

PROBLEM 5.58

At steady state, a refrigeration cycle operating between hot and cold reservoirs at 300 K and 275 K, respectively, removes energy by heat transfer from the cold reservoir at a rate of 600 kW.

- (a) If the cycle's coefficient of performance is 4, determine the power input required, in kW.
(b) Determine the minimum theoretical power required, in kW, for any such cycle.

ANALYSIS:

$$(a) \quad \beta = \frac{\dot{Q}_c}{\dot{W}_{\text{cycle}}} \Rightarrow \dot{W}_{\text{cycle}} = \frac{\dot{Q}_c}{\beta} = \frac{600 \text{ kW}}{4} = 150 \text{ kW} \quad \leftarrow (a)$$

$$(b) \quad \beta \leq \beta_{\text{MAX}} \Rightarrow \frac{\dot{Q}_c}{\dot{W}_{\text{cycle}}} \leq \frac{T_c}{T_H - T_c} \Rightarrow \dot{Q}_c \left[\frac{T_H - T_c}{T_c} \right] \leq \dot{W}_{\text{cycle}}$$
$$600 \text{ kW} \left[\frac{25 \text{ K}}{275 \text{ K}} \right] \leq \dot{W}_{\text{cycle}}$$
$$\Rightarrow \dot{W}_{\text{cycle}} \geq 54.5 \text{ kW} \quad \leftarrow (b)$$