1. From the first and second laws of thermodynamics, derive the "energy" and "entropy". (10%)

2. (a) Derive the maximum possible work done for a closed system in a polytropic process, Pv^n=constant. (5%)

   (b) For an open system what is the maximum possible work done in a polytropic process, Pv^n=constant? (5%)

3. Explain the first-law efficiency and second-law efficiency. (10%)

4. The state equation Pv=ZRT for a real gas, where Z is the compressibility factor, at what condition Z will be larger than one? Why? (10%)

5. Steam enters a turbine with a pressure of 30 bars, a temperature of 400℃, and a velocity of 160 m/s. Steam exits as saturated vapor at 100℃ with a velocity of 100 m/s. At steady state, the turbine develops work at a rate of 540 kJ per kg of steam flowing through the turbine. Heat transfer between the turbine and its surroundings occurs at an average outer surface temperature of 500 K.

   (a) Determine the rate at which entropy is produced within the turbine per kilogram of steam flowing, in kJ/kg · K. (10%)

   (b) Determine the irreversibility per unit mass of steam flowing through the turbine, in kJ/kg. Neglect the change in potential energy between inlet and exit. Let T_0=25℃, P_0= 1atm. (10%)

   Known: steam at 30 bars and 400℃, h=3230.9 kJ/kg, s=6.9212 kJ/kg · K; at 100℃ and saturated vapor, h=2676.1 kJ/kg, s=7.3549 kJ/kg · K.

6. A control volume operating at steady state has carbon dioxide entering at one location at 25℃, 1 atm and an equilibrium mixture of CO_2, CO, and O_2 exiting at another location at 3200 K, 1 atm. Determine the composition of the exiting equilibrium mixture in kmol of CO_2 entering. Known: At 3200 K, the equilibrium constant, K=0.647. (10%)

（背面仍有題目,請繼續作答）

本試題是否可以使用計算機： ☑可使用 ， □不可使用 （請命題老師勾選）

7. 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. (30%)

(a) Show that the thermal efficiency of the cycle can be expressed as

$$\eta = 1 - \frac{T_C}{T_H} - \frac{T_C I}{T_0 Q_H}$$

where T_0 is the temperature of the availability reference environment and I is the irreversibility for the cycle.

(b) Obtain an expression for the maximum theoretical value for the thermal efficiency.

(c) Derive an expression for the irreversibility for the case in which no net work is developed by the cycle.