

# 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.

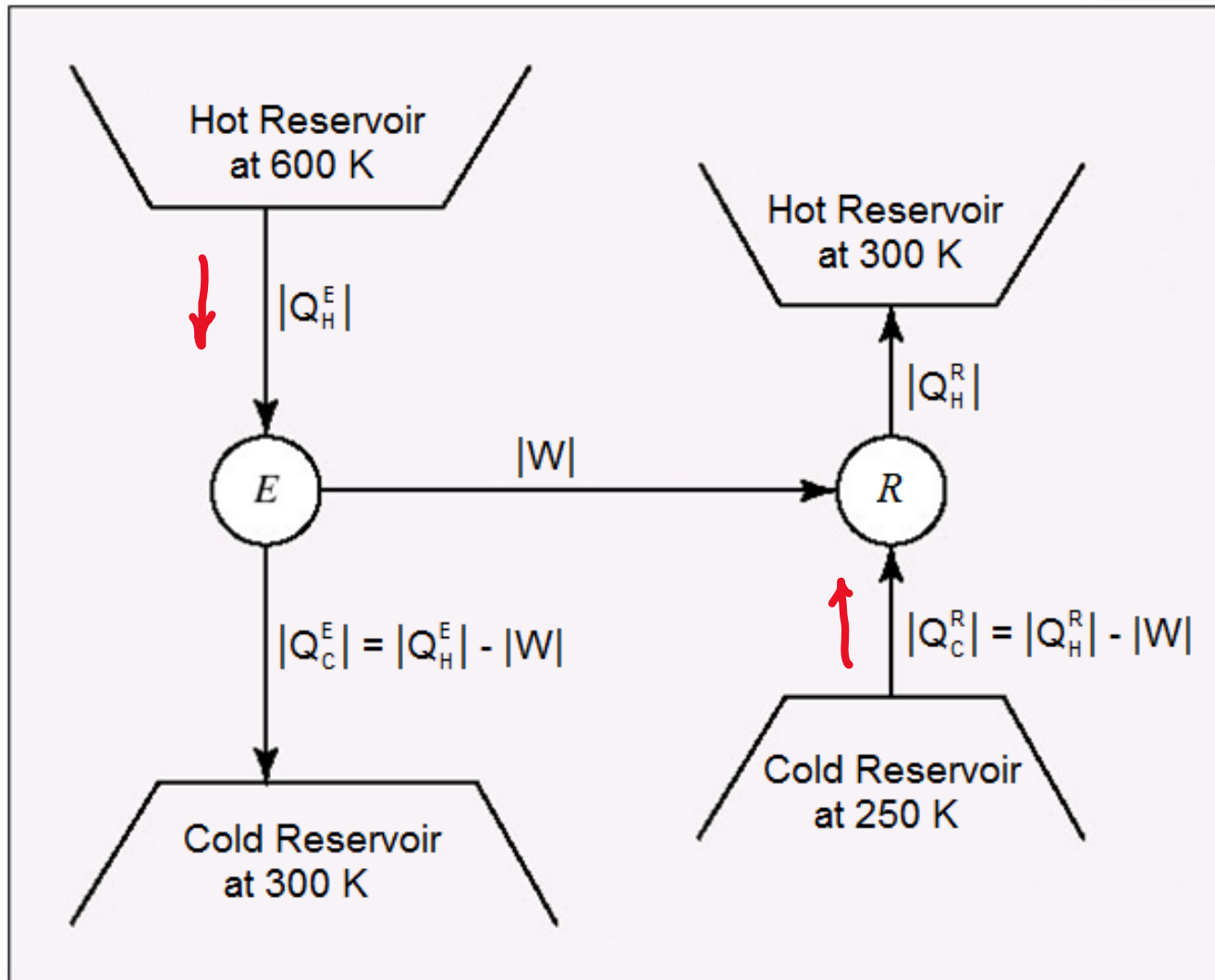
Determine a numerical value for the ratio of heat extracted by the refrigerator (“cooling load”) to the heat delivered to the engine (“heating load”).

“  $Q_C^R$  ”

“  $Q_H^E$  ”

# 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,  $\eta$   $\longleftrightarrow$  Coefficient of Performance, COP

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