MECH 310 THERMODYNAMICS I
ASSIGNMENT 3

Question 1 (8 points)

A well insulated tank containing 0.6 kg of air is at an initial temperature and pressure of 323 K and 1500 kPa respectively. The tank is connected to a well-insulated piston-cylinder set up through a valve that is initially closed. The piston sits at the bottom of the cylinder and its weight and the force of the atmosphere on the outside requires a pressure of 240 kPa to just lift it. The valve is now opened and the air flows into the cylinder to establish a final equilibrium state of the system. Calculate the final temperature of the air and the work done by the air. Is the process reversible?

Question 2 (6 points)

A fixed mass of an ideal gas undergoes a cycle 1-2-3 consisting of three processes. In the first process 1-2 it receives heat from a reservoir at 600 K. During the next adiabatic process 2-3 it delivers work output of 88 kJ to the surroundings. The gas rejects heat to a reservoir at 280 K during isothermal process 3-1 while it receives a work input of 64.5 kJ. Show that the cycle is irreversible.

Question 3 (8 points)

A Carnot cycle refrigerator operates between two heat reservoirs at -15^{o}C and 45^{o}C. (i) Calculate the COP of this refrigeration cycle. (ii) Calculate the COP of the cycle if it is operated as a heat pump. (iii) If the heat absorption at the low-temperature reservoir is 25 kW, calculate the power input to the refrigerator and the hear rejection rate. (iv) If the temperature difference between the reservoir and the working fluid of the refrigerator is 4^{o}C at each reservoir, calculate the COP of the refrigerator and the heat pump.

Question 4 (12 points)

The data listed below are claimed for a power cycle operating between reservoirs at 527^{o}C and 27^{o}C. For each case, determine if any principles of thermodynamics would be violated.

(a) Q_H =700 kJ, W_{cycle} = 400 kJ, Q_C = 300 kJ.
(b) Q_H = 640 kJ, W_{cycle} = 400 kJ, Q_C = 240 kJ.
(c) Q_H = 640 kJ, W_{cycle} = 400 kJ, Q_C = 200 kJ.

Question 5 (16 points)

A refrigeration cycle operating between two reservoirs receives energy QC from a cold reservoir at T_C = 280 K and rejects energy Q_H to a hot reservoir at T_H = 320 K. For each of the following cases determine whether the cycle operates reversibly, irreversibly, or is impossible:

(a) Q_C =1500 kJ, W_{cycle} = 150 kJ.
(b) Q_C =1400 kJ, Q_H = 1600 kJ.
(c) Q_H =1600 kJ, W_{cycle} = 400 kJ.
(d) COP = 5.