1. State the conditions under which each of the following equation is true : (10 %)
   (a) $\delta q = du + \delta w$
   (b) $\delta q = du + pdv$
   (c) $Tds = du + \delta w$
   (d) $W = -\int vdp - \Delta ke - \Delta pe$
   (e) $\delta Q = dH$

2. Develop an expression for the change in internal energy of a gas which follows the equation of state

   $$P = \frac{RT}{v-b} - \frac{a}{v^2}$$ (20 %)

3. If the inlet state and the exit pressure are specified (P_1, T_1, P_2 and C_p) for a two-stage compressor operating at steady state, show that the minimum total work input is required when the pressure ratio is the same across each stage. Use a cold-air standard analysis assuming that each compression process is isentropic, there is no pressure drop through the intercooler, and the temperature at the inlet to each compressor stage is the same. Kinetic and potential energy effects can be ignored. (20 %)

4. A cylinder/piston contains 100L of air at 110 kPa, 25°C. The air is compressed in a reversible polytropic process to a final state of 800 kPa, 200°C. Assume the heat transfer with the ambient at 25°C and determine the polytropic exponent n and the final volume of the air. Find the work done by the air, the heat transfer and the total entropy generation for the process.
   $R = 0.287$ kJ/kg K and $C_v = 0.717$ kJ/kg K (20 %)

(背面仍有題目,請繼續作答)

5. Thermocouple measurements show that steady-state conduction through a plane wall without heat generation produced a convex temperature distribution such that the midpoint temperature was ΔT_o higher than expected for a linear temperature profile. Assuming that the thermal conductivity has a linear dependence on temperature, $k = k_o(1+\alpha T)$, where α is a constant, develop a relationship to evaluate α in terms of ΔT_o, and the surface temperatures of the plane wall T_1, T_2. (10%)

6. A metal sphere of diameter d, which is at a uniform temperature T_i is suddenly removed from a furnace and suspended from a fine wire in a larger room with air at a uniform temperature T_∞ and the surrounding walls at a temperature T_{surr}. The sphere has a surface emissivity ε. Convection cooling from the sphere to the air is characterized by the heat transfer coefficient h. Derive an equation that could be used to predict the transient temperature of the sphere, under appropriate assumptions. (10%)

7. A furnace is shaped like a long semicylindrical duct of diameter $4m$. The base and the dome of the furnace have emissivities of 0.5 and 0.9, respectively; and are kept at uniform temperature of 350 and 1000 K, respectively. Determine the radiation heat transfer rate from the dome to the base surface per unit length during steady operation of the furnace. (10%)