※ 考生請注意：本試題 ☑可 ☐不可 使用計算機

1. Show compressed liquid, saturated liquid, saturated liquid vapor mixture, saturated vapor, superheated vapor, and the critical point on T (temperature) – v (volume) diagram for several different pressures for water. (10%)
2. State the first law of thermodynamics for a control mass undergoing a cycle. (3%) What are the concepts of "energy" and "internal energy"? Are they properties? Explain carefully. (8%)
3. What is a heat engine? (3%) State the second law of thermodynamics from the viewpoint of a heat engine. (5%) Prove that the two statements, Kelvin-Plank and Clausius, of the second law are equivalent. (7%)
4. Prove the Inequality of Clausius using reversible and irreversible refrigerators. (9%) Derive and explain the concept of "entropy" carefully. (7%)
5. Derive the pressure and specific volume relation for the ideal gas undergoing an isentropic process with constant specific heat. (8%)
6. Briefly prove the following fact by the second law of thermodynamics (5%) Heat transfer through a finite temperature difference is an irreversible process.
7. (A) Derive thermodynamic relations for a four-process ideal-gas Carnot cycle consisting of cylinder/piston shown in Figure 1 below (ex: $q_H = {}_1q_2 = RT_H \ln\frac{v_2}{v_1}$ for the isothermal expansion process between 1 and 2) (9%). (B) Air in a piston/cylinder setup goes through this above Carnot cycle. The high and low temperatures are 600 K and 300 K respectively. The heat added at the high temperature is 250 kJ/kg, and the lowest pressure in the cycle is 75 kPa. Find the specific volume and pressure after heat rejection and the net work per unit mass. (8%) You may use the result obtained in (A) for (B).
8. Show the temperature-entropy (T-s) diagram for the idealized four-steady-state-process Rankine cycle. Give the expressions or relations for determining the works for the pump and turbine. (6%) Give also the expressions or relations for determining the heat transfers for the boiler and condenser. (6%) Give the cycle thermal efficiency in terms of the areas on the T-s diagram. (6%)

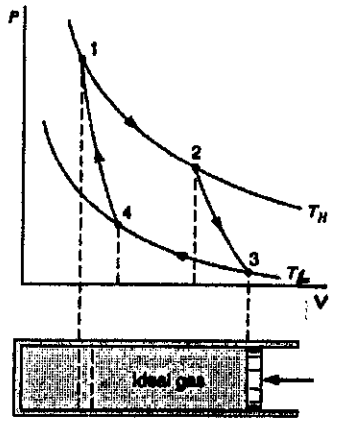

Figure 1