$$w = \frac{R(T_2 - T_1)}{1-k} = \frac{\left(53.35\frac{ft \cdot lb_f}{lb_m \cdot R}\right)[470°F - 77°F]}{1-1.4} = \frac{-52,416\frac{ft \cdot lb_f}{lb_m}}{778\frac{ft \cdot lb_f}{Btu}} = -67\frac{Btu}{lb_m}$$

Normally it would be required to change Farenheit to Rankine; however, since it is a temperature *difference*, the delta is unchanged.

Note the unit conversion from $ft \cdot lb_f$ to Btu.

Finally, note the negative sign of the answer which aligns with the question's implication that work is being done *to the system*. A positive value would be expected if work were being done *by the system*.

Answer B

39.10 What quantity of heat is released per unit mass when copper is cooled from $250°F$ to $75°F$?

A. $16\frac{Btu}{lb}$

B. $18\frac{Btu}{lb}$

C. $57\frac{Btu}{lb}$

D. $157\frac{Btu}{lb}$

For heat transfer by conduction, use:

$$Q = mc_p\Delta T$$

Divide by mass to specify heat transfer per unit mass:

$$q = c_p\Delta T$$

Look up the specific heat capacity of copper by searching the reference handbook for properties of metals.

Substitute and solve:

$$q = \left(.09\frac{Btu}{lb°F}\right)(250°F - 75°F) = 15.75\frac{Btu}{lb}$$

Answer A

39.11 An outside air handling unit delivers $5000cfm$ of outside air. On a winter day, the outside air is $18°F$ and is heated to $68°F$ using a hot water coil. Hot water is supplied at $165°F$ and returned at $140°F$. What is the required flow rate of hot water?

A. $0.4gpm$

B. $3gpm$

C. $22gpm$

D. $173gpm$

The air undergoes sensible heating. Use the sensible heating rule of thumb:

$$Q_s = 1.08CFM\Delta T_{air}$$

The heat given up by the water can be determined with the sensible heating/cooling rule of thumb for water:

$$Q_w = 500GPM\Delta T_{water}$$

The quantity of heat added to the air is supplied entirely by the hot water, therefore we can equate the two formulas:

$$1.08CFM\Delta T_{air} = 500GPM\Delta T_{water}$$

The GPM of the hot water is the only unknown. Isolate, substitute, and solve:

$$GPM = \frac{1.08CFM\Delta T_{air}}{500\Delta T_{water}} = \frac{1.08\,(5000)\,(68-18)}{500\,(165-140)} = 21.6GPM$$

Note that no units need to be included when using these "rules of thumb" provided *all input values are in the correct units in the first place* i.e. CFM, GPM, and Farenheit.

Answer C