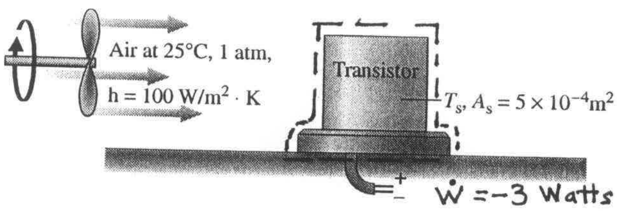
PROBLEM 2.60

KNOWN: Steady-state data are provided for a transistor cooled convectively.

FIND: Determine for the transistor the heat transfer rate and the outer surface temperature.

SCHEMATIC & GIVEN DATA:



ENGR. MODEL

1. The transistor is the closed system.
2. The system is at steady state.
3. No heat transfer occurs through the base of the transistor.

ANALYSIS: (a). An energy rate balance reads $\cancel{\frac{dE}{dt}}^{0} = \dot{Q} - \dot{W} \Rightarrow \dot{Q} = \dot{W} = -3 \text{ Watts}$ ←

(b) Since cooling occurs convectively, $\dot{Q} = -hA[T_s - T_{air}]$, where the minus sign is introduced because heat transfer is *from* the transistor and $T_s > T_{air}$. Solving

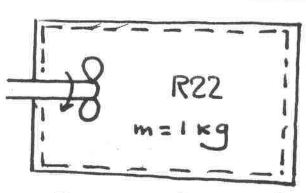
$$T_s = T_{air} - \left[\frac{\dot{Q}}{hA}\right] = 298\text{K} - \left[\frac{-3\text{ W}}{\left(100\frac{\text{W}}{\text{m}^2\cdot\text{K}}\right)(5\times10^{-4}\text{m}^2)}\right] = 358\text{K}\ (85°\text{C})$$ ←

PROBLEM 2.61

KNOWN: Data are provided for a ridgid, closed tank fitted with a paddle wheel. The tank contains Refrigerant 22.

FIND: (a) Q and W for the refrigerant. (b) Evaluate the constant K in the heat transfer relation provided.

SCHEMATIC & GIVEN DATA:



$\dot{Q} = -Kt$ (K in kW/min, t in min), $\dot{W} = -0.1\text{kW}$

$u_1 = 232.92$ kJ/kg

$u_2 = 276.67$ kJ/kg

$P_1 = 0.9$ MPa, $P_2 = 1.2$ MPa $\Delta t = 20$min.

ENGR. MODEL:

1. The Refrigerant 22 is the closed system.
2. No overall changes in kinetic or potential energy occur.

ANALYSIS: (a) $W = \int_1^2 \dot{W}\,dt = -(0.1\text{kW})(20\text{min})\left|\frac{60\text{s}}{1\text{min}}\right|\left|\frac{1\text{kJ/s}}{1\text{kW}}\right| = -120\text{kJ}$ ←

Energy Balance:

$$\Delta U + \cancel{\Delta KE} + \cancel{\Delta PE} = Q - W \Rightarrow Q = \Delta U + W \Rightarrow Q = m(u_2 - u_1) + W$$

$$\therefore\ Q = 1\text{kg}\,(276.67 - 232.92) + (-120\text{kJ}) = -76.25\text{ kJ}$$ ←

(b) $$Q = \int_1^2 \dot{Q}\,dt = \int_0^t -Kt\,dt = -\frac{Kt^2}{2} \Rightarrow$$

$$K = -\frac{2Q}{t^2} = -\frac{2(-76.25\text{kJ})}{(20\text{min})^2}\left|\frac{1\text{kW}}{1\text{kJ/s}}\right|\left|\frac{1\text{min}}{60\text{s}}\right|$$

$$= 6.354\times10^{-3}\ \frac{\text{kW}}{\text{min}}$$ ←