系所別：大氣物理研究所　科目：熱力學

1) Please answer the following questions briefly. (5% each)
   a) What is an ideal gas? Give an equation describing the ideal gas law.
   b) State the zeroth law of thermodynamics.
   c) What is the definition of enthalpy? Express the first law of thermodynamics in terms of enthalpy. Under what kind of condition is the enthalpy conserved?
   d) How is the reversible process defined?
   e) When you compress a container full of gas, what is the difference between an isothermal compression process and an adiabatic compression process?
   f) What is a free expansion process? How much work is done during the process?
   g) What is an isentropic process?
   h) Illustrate a Carnot cycle on a *P-V* diagram and a *T-V* diagram, respectively. On the diagram please indicate the type of thermodynamic process for each stage in the whole cycle.

2) For a system of N molecules of O_2 at a state of high temperature,
   a) list all possible temperature-dependent forms of energy that an O_2 molecule may have,
   b) how many degrees of freedom that an O_2 molecule may have?
   c) what is the total thermal energy of this system? (15%)

3) When two bodies with initially different temperatures T_{1i} and T_{2i} are allowed to interact isobarically with each other but not with their surroundings (i.e., an isolated system of two components). What information about the final temperatures T_{1f} and T_{2f} can you get if only the first law of thermodynamics is applied? (15%)

4) The potential temperature Θ of an air parcel at a height in the atmosphere with pressure p and temperature T is defined as the temperature this air parcel would have if it were brought adiabatically and reversibly to a reference height where the pressure is p_o. From the Poisson's relation, $p^{1-\gamma/\gamma}T = constant$, show that $\Theta = T\left(\frac{p_o}{p}\right)^{R/c_p}$, where $\gamma = c_p/c_v$, R is the gas constant, c_p and c_v are specific heat capacity at constant pressure and constant volume, respectively. (15%)

5) Please answer the following questions concerning the van der Waals equation of state:
   a) In what kind of situation should this equation of state be applied?
   b) What additional factors are accounted for in this equation of state?
   c) Define the critical temperature with van der Waals isotherms on a *P-V* diagram. (15%)