Homework #5

MEMS 0051 - Introduction to Thermodynamics

Assigned June 19th, 2018
Due June 25th, 2018

Problem #1

Two rigid tanks are initially in thermodynamic equilibrium. The first tank is 0.5 [m] tall and sufficiently insulated, and contains 5 [kg] of carbon dioxide at 80 °C and a pressure of 200 [kPa]. The second tank is 0.25 [m] in diameter and not insulated, and contains 10 [kg] of argon at 25 °C and a pressure of 500 [kPa]. The two tanks are connected by a rigid piping system that contains a valve, which is then opened. After an extended period of time (assuming sufficiently long to achieve thermodynamic equilibrium internally and thermal equilibrium with the environment, which is 25°C), determine:

A The final pressure (i.e. mechanical equilibrium pressure).
B The heat transferred into our out of the tank system.

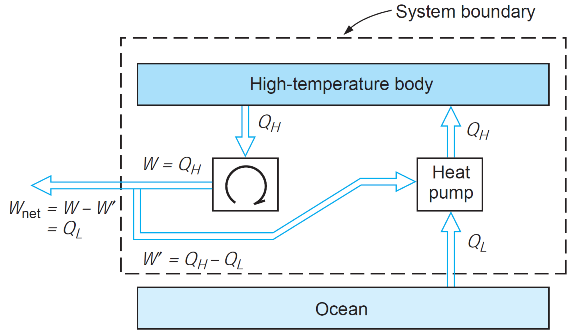
Problem #2

For the following scenarios, determine the amount of heat transfer.

A Heating a 2 [kg], 0.1 [m] long copper bar from 25°C to 100°C.
B 1,000 [kg] of asphalt cooling from 50°C to 20°C.
C The heating of 1 [kg] of oxygen in a mass-less piston-cylinder from 300 to 1,500 K.
D A piston-cylinder containing 0.1695 [kg] of nitrogen at 150 [kPa] and 25°C that is isothermally compressed to 1.0 [MPa], which requires 20 [kJ] of work.

Problem #3

Given the system below, where a heat pump transfers heat from a low-temperature infinite reservoir (the ocean) and transfers heat to a high-temperature infinite reservoir (say a room). The work powering the heat pump comes from a heat engine, which accepts heat from the same high-temperature reservoir. Is this configuration acceptable (i.e. does not violate the Kelvin-Planck and/or Clausius statements, nor is a perpetual motion machine of the 1st, 2nd and 3rd kind)?



Problem #4

Two heat engines that operate in series (i.e. $\dot{Q}_H$ enters HE1 which rejects $\dot{Q}_M$, which is the input into HE2, which rejects $\dot{Q}_L$) between a high-temperature reservoir T_H and a low-temperature reservoir T_L. HE1 produces work $\dot{W}_1$ and HE2 produces work $\dot{W}_2$. Find the efficiency of each heat engine, and the efficiency of the overall system.

Problem #5

A heat engine operates between a high-temperature reservoir T_{H1} and a low-temperature reservoir T_{ambient}. The work produced, $\dot{W}_1$, which is the difference of heat input $\dot{Q}_{H1}$ and heat rejected $\dot{Q}_{L1}$, powers a heat pump. Part of the work from the heat engine enters the heat pump $\dot{W}_2$, whereas the difference between $\dot{W}_1$ and $\dot{W}_2$ is designated as the net work, $\dot{W}_{\text{net}}$. The heat pump accepts heat $\dot{Q}_{L2}$ from the same low-temperature reservoir (T_{ambient}) and rejects heat $\dot{Q}_{H2}$ to a secondary high-temperature reservoir T_{H2}. Assuming T_{H1}=T_{H2}>T_{ambient}, determine, based upon the following cases (a-c), if this system satisfies the First Law and/or violates the Second Law. Then, assuming T_{H1}>T_{H2}>T_{ambient}, determine if this system satisfies the First Law and/or violates the Second Law.

	$\dot{Q}_{H1}$	$\dot{Q}_{L1}$	$\dot{W}_1$	$\dot{Q}_{H2}$	$\dot{Q}_{L2}$	$\dot{W}_2$
a	6	4	2	3	2	1
b	6	4	2	5	4	1
c	3	2	1	4	3	1