1. Explain the following terms: (7%)

   (a) state postulate, (b) critical temperature, (c) heat engine.

2. For the following processes, consider the total entropy generated in the control mass and in the surroundings. Describe the processes that change the entropy and the sign change of each process. **Explain your answer.** (8%)

   (a) A cake of ice floating in water that is very near the freezing temperature slowly increases in mass until all the water is frozen. (Take the control mass as the ice plus the water.)

   (b) One kilogram of putty is dropped onto a floor tile and sticks without bouncing.

3. Starting with the second Tds relation, show that for an ideal gas undergoing an isentropic process, the temperature and specific volume obeys the following relation, if the specific heats are approximately constant. (10%)

$$T\, v^{k-1} = \text{constant}$$

4. Air exits an adiabatic turbine at a pressure of 1 atm. The inlet condition are $T_1 = 1100\ ^\circ C$ and $P_1 = 5$ atm. The actual work output is 381.8 kJ/kg. Determine the isentropic efficiency of the turbine. *Please define the system or control volume clearly, and list all assumptions used.* (10%)

5. Describe the processes of the ideal Otto cycle and derive the thermal efficiency, which is function of compression ratio. (20%)

6. Determine the Joule-Thomson coefficient (temperature-pressure relation for a fluid) for an ideal gas. (15%)

7. Please make a brief description of the definition, physical significance and dimension of the following items. (18%)
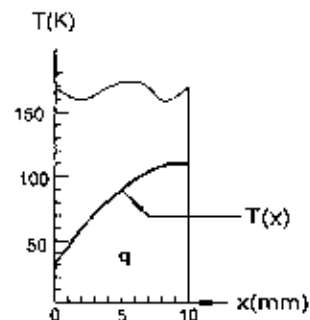
   (a) thermal resistance,　　(b) Biot number,　　(c) fin effectiveness
   (d) heat transfer coefficient,　(e) Nusselt number,　(f) radiative emissivity

   [Example]
   　Reynolds number: $Re_D = \rho u D/\mu$, ratio of inertia force to viscous force, dimensionless.

8. The variation of temperature in a flat plate with heat generation rate q is during a steady state process. The conductivity of that wall is 1.0 W/m K.

   (a) Estimate the heat flux on both sides of the wall. (6%)

   (b) What is the heat generation rate per unit volume of the plate? (6%)