1. Prove the van-der Waals gas where $\left(\dfrac{\partial U}{\partial V}\right)_T = \dfrac{a}{Vm^2}$ 　　　　(10%)

2. A polymer chain consists of 1000 segments, each 1 nm long. If the chains were ideally flexible, what would be the root-mean squared separation of the ends of the chain? 　　(10%)

3. A gas obeys the van der Waals equation with $P_c = 20$ atm and $T_c = 400$ K. Calculate the value of the van der Waals constants of a and b for this gas. 　　(20%)

4. When 3 mole of water undercooled to -5 °C freezes isothermally, what are the entropy change of the system and surroundings? Give the molar enthalpy of the melting of ice at 0 °C is 6025 J/mol, the molar heat capacities of ice and water are 37.3 and 75.3 J/mol.K, respectively. 　　(20%)

5. On the basis of the following proposed mechanism, calculate the rate law of N_2O_5 for the decomposition $2N_2O_5(g) \rightarrow 4NO_2 + O_2(g)$, where the mechanism was summarized as follows:

   (1) $N_2O_5 \leftrightarrow NO_2 + NO_3$ (forward k_1, reverse k_1')

   (2) $NO_2 + NO_3 \rightarrow NO_2 + O_2 + NO$ (k_2)

   (3) $NO + N_2O_5 \rightarrow 3NO_2$ (k_3) 　　(20%)

6. Calculate the change in Gibbs energy when a spherical droplet of mercury (1 g) disperses into the diameter of 30 nm particles where density of mercury is 13.6×10^3 kg.m^{-3} and the surface tension of mercury is 483×10^{-3} N.m^{-1} 　　(20%)