39.2 What is the enthalpy of $1 lb \cdot mole$ of $300°F$ steam with a quality of 60%?

A. $630 Btu$

B. $820 Btu$

C. $11,400 Btu$

D. $14,700 Btu$

$1 lb \cdot mol$ of H_2O weighs: $2(1) + 16 = 18 lbs$

From the Properties of Saturated Water and Steam Table @$300°F$:

$$h_f = 269.7 \frac{Btu}{lb}$$

$$h_{fg} = 910.2 \frac{Btu}{lb}$$

Find the specific enthalpy at 60% quality:

$$h = h_f + \chi h_{fg} = 269.7 \frac{Btu}{lb} + (.6)\left(910.2 \frac{Btu}{lb}\right) = 815.8 \frac{Btu}{lb}$$

Specific Enthalpy is the total enthalpy per unit mass, expressed as: $h = \frac{H}{m}$ which can be rearranged to $H = mh$ where mass and specific enthalpy are both known.

Substitute and solve:

$$H = mh = (18 lbs)\left(815.8 \frac{Btu}{lb}\right) = 14,684 Btu$$

Answer D

39.3 What is the ratio of specific heats for $1020°F$ air? Assume $c_{p,air} = 0.249 \frac{Btu}{lb_m °R}$ at $1000°R$ and $c_{p,air} = 0.264 \frac{Btu}{lb_m °R}$ at $1500°R$.

A. 1.35

B. 1.38

C. 1.40

D. 1.43

The Ratio of Specific Heats is defined as:

$$k = \frac{c_p}{c_v}$$

Another important relationship between the specific heats for a gas is that their difference is the specific gas constant, as such:

$$c_p - c_v = R$$

The Specific Gas Constant for air is:

$$R_{air} = 53.35 \frac{ft \cdot lb_f}{lb_m {}^\circ F}$$

Add 460 to the Temperature in degrees Farenheit to get the temperature in absolute terms i.e. Rankine: $1020^\circ F + 460 = 1480^\circ R$

Since the temperature is between two known states, interpolate:

Temperature $[R^\circ]$	$c_p \left[\frac{Btu}{lb_m \cdot R^\circ}\right]$
1000	0.49
1480	x
1500	0.264

$$\frac{1480 - 1000}{1500 - 1000} = \frac{x - 0.249}{0.264 - 0.249} \rightarrow x = 0.2634 \frac{Btu}{lb_m \cdot R^\circ}$$

Rearrange and substitute to solve for c_v @1480R. Find the conversion factor required to align the units in Measurement Relationships, $778 \frac{ft \cdot lb_f}{Btu}$.

$$c_p - c_v = R \rightarrow c_v = c_p - R = 0.2634 \frac{Btu}{lb_m \cdot R^\circ} - \frac{53.35 \frac{ft \cdot lb_f}{lb_m {}^\circ F}}{778 \frac{ft \cdot lb_f}{Btu}} = 0.195 \frac{Btu}{lb_m \cdot R^\circ}$$

Finally, solve for k:

$$k = \frac{c_p}{c_v} = \frac{2634 \frac{Btu}{lb_m \cdot R^\circ}}{0.195 \frac{Btu}{lb_m \cdot R^\circ}} = 1.35$$

Note the value for k at standard conditions is typically 1.4; however, extreme temperature conditions were being investigated here.

Alternate Solution: Use the table Properties of Air at Low Pressure to look up the k value directly. Interpolate for $1480R$.

$$\frac{1500R - 1480R}{1500R - 1000R} = \frac{1.351 - k}{1.351 - 1.381}$$

$$k = 1.352$$

Answer A