說明: 1. 答案一律寫在試卷上,計算題必須寫出計算過程,否則不予計分。
2. 請依序作答,並標明題號。
3. $R = 8.314$ J $K^{-1}mol^{-1} = 8.206 \times 10^{-2}$ atm L $K^{-1}mol^{-1}$, $h = 6.626 \times 10^{-34}$ J s

1. Please describe or give definition to the following terms. (12%)
   (a) Bohr radius and Bohr magneton
   (b) Boltzmann distribution and Planck distribution
   (c) Zeeman effect and Raman effect

2. Derive the term symbols for the ground (a) H, (b) He, and (c) B atoms. (12%)

3. For the species (a) O_2, (b) O_2^{2-}, (c) N_2^- and (d) NO^+, give the electron configuration, magnetic property, and bond order for each using the Molecular Orbital theory. (12%)

4. A gas sample consisting of 1.00 mol Ar is expanded isothermally at 0℃ from 22.4 L to 44.8 L (a) reversibly, (b) against a constant external pressure equal to the final pressure of the gas, and (c) freely (against zero external pressure). For the three processes calculate q, w, ΔU, and ΔH. (12%)

5. In the classical mechanics the energies of vibration and rotation can be continuous, but they are quantized in quantum mechanics. Explain them. (10%)

6. What kinds of effects will contribute to the widths of spectroscopic lines in the gas-phase samples? Explain them. (9%)

7. Please illustrate the three principal laws of thermodynamics and also express them by equations. (9%)

8. When a 2.00 mol of a gas at 25℃ and 3.50 atm is subjected to isothermal compression, its entropy decreases by 25.0 J K^{-1}. Calculate (a) the final pressure of the gas and (b) ΔG for the compression. (8%)

9. Liquid methane, $CH_4(l)$, vaporizes reversibly at 1 bar and −161.5℃. Under these conditions, the enthalpy of vaporization is +8.18 kJ mol^{-1}. Calculate the standard entropy of vaporization, $\Delta S_{vap}°$, for the vaporization of exactly 1 mol of $CH_4(l)$. (8%)

10. Draw scale vector diagrams to present the states (a) $s=1/2$, $m_s=+1/2$ and (b) $l=1$, $m_l=+1$. Also calculate the angle between the angular momentum and the z-axis. (8%)