Chapter 20 Tutorial

Thermodynamics-IV

Chapter 20 : The Second Law of Thermodynamics

Question 1:

A room air conditioner has a coefficient of performance of 2.9 on a hot day and uses 850 W of electrical power.

(a) How many joules of heat does the air conditioner remove from the room in one minute?
(b) How many joules of heat does the air conditioner deliver to the hot outside air in one minute?
(c) Explain why your answers to parts (a) and (b) are not the same.

IDENTIFY: $K = \dfrac{|Q_C|}{|W|}$ and $|Q_H| = |Q_C| + |W|$.

SET UP: The heat removed from the room is $|Q_C|$ and the heat delivered to the hot outside is $|Q_H|$. $|W| = (850\text{ J/s})(60.0\text{ s}) = 5.10\times10^4\text{ J}$.

EXECUTE: **(a)** $|Q_C| = K|W| = (2.9)(5.10\times10^4\text{J}) = 1.48\times10^5\text{ J}$

(b) $|Q_H| = |Q_C| + |W| = 1.48\times10^5\text{ J} + 5.10\times10^4\text{ J} = 1.99\times10^5\text{ J}$.

EVALUATE: **(c)** $|Q_H| = |Q_C| + |W|$, so $|Q_H| > |Q_C|$.

Question 2:

An aircraft engine takes in 9000 J of heat and discards 6400 J each cycle.

(a) What is the mechanical work output of the engine during one cycle?
(b) What is the thermal efficiency of the engine?

IDENTIFY: For a heat engine, $W = |Q_H| - |Q_C|$. $e = \dfrac{W}{Q_H}$. $Q_H > 0$, $Q_C < 0$.

SET UP: $|Q_H| = 9000\text{ J}$. $|Q_C| = 6400\text{ J}$.

EXECUTE: **(a)** $W = 9000\text{ J} - 6400\text{ J} = 2600\text{ J}$.

(b) $e = \dfrac{W}{Q_H} = \dfrac{2600\text{ J}}{9000\text{ J}} = 0.29 = 29\%$.

EVALUATE: Since the engine operates on a cycle, the net Q equal the net W. But to calculate the efficiency we use the heat energy input, Q_H.

Question 3:

The Otto-cycle engine in a Mercedes-Benz SLK230 has a compression ratio of 8.8.

(a) What is the ideal efficiency of the engine? Use Y = 1.40.
(b) The engine in a Dodge Viper GT2 has a slightly higher compression ratio of 9.6. How much increase in the ideal efficiency results from this increase in the compression ratio?

IDENTIFY: $e = 1 - r^{1-\gamma}$

SET UP: r is the compression ratio.

EXECUTE: **(a)** $e = 1 - (8.8)^{-0.40} = 0.581$, which rounds to 58%.

(b) $e = 1 - (9.6)^{-0.40} = 0.595$ an increase of 1.4%.

EVALUATE: An increase in r gives an increase in e.