Use the same line in the table to obtain the entropy values s_f and s_{fg}. Calculate the entropy at State 4 using the quality, χ_4.

$$s_f = 0.102 \frac{Btu}{lb^\circ R}$$

$$s_{fg} = 0.199 \frac{Btu}{lb^\circ R}$$

$$s_4 = s_f + \chi_4 s_{fg} = \left(0.102 \frac{Btu}{lb^\circ R}\right) + (0.404)\left(0.199 \frac{Btu}{lb^\circ R}\right) = 0.182 \frac{Btu}{lb^\circ R}$$

Finally, calculate the change in entropy during the expansion process.

$$\Delta s = s_4 - s_3 = 0.182 \frac{Btu}{lb^\circ R} - 0.138 \frac{Btu}{lb^\circ R} = 0.044 \frac{Btu}{lb^\circ R}$$

Answer D

47.21 A flash distilation vessel boils seawater to make potable water. The pressure in the vessel is held at $10\ in\ Hg$ vacuum. What temperasure does the seawater boil at?

A. $162^\circ F$

B. $192^\circ F$

C. $212^\circ F$

D. $228^\circ F$

Convert the pressure in the vessel to absolute terms of *psia*, using conversions from the Measurement Relationships table as needed. Recall that vacuum pressure reads negative on a gauge, but pressure is always positive in absolute terms.

$$P_g = (-10 in\, Hg)\left(\frac{1psi}{2.036 in\, Hg}\right) = -4.91psig$$

$$P_a = P_g + 14.7psi = -4.91psig + 14.7psi = 9.8psia$$

Use the Properties of Saturated Water and Steam table to look up the saturation temperature at $9.8psia$. The saturation temperature is the boiling point of water at a given pressure. As a sense check, the boiling point should be *lower* than at standard conditions since there is less pressure holding the molecules from escaping.

$$T_{sat@9.8psia} \approx 192^\circ F$$

Ignore boiling point elevation; salinity accounts for only about $+1^\circ F$ and is outside the intended scope of the problem.

Answer B

47.22 **$5lb_m$ of $80°F$ air is compressed at constant temperature from $15psia$ to $90psia$. How much work is done on the closed system?**

A. $50Btu$

B. $110Btu$

C. $220Btu$

D. $330Btu$

For a Constant Temperature Process in a Closed System, with the initial and final pressures known, select the equation below. Make sure to use absolute temperature. Look up the Gas Constant for air.

$$w = RTln\left(\frac{P_1}{P_2}\right)$$

$$w = \left(53.35\frac{ft \cdot lb_f}{lb_m°R}\right)(540°R)\,ln\left(\frac{15psia}{90psia}\right) = -51,619\frac{ft \cdot lb_f}{lb_m}$$

Convert units to $\frac{Btu}{lb_m}$. Search Measurement Relationships for relevant conversions.

$$w = \left(-51,619\frac{ft \cdot lb_f}{lb_m}\right)\left(\frac{1Btu}{778ft \cdot lb_f}\right) = -66\frac{Btu}{lb_m}$$

Note this result is the *specific* work i.e. the work per unit mass. Multiply by the mass to determine the total work. The negative sign implies work done *on the system* and may be omitted since the problem statement calls for the work on the system.

$$W = mw = (5lb_m)\left(66\frac{Btu}{lb}\right) = 330Btu$$

Answer D

47.23 **$300psia$ superheated steam enters an isentropic turbine and exits at $170°F$ with 10% moisture content. What is the temperature of the entering steam?**

A. $420°F$

B. $690°F$

C. $960°F$

D. $1230°F$

Consider the entering consitions to be State 1, and exit conditions to be State 2. Since there is some moisture content at State 2, it can be inferred that the steam is a saturated mixture. 10% moisture content implies a quality of $\chi_2 = 0.9$. Use the Properties of Saturated Water and Steam table to look up the entropies s_f and s_{fg}. Calculate the entropy at State 2.