Problem 5

Given: A substance initially at 14 bar, 60°C that undergoes an isothermal, internally reversible expansion process to 2.8 bar

Determine: Heat transfer and work per kg for
(a) R-134a
(b) Air as an ideal gas

(a) $Q = mT(s_2 - s_1)$

$\frac{Q}{m} = T(s_2 - s_1)$

Table A-12

@ $p = 14$ bar, $T = 60°C$
$s_1 = 0.9297$ kJ/kg·K
$u_1 = 262.17$ kJ/kg

@ $p = 2.8$ bar, $T = 60°C$
$s_2 = 1.1079$ kJ/kg·K
$u_2 = 277.23$ kJ/kg

$$\frac{Q}{m} = (60+273)(1.1079-0.9297) = 59.34\ kJ/kg$$

$$m(u_2-u_1) = Q - W \qquad u_2-u_1 = \frac{Q}{m} - \frac{W}{m}$$

$$(277.23\ kJ/kg - 262.17\ kJ/kg) = 59.34\ kJ/kg - \frac{W}{m}$$

$$\boxed{\frac{W}{m} = 44.28\ kJ/kg}$$

(b) $$\frac{Q}{m} = T(s_2-s_1)$$

$$u_2 - u_1^{0} = \frac{Q}{m} - \frac{W}{m} \qquad \frac{W}{m} = \frac{Q}{m}$$

$$s_2 - s_1 = s^{o}(T_2) - s^{o}(T_1)^{0} - R\ln\left(\frac{P_2}{P_1}\right)$$

$$s_2 - s_1 = -\left(\frac{8.314}{28.97}\right)\ln\left(\frac{2.8\ bar}{14\ bar}\right)$$

$$s_2 - s_1 = 0.46189\ kJ/kg\cdot K$$

$$\frac{Q}{m} = (60^{\circ}C + 273)(0.46189)$$

$$\frac{Q}{m} = 153.81 \text{ kJ/kg} = \frac{W}{m}$$