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）

1. (25 %)
   A piston-cylinder device contains air initially at 200 kPa, 25 °C and 0.5 m^3.
   a). Please compare the works required for the *isothermal*, *isentropic* and *polytropic* processes during the compression of air to 0.1 m^3. Please derive the equation relating the work to the properties P, V, and T and show them in a $T - s$ diagram.
   b). Please also determine the amount of heat loss or gain during these processes.
   Note: $C_p = 1.005$ kJ/kg · K

2. (25 %)
   An insulated 3 m^3 rigid tank contains air at 600 kPa and 100 °C. A valve connected to the tank is opened and air is allowed to escape until the pressure inside drops to 250 kPa. The air temperature during this process is maintained constant by an electric heater placed in the tank. With $R_u = 8.314$ kJ/kmol · K, determine
   a). the mass of air escaped from the tank,
   b). the work done by the system,
   c). the electrical work done during this process.

3. (25 %)
   Consider two Carnot heat engines operating in series. The first engine receives heat from the reservoir at 1000 K and rejects waste heat to another reservoir at temperature T. The second engine receives this energy rejected by the first one, converts it to work and rejects the rest to a reservoir at 300 K.
   a). Please determine whether it is possible (or not) to find the temperature T of the intermediate reservoir so that the total work output from both heat engines is equal to the work output from a single Carnot heat engine operating between these two temperatures (1000 and 300 K)?
   b). If yes, please determine the temperature T and explain your results.

（背面仍有題目，請繼續作答）

4. (25 %)
The Clausius statement of the second law of thermodynamics may be given as : "It is impossible for any system to operate in such a way that the sole result would be an energy transfer by heat from a cooler to a hotter body" and the Kelvin-Planck statement of the second law gives "It is impossible for any system to operate in a thermodynamic cycle and deliver a net amount of work to its surroundings while receiving energy by heat transfer from a single thermal reservoir."

a). Please show the equivalence of the above two statements.

The Carnot corollaries states:
Corollary 1: The thermal efficiency of an irreversible power cycle is always less than the thermal efficiency of a reversible power cycle when each operates between the same two thermal reservoirs.
Corollary 2: All reversible power cycles operating between the same two thermal reservoirs have the same thermal efficiency.

b). Please demonstrate graphically and argue the correctness of the above corollaries based on the second law statements.

c). Please briefly describe the Carnot cycle and show that the Carnot cycle is a reversible power cycle in agreement with the above corollaries.