35.27 An outside air handling unit is equipped with a hot water coil to temper the fresh air intake during winter operation. The heating coil is sized for 80,000 Btu/hr. The outside conditions are 20 °F and 50% relative humidity. What is the humidity ratio after heating?

A. $0.001 \frac{lb_w}{lb_{da}}$

B. $0.002 \frac{lb_w}{lb_{da}}$

C. $0.003 \frac{lb_w}{lb_{da}}$

D. $0.004 \frac{lb_w}{lb_{da}}$

The humidity ratio after heating is the same as the humidity ratio before heating because the heating process is purely sensible only, i.e. there is no moisture being added or removed by the heating coil. Therefore, the problem can be distilled down to finding the humidity ratio of the outside air based on known temperature and relative humidity. Although the state is fully defined, the Psychrometric Chart only goes down to $35°F$ and no low temperature psychrometric chart is provided in the Reference Handbook.

As an alternative, search for the table Thermodynamic Properties of Moist Air and note the humidity ratio at saturation (100% relative humidity):

$$@T = 20°F \rightarrow \omega_s = 0.002153 \frac{lb_w}{lb_{da}}$$

The humidity ratio at any other level of humidity can be calculated by using the Degree of Saturation, μ. As an approximation, it is acceptable to assume the degree of saturation is roughly equivalent to the relative humidity. This is not strictly true but works well in a pinch. Solve for the humidity ratio using μ.

$$\phi \approx \mu \approx 50\%$$

$$\mu = \frac{\omega}{\omega_s} \rightarrow \omega = \mu\omega_s$$

$$\omega = (.5)\left(0.002153 \frac{lb_w}{lb_{da}}\right) = 0.00108 \frac{lb_w}{lb_{da}}$$

Answer A