Phys 340

Assignment #8

Answer the following questions:

1. A system undergoes a process between two fixed states first in a reversible manner and then in an irreversible manner. For which case is the entropy change of the system greater? Why?

2. Is an isothermal process necessarily internally reversible? Explain your answer with an example.

3. A piston-cylinder device contains helium gas. During a reversible, isothermal process, the entropy of the helium will (*never, sometimes, always*) increase.

4. A piston-cylinder device contains superheated steam. During an actual adiabatic process, the entropy of the steam will *(never, sometimes, always)* increase.

5. A rigid tank contains an ideal gas at 40°C that is being stirred by a paddle wheel. The paddle wheel does 200 kJ of work on the ideal gas. It is observed that the temperature of the ideal gas remains constant during this process as a result of heat transfer between the system and the surroundings at 25°C. Determine *(a)* the entropy change of the ideal gas and *(b)* the total entropy generation. Is the increase of entropy principle satisfied during this process?

Answers: (a) 0, *(b)* 0.671 kJ/K

6. Air is compressed by a 8-kW compressor from P_1 to P_2. The air temperature is maintained constant at 25°C during this process as a result of heat transfer to the surrounding medium at 10°C. Determine the rate of entropy change of the air and the rate of total entropy generation. State the assumptions made in solving this problem. Does this process satisfy the second law of thermodynamics?
Answers: -0.0268 kW /K, 0.0015 kW/K

7. During the isothermal heat addition process of a Carnot cycle, 900 kJ of heat is added to the working fluid from a source at 400°C. Determine *(a)* the entropy change of the working fluid, *(b)* the entropy change of the source, and *(c)* the total entropy generation for the process.

8. During the isothermal heat rejection process of a Carnot cycle, the working fluid experiences an entropy change of -0.6 kJ/K. If the temperature of the energy sink is 30°C, determine *(a)* the amount of heat transfer to the sink, *(b)* the entropy change of the sink, and *(c)* the total entropy generation for this process.
Answers: (a) 181.8kJ, *(b)* 0.6kJ/K, *(c)* 0

9. Some properties of ideal gases such as internal energy and enthalpy vary with temperature only [that is, $U = U(T)$ and $H = H(T)$]. Is this also the case for entropy?

10. An ideal gas undergoes a process between two specified temperatures, first at constant pressure and then at constant volume. For which case will the ideal gas experience a larger entropy change? Explain.

11. A 0.5-m^3 insulated rigid tank contains 0.9 kg of carbon dioxide at 100 kPa. Now paddle-wheel work is done on the system until the pressure in the tank rises to 120 kPa. Determine the entropy change of carbon dioxide during this process in kJ /K. Assume constant specific heats.
Answer: 0.108 kJ /K

12. A mass of 3 kg of helium undergoes a process from an initial state of 3 m^3/kg and 20°C to a final state of 0.5 m^3/kg and 120°C. Determine the entropy change of helium during this process, assuming *(a)* the process is reversible and *(b)* the process is irreversible.

13. An insulated rigid tank is divided into two equal parts by a partition. Initially, one part contains 5 kmol of an ideal gas at 400 kPa and 50°C, and the other side is evacuated. The partition is now removed, and the gas fills the entire tank. Determine the entropy generation during this process.

Answer: 28.81 kJ /K

14. The inner and outer surfaces of a 0.5-cm thick 2m x 2m window glass in winter are l0 °C and 3°C, respectively. If the thermal conductivity of the glass is 0.78 W/(m.°C), determine the amount of heat loss, in kJ, through the glass over a period of 5 h. Also determine the amount of entropy generated during this process within the glass.

15. A piston-cylinder device initially contains 0.5 m^3 of helium gas at 150 kPa and 20°C. Helium is now compressed in a polytropic process (PV^n = constant) to 400 kPa and 140°C. Determine the entropy change of helium and whether this process is reversible, irreversible, or impossible. Assume the surroundings are at 20°C.

16. A 4m x 5m x 6m well-sealed room is to be heated by one ton (1000 kg) of liquid water contained in a tank that is placed in the room. The room is losing heat to the outside air at 5°C at an average rate of 10,000 kJ/h. The room is initially at 20°C and 100 kPa, and is maintained at an average temperature of 20°C at all times. If the hot water is to meet the heating requirements of this room for a 24-h period, determine (a) the minimum temperature of the water when it is first brought into the room and (b) the entropy generated during a 24-h period. Assume constant specific heats for both air and water at room temperature.

17. Consider a well-insulated horizontal rigid cylinder that is divided into two compartments by a piston that is free to move but does not allow either gas to leak into the other side. Initially, one side of the piston contains 1m^3 of N_2 gas at 500 kPa and 80°C while the other side contains 1m^3 of He gas at 500 kPa and 25°C. Now thermal equilibrium is established in the cylinder as a result of heat transfer through the piston. Using constant specific heats at room temperature, determine (a) the final equilibrium temperature in the cylinder and (b) the entropy generation during this process. What would your answer be if the piston were not free to move?

18. Consider two bodies of identical mass m and specific heat c used as thermal reservoirs (source and sink) for a heat engine. The first body is initially at an absolute temperature T_1 while the second one is at a lower absolute temperature T_2. Heat is transferred from the first body to the heat engine which rejects the waste heat to the second body. The process continues until the final temperatures of the two bodies T_f become equal. Show that $T_f = (T_1 T_2)^{1/2}$ when the heat engine produces the maximum possible work.

Appendix

Useful constants

Substance	Molar mass (M) (kg/kmol)	R* gas constant (kJ/kg.K)	Cp (kJ/kg.K)	C_V (kJ/kg.K)	γ
air	28.97	0.2870	1.005	0.718	1.4
Carbon dioxide	44.01	0.1889	0.846	0.657	1.289
Helium (He)	4.003	2.0769	5.1926	3.1156	1.667
Hydrogen (H_2)	2.016	4.1240	14.307	10.183	1.405
Nitrogen (N_2)	28.013	0.2968	1.039	0.743	1.400

R* (in kJ/kg.K) = R/M = 8.314 (in kJ/kmol.K) / molecular mass (in kg/kmol)