Thermodynamics. Problems. Sheet 3.

1. A certain amount of ideal gas ($c_{p,molar}$= 7R/2) at 20°C and 1 atm, has a volume of 70 m^3 and is heated at constant pressure to 25°C by heat transfer from a thermal reservoir at 40°C.

   a) What is the heat transferred to the gas?
   b) Is the process irreversible?
   c) What is the change in entropy of the thermal reservoir?
   d) What is the change in entropy of the gas?

2. A rigid container with a volume of 50 dm^3 contains an ideal gas ($c_{v,molar}$ = 5R/2) at 500 K and 1 atm.

   a) Compute the change in entropy of the gas if 2870 cal are transferred to it as heat.
   b) If the vessel has a stirrer that rotates such that the shaft's work delivered to the gas equals 12.0 kJ, compute the entropy change of the gas if the process is adiabatic.
   c) Compute the total entropy in stage b. Is the process irreversible?

3. Very pure liquid water can be subcooled at atmospheric pressure to temperatures well below 0ºC. One kilogram of liquid water chilled to -6ºC partially freezes in an adiabatic process at atmospheric pressure.

   a) What fraction of the system freezes?
   b) What is its final temperature?
   c) What is the ΔS_{total} for the process?
   d) Is the process reversible or irreversible?

   $\Delta H_{melting}$ of water at 0ºC = 333.4 J g^{-1}.
   c_p of subcooled liquid water = 4.226 J g^{-1} $ºC^{-1}$.

4. Compute the entropy change that occurs when a 50-gram block of iron at a temperature of 90ºC (c_p= 0.449 J/g K) is placed in an insulated container containing 100 g of water (c_p= 4180 J kg^{-1} K^{-1}) at 25ºC. Is the process irreversible? Why? Consider the heat capacities to be constant within the working temperature range.

5. Compute the change in internal energy, enthalpy and entropy for the expansion of 10 mol of oxygen from 200 to 2000 liters at 25ºC.

6. A plant operates with a source at 300°C and a sink at 25°C. If the thermal efficiency is equal to 60% of that of a Carnot engine for the same temperatures,

   a) What is the thermal efficiency of the plant?
   b) What increase must be given to the source temperature so that the thermal efficiency of the plant increases to 40%? Again, η is equal to 60% of the value corresponding to the Carnot engine.

7. A heat engine works between a hot source at 900 K and a cold source at 300 K following a reversible Carnot cycle. The work produced is used in operating a crane. If 10% of the work of the heat engine is lost in the form of heat due to friction of the pulleys and the total amount of heat given off by the heat engine-pulleys assembly is 72 kJ, compute the heat absorbed from the hot source, the work done by the engine, and the heat transferred to the coolant.

8. The work obtained from a heat engine operating between 1200°C and 25°C, following a reversible Carnot cycle, is used to operate a Carnot refrigerating engine operating between 0°C and 25°C. Compute the relationship between the heat absorbed by the heat engine and the heat extracted from the refrigerating engine if it is assumed that both work reversibly.