Chapter 20: Entropy and the Second Law of Thermodynamics

Entropy

Q1. One mole of an ideal monatomic gas is heated quasi-statically at constant volume from 100 K to 105 K. What is the change in entropy of the gas?Ans:0.61 J/K.

Q2. Suppose that 10 kg of water at 50 degree-C is mixed with an equal amount of water at 10 degree-C. When thermal equilibrium is reached, what is the change in entropy of the mixture? The specific heat of water is 4186 J/kg.K.Ans:183 J/K

Q3. Five moles of an ideal diatomic gas (Cp = 7R/2) is taken through an isovolumetric process. If the final pressure is five times the initial pressure, what is the change in entropy of the gas?Ans:167 J/K

Q4. Find the change in entropy when 100 g of ice at 0 degree-C is heated slowly to 80 degrees-C. (C(water) = 1.0 cal/g.degree-C, L(f) = 80 cal/g).Ans:55 cal/K

Q5. The left-hand side of the container shown in Figure 2 contains 5 moles of nitrogen gas, in thermal equilibrium with the right hand side, which contains 3 moles of hydrogen gas. The two sides are separated by a partition, and the container is insulated. After the partition is broken, what is the change in entropy of the system? Ans:49 J/K

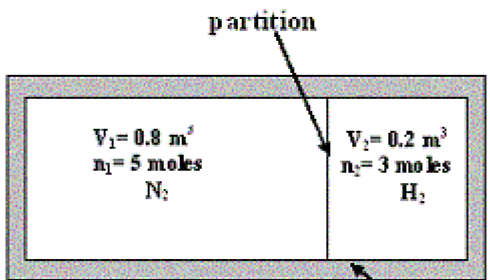


Figure 2

Engines

Q6. An ideal heat pump is used to absorb heat from the outside air at -10 degree-C and transfers it into a house at a temperature of 30 degree-C. What is the heat energy transferred into the house if 5.0 kJ of work is done on the heat pump?Ans:38 kJ

Q7. One mole of an ideal monoatomic gas (C_v = 3R/2)is taken through the cycle shown in Figure 1. If T_a = 590 K, T_b = 450 K and T_c = 300 K, calculate the efficiency of an engine operating in this cycle. Ans:0.14

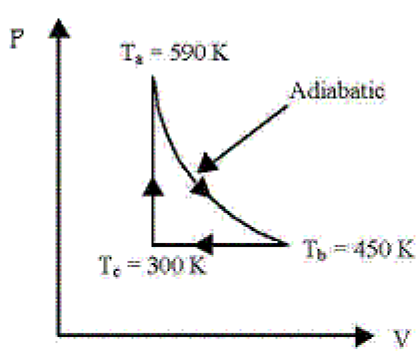
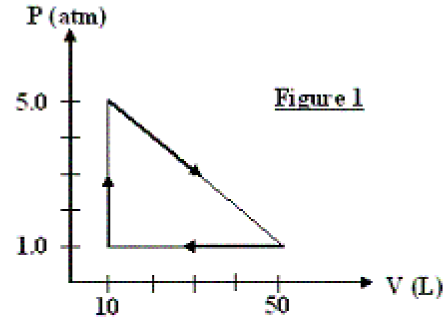


Figure 1

Q8. A heat engine has a monatomic gas as the working substance and its operating cycle is shown by the P-V diagram in Figure 1. In one cycle, 18.2 kJ of heat energy is absorbed by the engine. Find the efficiency of the heat engine. Ans:0.44



Q9. A Carnot engine whose low temperature reservoir is at 7 degrees-C has an efficiency of 50%. It is desired to increase the efficiency to 70%. By how many degrees should the temperature of the high temperature reservoir be increased while the cold reservoir remains at the same temperature?Ans:373 K

Q10. A heat engine absorbs 8.71×10^3 J per cycle from a hot reservoir with an efficiency of 25% and executes 3.15 cycles per second. What is the power output of the heat engine?
Ans:6.86×10^3 W.

Refrigerators

Q11. An ideal freezer has a coefficient of performance (COP) of 5. If the temperature inside the freezer is - 20 degrees-C, what is the temperature at which heat is rejected?Ans:31 degrees-C

Q12. What is the coefficient of performance of a refrigerator that absorbs 40 cal/cycle at low temperature and expels 51 cal/cycle at high temperature?Ans:3.6.

Q13. During one cycle, a Carnot refrigerator does 200 J of work to remove 600 J from its cold compartment. How much energy per cycle is exhausted to the kitchen as heat?Ans:800 J.

Q14. A Carnot refrigerator has a coefficient of performance equal to 6. If the refrigerator expels 80 J of heat to a hot reservoir in each cycle, find the heat absorbed from the cold reservoir.Ans:69 J.

Q15. A Carnot refrigerator has a coefficient of performance equal to 5. The refrigerator absorbs 120 J of heat from a cold reservoir in each cycle. How much heat is expelled to the hot reservoir?Ans:144 J