CH365 Chemical Engineering Thermodynamics

Lesson 26
Review

Homework

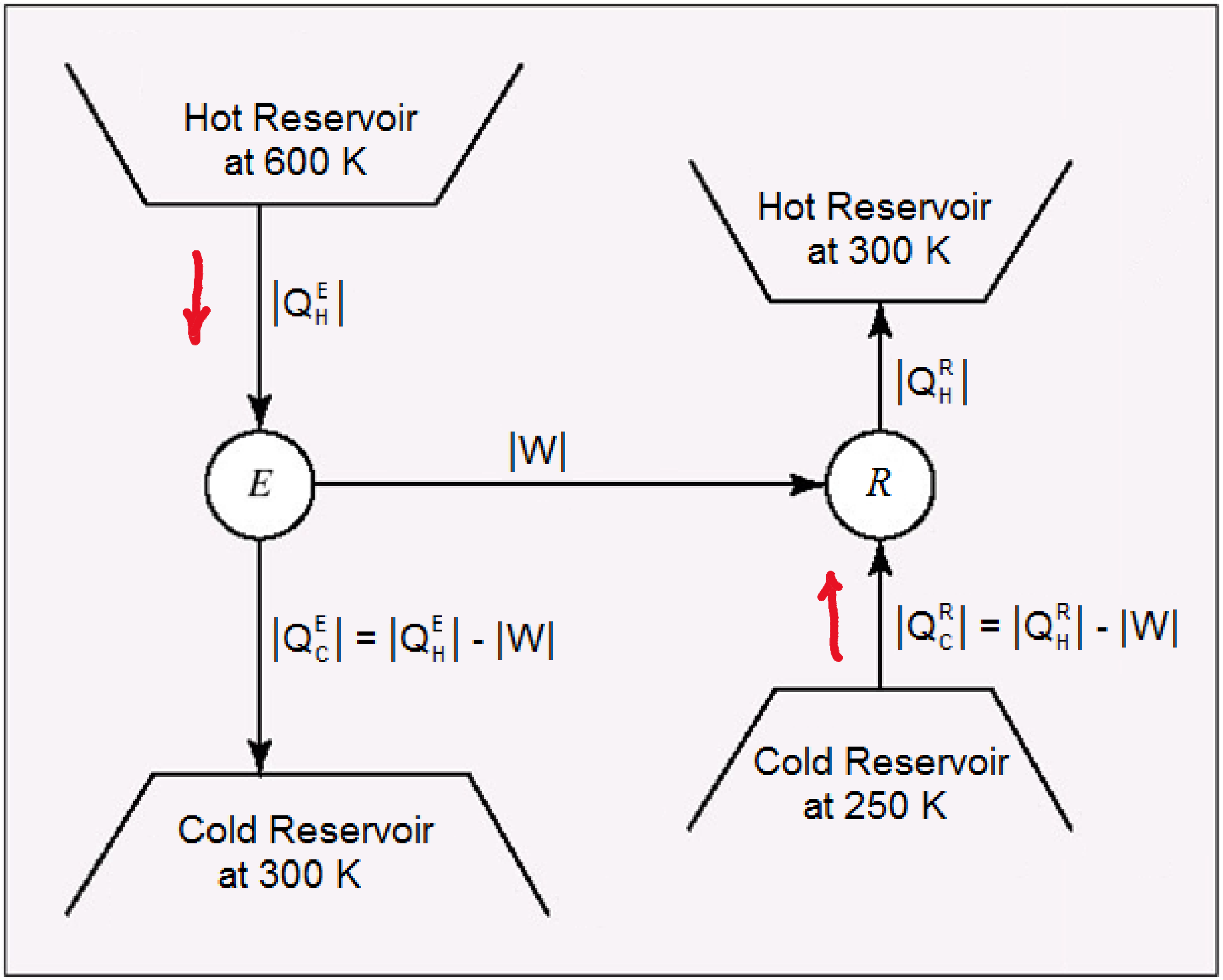
Problem 5.17

A Carnot engine operates between temperature levels of 600 K and 300 K. It drives a Carnot refrigerator, which provides cooling at 250 K and discards heat at 300 K.

Determine a numerical value for the ratio of heat extracted by the refrigerator $\underbrace{\text{(“cooling load”)}}_{\text{“} Q_C^R \text{”}}$ to the heat delivered to the engine $\underbrace{\text{(“heating load”)}}_{\text{“} Q_H^E \text{”}}$.

Problem 5.17, continued

Determine a numerical value for the ratio of heat extracted by the refrigerator ("cooling load") to the heat delivered to the engine ("heating load").



Want relationship between Q_C^R and Q_H^E

Problem 5.17, continued

Carnot Efficiency, η ⟷ Coefficient of Performance, COP

absorbs $\lvert Q_H^E \rvert$, discards $\lvert Q_C^E \rvert$, and produces $\lvert W \rvert$	absorbs $\lvert Q_C^R \rvert$, discards $\lvert Q_H^R \rvert$, and consumes $\lvert W \rvert$
$\lvert W \rvert = \lvert Q_H^E \rvert - \lvert Q_C^E \rvert$ 1st Law	$\lvert W \rvert = \lvert Q_H^R \rvert - \lvert Q_C^R \rvert$ 1st Law
$\frac{\text{output}}{\text{input}}$ $\eta \equiv \frac{\lvert W \rvert}{\lvert Q_H^E \rvert}$ (Eq. 5.6) definition of efficiency input > output	$\frac{\text{output}}{\text{input}}$ $COP \equiv \frac{\lvert Q_C^R \rvert}{\lvert W \rvert}$ definition of coefficient of performance (or COP) output > input
$\eta = \frac{\lvert Q_H^E \rvert - \lvert Q_C^E \rvert}{\lvert Q_H^E \rvert} = 1 - \frac{\lvert Q_C^E \rvert}{\lvert Q_H^E \rvert}$	$COP = \frac{\lvert Q_C^R \rvert}{\lvert Q_H^R \rvert - \lvert Q_C^R \rvert} \Rightarrow \frac{1}{COP} = \frac{\lvert Q_H^R \rvert - \lvert Q_C^R \rvert}{\lvert Q_C^R \rvert} = \frac{\lvert Q_H^R \rvert}{\lvert Q_C^R \rvert} - 1$
Carnot's equation $0 = \frac{Q_H^E}{T_H^E} + \frac{Q_C^E}{T_C^E}$ $\frac{\lvert Q_C^E \rvert}{\lvert Q_H^E \rvert} = \frac{T_C^E}{T_H^E}$ (Eqns. 5.4 L22 Slide 7)	Carnot's Equation $0 = \frac{Q_H^R}{T_H^R} + \frac{Q_C^R}{T_C^R}$ $\frac{\lvert Q_H^R \rvert}{\lvert Q_C^R \rvert} = \frac{T_H^R}{T_C^R}$
$\eta = 1 - \frac{T_C^E}{T_H^E}$ (Eq. 5.7)	$\frac{1}{COP} = \frac{T_H^R}{T_C^R} - 1 = \frac{T_H^R - T_C^R}{T_C^R} \Rightarrow COP = \frac{T_C^R}{T_H^R - T_C^R}$