1. Write a definition of availability(exergy). Is it possible for availability to be negative? Discuss. (20%)

2. A system undergoes a power cycle while receiving energy Q_H by heat transfer at temperature T_H and discharging energy Q_C by heat transfer at a lower temperature T_C. There are no other heat transfers. Show that the thermal efficiency of the cycle can be expressed as

$$\eta = 1 - \frac{T_C}{T_H} - \frac{T_C I}{T_o Q_H}$$

where T_o is the temperature of availability reference environment and I is the irreversibility for the cycle. (20%)

3. An isolated system of total mass m is formed by mixing two equal masses of the same liquid initially at the temperatures T_1 and T_2. Eventually, the system attains an equilibrium state. Each mass is incompressible with constant specific heat c. Show that the amount of entropy produces σ is

$$\sigma = mc \ln\left[\frac{T_1 + T_2}{2(T_1 T_2)^{1/2}}\right] \quad (20\%)$$

4. A two-phase liquid-vapor mixture of H_2O with an initial quality of 25% is contained in a piston-cylinder assembly as shown in Fig.1. The mass of the piston is 40 kg, and its diameter is 10 cm. The atmospheric pressure of the surroundings is 1 bar. The initial and final positions of the piston are shown on the diagram. As the water is heated, the pressure inside the cylinder remains constant until the piston hits the stops. Heat transfer to the water continues until its pressure is 3 bars. Friction between the piston and the cylinder wall is negligible. Determine the total amount of heat transfer, in J. Let g=9.81 m/s^2. (1 bar=100 kPa =10^5 N/m^2) (20%)

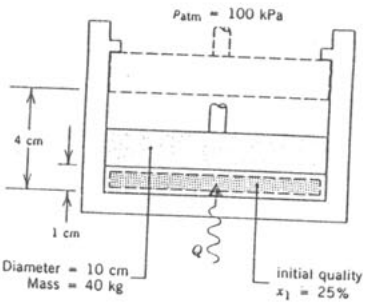

Fig.1

(背面仍有題目,請繼續作答)

5. Consider a closed system containing four ideal gas components, A, B, C, and D, at a given temperature and pressure, subject to a chemical reaction of the form

$$\nu_A A + \nu_B B \Leftrightarrow \nu_C C + \nu_D D$$

where the $\nu's$ are stoichiometric coefficients. The equilibrium constant, K, can be expressed as

$$-\frac{\Delta G^\circ}{\bar{R}T} = \ln K(T)$$

where ΔG° is the change in the Gibbs function for the reactants and products at temperature T and a pressure of 1 atm. (20%)