CH365 Chemical Engineering Thermodynamics

Lesson 26
Review

Homework

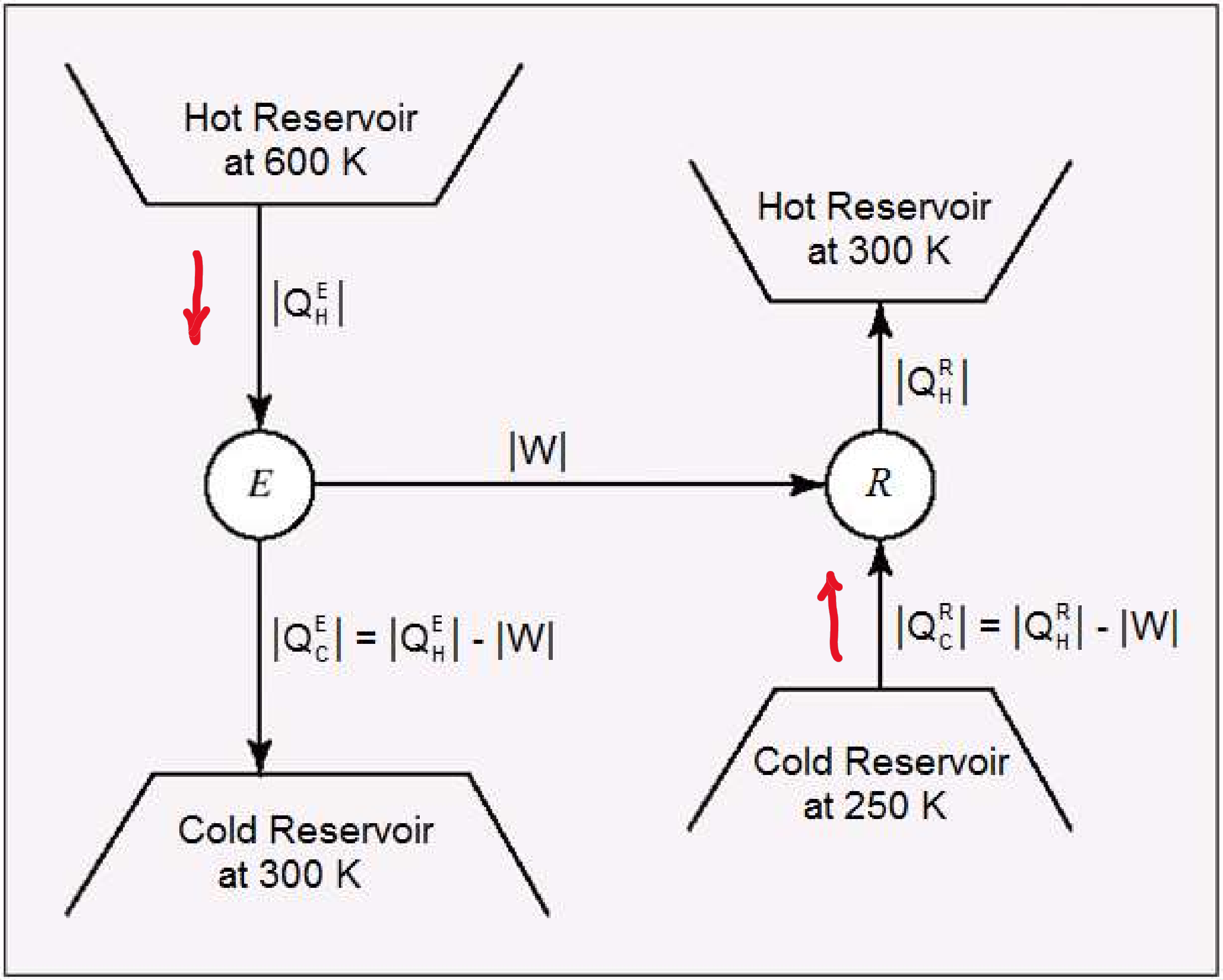
Problem 5.17

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

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
$\eta = \frac{\lvert Q_H^E\rvert - \lvert Q_C^E\rvert}{\lvert Q_H^E\rvert} = 1 - \frac{\lvert Q_C^E\rvert}{\lvert Q_H^E\rvert}$	$COP = \frac{\lvert Q_C^R\rvert}{\lvert Q_H^R\rvert - \lvert Q_C^R\rvert} \Rightarrow \frac{1}{COP} = \frac{\lvert Q_H^R\rvert - \lvert Q_C^R\rvert}{\lvert Q_C^R\rvert} = \underbrace{\frac{\lvert Q_H^R\rvert}{\lvert Q_C^R\rvert}} - 1$
Carnot's equation $0 = \frac{Q_H^E}{T_H^E} + \frac{Q_C^E}{T_C^E}$ (Eqns. 5.4 L22 Slide 7) $\frac{\lvert Q_C^E\rvert}{\lvert Q_H^E\rvert} = \frac{T_C^E}{T_H^E}$	Carnot's Equation $0 = \frac{Q_H^R}{T_H^R} + \frac{Q_C^R}{T_C^R}$ $\frac{\lvert Q_H^R\rvert}{\lvert Q_C^R\rvert} = \underbrace{\frac{T_H^R}{T_C^R}}$
$\eta = 1 - \frac{T_C^E}{T_H^E}$ (Eq. 5.7)	$\frac{1}{COP} = \frac{T_H^R}{T_C^R} - 1 = \frac{T_H^R - T_C^R}{T_C^R} \Rightarrow COP = \frac{T_C^R}{T_H^R - T_C^R}$