**Chapter 22. Heat engines, entropy, and the second law of thermodynamics**

St. ID: , Name:

1. A particular heat engine has a mechanical power output of 5.00 kW and an efficiency of 25.0%. The engine expels 8.00 ×103 J of exhaust energy in each cycle. Find (a) the energy taken in during each cycle and (b) the time interval for each cycle.

Ans:

(a) We have 

With |*Qc*|=8 000 J, we have 

(b) The work per cycle is

*W*eng=|*Qh*|–|*Qc*|=2 667 J

From the definition of output power,



we have the time for one cycle:



1. A gun is a heat engine. In particular, it is an internal combustion piston engine that does not operate in a cycle, but comes apart during its adiabatic expansion process. A certain gun consists of 1.80 kg of iron. It fires one 2.40-g bullet at 320 m/s with an energy efficiency of 1.10%. Assume the body of the gun absorbs all the energy exhaust—the other 98.9%—and increases uniformly in temperature for a short time interval before it loses any energy by heat into the environment. Find its temperature increase.

Ans:

The engine’s output work we identify with the kinetic energy of the bullet:

The energy exhaust is



1. A refrigerator has a coefficient of performance equal to 5.00. The refrigerator takes in 120 J of energy from a cold reservoir in each cycle. Find (a) the work required in each cycle and (b) the energy expelled to the hot reservoir.

Ans:



(a) If |*Qc*|=120 J and COP=5.00, then *W*=24.0 J.

(b) |*Qh*|=|*Qc*|+*W*=120 J+24 J=144 J

1. A heat engine operates between a reservoir at 25.0°C and one at 375°C. What is the maximum efficiency possible for this engine?

Ans:

The maximum possible efficiency for a heat engine operating between reservoirs with absolute temperatures of *Tc* = 25° + 273 = 298 K and *Th* = 375° + 273 = 648 K is the Carnot efficiency:

