國立中央大學九十一學年度碩士班研究生入學試題卷

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91 學年度碩士班研究生入學考試　熱力學

1) According to the Equipartition Theorem, at temperature T, the average energy of any quadratic degree of freedom is $\frac{1}{2}kT$ where k is the Boltzmann's constant. For a O_2 molecule at high temperature, give all possible temperature-dependent forms of energy and count the degrees of freedom for each form of energy. If a system containing N molecules of O_2, what is its total thermal energy? (15%)

2) What are the contents of the four (the zeroth, the first, the second, and the third) basic laws of thermodynamics? From the first law of thermodynamics and the ideal gas law, derive the Poisson's relations. And, based on the second law of thermodynamics in terms of entropy, define the reversible and irreversible processes. (30%)

3) What are the differences between an isothermal compression process and an adiabatic compression process? Also, illustrate both processes on a PV diagram. (15%)

4) The entropy (S) of an ideal gas depends on its volume (V), energy (U), and number of particles (N), which can be expressed by a simplified equation as $S = Nk\ln V + Nk\ln U^{3/2} + f(N)$ where $f(N)$ is a function of N. Now consider an ideal gas in a chamber, which occupies only half of the volume initially. A) If the gas expands to the whole volume of the chamber by a quasistatic isothermal expansion process, how much does its entropy change? B) If, instead, by a process of free expansion, how much does its entropy change? C) What are the differences between two processes in A) and B)? (20%)

5) Assuming the thermodynamic process is quasistatic, the work required to compress/expand an ideal gas isothermally from volume V_i to V_f is $NkT\ln\frac{V_i}{V_f}$, however, it is found that $TV^{\gamma-1} = constant$ if the gas is compressed/expanded adiabatically (γ is the ratio of heat capacities). For a Carnot heat engine, if the working substance is an ideal gas, show that the engine's efficiency $e = 1 - \frac{T_c}{T_h}$ where T_c and T_h are temperatures at the cold and hot reservoirs, respectively. (20%)