1. For an ideal gas, prove the following:
   (a) With constant specific heat and undergoing a reversible adiabatic process, the P-v relation will be a special case of a polytropic process in which the polytropic exponent n is equal to the specific heat ratio k. (10%)
   (b) Through a point in T-s diagram, the constant specific volume line has a steeper slope than the constant pressure line. (10%)

2. A certain industrial process requires a steady 0.5 kg/s of air at 200 m/s, at the condition of 150 kPa, 300 K. This air is to be the exhaust from a specially designed turbine whose inlet pressure is 400 kPa and inlet velocity is negligible. The heat transfer comes from a source at a temperature 100°C higher than the turbine inlet temperature. The turbine process may be assumed to be reversible and polytropic, with polytropic exponent $n = 1.20$. Assume air is an ideal gas, with constant specific heat, $C_p = 1.004$ kJ/kg-K, and $R = 0.287$ kJ/kg-K.
   (a) What is the turbine inlet temperature? (5%)
   (b) What are the power output and heat transfer rate for the turbine? (15%)
   (c) Is this design possible? (10%)

背面仍有題目,請繼續作答

3. The Clapeyron relation is a differential equation that can, in principle, be solved to find the slope of the phase boundary curve. To solve it, however, you have to know how both the latent heat (L) for converting the material from one phase to the other and the volume difference between the two phases (ΔV) depend on temperature and pressure. Often, over a reasonably small section of the curve, you can take L to be constant. Moreover, if one of the phases is a gas, you can usually neglect the volume of the condensed phase and just take ΔV to be the volume of the gas, expressed in terms of temperature and pressure using the ideal gas law.

(a) Making all these assumptions, solve the differential equation explicitly to obtain the following formula for the phase boundary curve: $P = (\text{constant}) \times e^{-L/RT}$.

(b) Use the result of part (a) and data available in the following table to determine the sublimation pressure of water vapor at $-60^\circ C$. Besides, the gas constant of water is $R = 0.46152$ kJ/kg-K. (25%)

Properties of saturated water:

$T(^\circ C)$	P (kPa)	h_{ig} (kJ/kg)
0.01	0.6113	2834.7
0	0.6108	2834.8
-20	0.10355	2838.4
-40	0.01286	2838.9

4. A vessel contains $10^{-3} m^3$ of helium gas at 3 K and 10^3 Pa. Take the zero of internal energy of helium to be at this point.

(a) The temperature is raised at constant volume to 300 K. Assuming helium to behave like an ideal monatomic gas, what is the new internal energy of the helium? The universal gas constant is $\overline{R} = 8.3145$ J/mole-K.

(b) Next, the helium is expanded adiabatically to 3 K. How much work is done?

(c) The helium is then compressed isothermally to its original volume. Plot the cycle on a PV diagram. What is the efficiency of the cycle? (25%)