1. (a) Please describe the thermodynamic equilibrium conditions. What kind of conditions our physical
(20%) body is in the daily life? Explain.

(b) 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 1 m^3 of N_2 gas at 500 kPa and 300^0 C while the other side contains 2 m^3 of air at 400 kPa and 25^0 C Now the thermodynamic equilibrium is established in the cylinder as a result of heat transfer through the piston and the piston motion. Please determine the equilibrium pressure and temperature. Please also determine the work done by the piston.

2. (a) In an effort to conserve energy in a heat-engine cycle, somebody suggests incorporating a
(20%) refrigerator that will absorb some of the waste energy Q and transfer it to the energy source of the heat engine. Is this a smart idea? Explain.

(b) A piston-cylinder device initially contains 10 ft^3 of air at 30 psia and 70^0F. The gas is now compressed in a polytropic process to 100 psia and 300^0F. Please determine (a) the entropy change of the gas and the surroundings, (b) the work done and entropy generation during the process, (c) show this process in the p-v diagram.

3. (a) Consider two systems that are at the same pressure P_1. The first system is at the same temperature
(20%) as the environment, whereas the second system is at a lower temperature than the environment. Please compare the exergies (availability) of these two systems.

(b) A 50-cm external diameter, 10-m long hot water pipe at 90^0C is losing heat to the surrounding air at 5^0C by natural convection with a heat transfer coefficient of $25W(m^2 \cdot {}^0C)$. Determine the rate of heat loss from the pipe and the rate at which the work potential is wasted during this process.

(20%) 4. (a) The gas refrigeration system is frequently used for ventilation system in an aircraft. Please describe the advantages and disadvantage of using gas refrigeration cycle in the aircraft as compared with the vapor-compression refrigeration cycle.

(b) Please describe how would you modify a simple Bryton cycle and get a high net work output and a higher thermal efficiency.

(20%) 5. A partition is used to divide an insulated tank so that one part of the tank contains 5 kg of O_2 gas at 50^0C and 100 kPa and the other part contains 5 kg of N_2 gas at 30^0C and 200 kPa. Now the partition is removed and gases are allowed to mix. Please determine (a) the final T and P of the system,

(b) the entropy changes (c_p of $O_2 = 0.918$ kJ/kg^{0}K,

c_p of $N_2 = 1.039$ kJ/kg^{0}K, $R_u = 8.314$ kPa$\cdot m^3$/kmol^{0}K,

T_{cr} of $O_2 = 154.8^0$K, P_{cr} of $O_2 = 5.08$ MPa,

T_{cr} of $N_2 = 126.2^0$K, P_{cr} of $N_2 = 3.39$ MPa)