1) Please answer the following questions briefly. (5% each)

   a) What is an ideal gas?

   b) What does the degree of freedom mean? How many degrees of freedom does a monoatomic molecule have?

   c) Describe the process of adiabatic compression and show this process on a P-V diagram.

   d) What is the definition of enthalpy? Instead of energy, what is the advantage of using enthalpy?

   e) Please define the reversible and irreversible processes based on the concepts of entropy change.

   f) State conceptually the second law of thermodynamics.

   g) What is an isentropic process?

   h) What is a heat engine?

2) Taking an example of flipping three fair coins, please list all the possible microstates and macrostates. Please also count the multiplicity for each macrostate. (15%)

3) What is the definition of heat capacity and specific heat capacity, respectively? By the first law of thermodynamics, show that $C_P = C_V + nR$ where C_P is the heat capacity at constant pressure, C_V is the heat capacity at constant volume, n is the number of moles of gas, and R is the gas constant. (15%)

4) Please use a P-V diagram to explain what is a Carnot cycle. On the diagram please indicate the temperature and the type of thermodynamic process for each stage in the whole cycle. Although a Carnot cycle is very efficient, why is it impractical? (15%)

5) Under what kind of situation van der Waals equation is used instead of the equation of state for an ideal gas? In the figure below, the right panel gives an isotherm on a P-V diagram for a van der Waals fluid at temperature $T = 0.9T_c$ while the left panel gives its corresponding curve on a Gibbs free energy vs. pressure diagram (The subscript, c, denotes the critical point.). Please explain why states in the range 2-3-4-5-6 are unstable. (15%)