___ 1 A heat engine absorbs 250 J of heat from a hot reservoir and rejects 110 J to a cold reservoir. What is the efficiency of this engine?

A) 39.% B) 78.% C) 31.% D) 85.% E) 56.%

Solution:

The efficiency is $(Q_h - Q_c)/Q_h = (250 - 110)/250 = 56.\%$.

The correct answer is: E

___ 2 A heat engine with an output of 300 W has an efficiency of 30% and works at a frequency of 10 cycles/second. How much heat is absorbed (Q_h) and how much rejected (Q_c) in each cycle?

A) $Q_h = 200.\,\text{J}$ $Q_c = 140.\,\text{J}$ B) $Q_h = 143.\,\text{J}$ $Q_c = 9.00\,\text{J}$ C) $Q_h = 1000.\,\text{J}$ $Q_c = 700.\,\text{J}$
D) $Q_h = 100.\,\text{J}$ $Q_c = 70.0\,\text{J}$ E) $Q_h = 129.\,\text{J}$ $Q_c = 90.0\,\text{J}$

Solution:

The work done per cycle is the power divided by the frequency $300\,\text{W}/10\,\text{Hz} = 30\,\text{J}$. If the efficiency is ϵ, the heat absorber per cycle is $Q_h = W/\epsilon = 30\,\text{J}/0.300 = 100.\,\text{J}$. The heat rejected per cycle is $Q_c = (1 - \epsilon)Q_h = 0.700 \times 100.\,\text{J} = 70.0\,\text{J}$.

The correct answer is: D

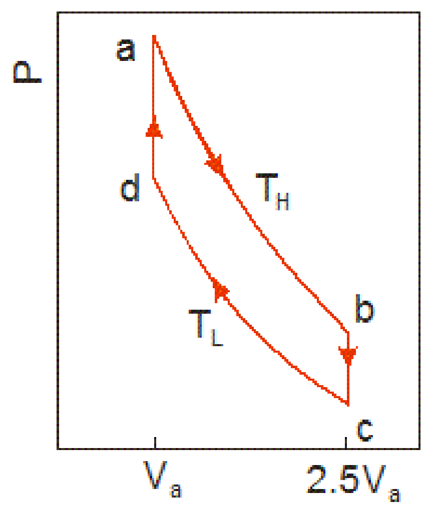

Figure 1: Problem 3

___ 3 Refer to Fig. 1. An ideal heat engine uses 0.300 mol of ideal gas and operates between a hot reservoir at $T_{\text{H}} = 400\,\text{K}$ and cold reservoir at $T_{\text{L}} = 300\,\text{K}$, in a cycle from $a \to b \to c \to d \to a$. From $a \to b$ the gas undergoes an isothermal expansion, changing its volume from V_a to $2.5V_a$. From $b \to c$, the pressure is reduced at a constant volume. From $c \to d$, the gas undergoes an isothermal compression, and from $d \to a$, the pressure is increased at a constant volume until the gas is back at the original condition at a. How much heat is absorbed in going from $a \to b$?

A) 1100. J B) 686. J C) 823. J D) 3050. J E) 914. J

Solution:

Process a→b is isothermal. The internal energy of an ideal gas depends only on temperature so the heat in during an isothermal process is equal to the work done. That work is $\int_{V_a}^{V_b} PdV = nRT_{\text{H}} \ln{(2.5V_a/V_a)} =$ 914. J.

The correct answer is: E

___ 4 Two refrigerators, one with a COP of 3.5 and another with a COP of 5.0, both extract 400 kJ of heat from the cold reservoir (food). Calculate the difference in energy they exhaust to the hot reservoir and hence the room.

A) 34. kJ B) 24. kJ C) 38. kJ D) 31. kJ E) 41. kJ

Solution:

The difference is $Q_c(1/COP_1 - 1/COP_2) = 400(1/3.5 - 1/5.0)\,\text{kJ} = 34.\,\text{kJ}$.

The correct answer is: A

___ 5 A water-cooled electric power plant generates 250 MW of power at an efficiency of 35.0%. At what rate must water be circulated past the condenser if the change in water temperature is not to exceed 10 °C? (The specific heat of water is 4.2×10^3 J/ kg °C)

A) 11100. kg/ s B) 8840. kg/ s C) 2630. kg/ s D) 6630. kg/ s E) 111000. kg/ s

Solution:

The power produced is 250 MW. The power consumed by the plant is $P/0.350 = 714.$ MW The heat energy per unit time rejected by the plant into the environment is $P_Q = P - P/0.350 = 464.$ MW. If the cooling water undergoes a temperature increase of ΔT, and if water has has a specific heat of c, the mass of water consumed per unit time is $P_Q/c\Delta T = 11100.$ kg/ s.

The correct answer is: A

___ 6 What is the maximum possible coefficient of performance of a heat pump that is capable of maintaining the interior of a house at 28 °C when the temperature outside is −40 °C?

A) 0.44 B) 0.41 C) 4.4 D) 0.56 E) 3.4

The maximum COP is $T_\text{h}/(T_\text{h} - T_\text{c}) = 301/(301 - 233) = 4.4$.

The correct answer is: C

1. E
2. D
3. E
4. A
5. A
6. C