btu \cdot ft}{hr \cdot ft^2 \cdot ^\circ F}} = .794\frac{hr \cdot ft^2 \cdot ^\circ F}{Btu}$$

$$U_{brick} = \frac{1}{R_{brick}} = \frac{1}{.794\frac{hr \cdot ft^2 \cdot ^\circ F}{Btu}} = 1.26\frac{Btu}{hr \cdot ft^2 \cdot ^\circ F}$$

$$\dot{q} = U\Delta T \rightarrow \Delta T = \frac{\dot{q}}{U_{brick}} = \frac{4.88\frac{Btu}{hr \cdot ft^2}}{1.26\frac{Btu}{hr \cdot ft^2 \cdot ^\circ F}} = 3.87^\circ F$$

$$\Delta T = T_2 - T_1 = T_2 - 0^\circ F = 3.87^\circ F$$

$$T_2 = 3.87^\circ F \approx 4^\circ F$$

Answer A

42.11 $100lbs$ of Haddock initially at $45^\circ F$ is to be frozen to $20^\circ F$ within $3hrs$. What is the minimum required refrigeration capacity?

A. $0.2tons$

B. $0.4tons$

C. $1ton$

D. $2tons$

Calculate the total heat to be removed from the Haddock by finding the sum of sensible cooling *above* the freezing point, latent cooling, and sensible cooling *below* the freezing point. Note the freezing point of the fish, like many foods, is not exactly the same as the freezing point of water. In this case it is $28^\circ F$. Use the table Properties of Foods to look up the specific heat capacity and freezing point.

$$Q_{total} = Q_{sensible,above\,FP} + Q_{latent\,@FP} + Q_{sensible,below\,FP}$$

$$Q_{sensible,above\,FP} = mc_{p,above}\Delta T$$

$$Q_{sensible,above\,FP} = (100lb)\left(.9\frac{Btu}{lb^\circ F}\right)(45^\circ F - 28^\circ F) = 1530Btu$$

$$Q_{latent\,@FP} = mh_{fg} = (100lb)\left(115\frac{Btu}{lb}\right) = 11,500Btu$$

$$Q_{sensible,below\,FP} = mc_{p,below}\Delta T$$

$$Q_{sensible,below\,FP} = (100lb)\left(.51\frac{Btu}{lb^\circ F}\right)(28^\circ F - 20^\circ F) = 408Btu$$

$$Q_{total} = 1530Btu + 11,500Btu + 408Btu = 13,438Btu$$

Divide by time and convert to tons to determine the required refrigeration capacity i.e. rate of heat removal in *tons*:

$$\dot{Q} = \frac{Q}{t} = \frac{13,438Btu}{3hr} = 4480\frac{Btu}{hr}\left(\frac{1ton}{12,000\frac{Btu}{hr}}\right) = .37tons$$

Answer B

42.12 Steam at $40psia$ has a quality of 75%. What is the density?

A. $0.13\frac{lb_m}{ft^3}$

B. $0.17\frac{lb_m}{ft^3}$

C. $0.19\frac{lb_m}{ft^3}$

D. $0.38\frac{lb_m}{ft^3}$

Density is the inverse of specific volume. Use the Properties of Saturated Water and Steam table (by Pressure) to look up the specific volume for saturated liquid water, h_f, and the change in specific volume associated with heating to a saturated vapor at constant pressure, h_{fg}. The formula/property for specific volume based on quality is best memorized rather than looked up, but can be found in the Reference Handbook by searching: Specific Volume of a Two-phase System.

$$v = v_f + \chi v_{fg}$$

$$v = .0171\frac{ft^3}{lb} + (.75)\left(10.49\frac{ft^3}{lb}\right) = 7.88\frac{ft^3}{lb}$$

Calculate the density:

$$\rho = \frac{1}{v} = \frac{1}{7.88\frac{ft^3}{lb}} = .127\frac{lb}{ft^3}$$

Answer A