說明： 1. 請儘量依序作答、並標明題號，但不必抄題。
2. $R=8.314\ J\ K^{-1}mol^{-1}$, $h=6.626 \times 10^{-34} J\ s$, $k=1.38 \times 10^{-23} J\ K^{-1}$

1. "The larger the heat liberated by a chemical reaction, the faster the rate of this reaction." Is this statement correct? Why? (4%)

2. Calculate the work done when 0.171 mol of methane expands reversibly and isothermally from 1.55L to 3.55L. The van der Waals constants of methane are $a=2.28\ L^2$ bar mol^{-2} and $b=0.0428\ L\ mol^{-1}$. (6%)

3. Prove that the final temperature (T_2)of *n* moles of an ideal gas that expanded (or compressed) adiabatically and reversibly from a volume V_1 and temperature T_1 to a final volume V_2 is given by $T_2=T_1(V_1/V_2)^{nR/C_v}$ (C_v: heat capacity at constant volume) (6%)

4. Predict the effect of a two-fold increase of pressure on the value of K_y (y: mole fraction) of the ammonia synthesis at equilibrium. ($N_2(g) + 3H_2(g) = 2NH_3(g)$) (6%)

5. Estimate the solubility of $O_2(g)$ in water at 25°C and a partial pressure of 190 torr. (Herry's law constant of $O_2(g)$ is 3.30×10^7 torr) (6%)

6. One mole of an ideal gas at 298K expands freely and isothermally from a pressure of 10 bar to 1 bar. Calculate (a) w, (b) ΔH, (c) ΔS and (d) ΔG (8%)

7. For $O_2(g)$ at 25°C and a pressure of 1 bar, the number of collision Z_{11} is 1.26×10^8 mol L^{-1} s^{-1}. Estimate the collision diameter of O_2 molecules. (8%)

8. For the three parallel reactions $A \xrightarrow{k_1} B$, $A \xrightarrow{k_2} C$, and $A \xrightarrow{k_3} D$, drive the activation energy E_a for the disappearance of A in terms of the activation energies E_1, E_2, and E_3 for these three paths. (8%)

9. The dissociation reaction of ozone $2O_3(g) \rightarrow 3O_2(g)$ follows the rate law $-d[O_3]/dt=k[O_3]^2/[O_2]$. It is observed that oxygen atoms are the intermediate species in this reaction. Suggest the mechanism that leads to the above rate law. (8%)

10. Use diagrams to explain the following terms. (6%)
(a) Franck-Condon principle (b) predissociation

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11. Name the point groups (Schoenfiles) of the following molecules. (6%)
(a) C_6H_6 (b) $C_6H_3Cl_3$ (1,3,5-trichlorobenzene) (c) C_3H_4 ($H_2C=C=CH_2$)

12. Which vibrational level and which rotational level are the maximum populated levels in diatomic molecules with the vibrational frequency ν (in Hz) and with the rotational constant B (in cm^{-1}) in the room temperature? Explain your answers. (6%)

13. The wavefunction for a particle moving only between 0 and a in a one-dimension box is $\Psi = (2/a)^{1/2}\sin(n\pi x)$. Calculate the probability that the particle can be found in the first third (i.e. between x=0 and x=a/3) and middle third (i.e. between x=a/3 and x=2a/3) of the box for n=2? ($\int \sin^2(ax)dx = (x/2) - (1/4a)\sin(2ax)$) (6%)

14. How many spectral lines of the H_α line ($n=3 \rightarrow n=2$) in the atomic hydrogen spectra by (a) a low-resolution spectroscopy and (b) a high-resolution spectroscopy? (6%)

15. Explain in a diatomic system (a) why the vibrational spacing is becoming smaller when increasing the vibrational quantum number v, and (b) why the rotational spacing is becoming larger when increasing the rotational quantum number J? (6%)

16. The pure rotational spectrum of $^1H^{131}I$ consists of a series of lines seperated by 13.10 cm^{-1}. Calculate (a) the moment of inertia, and (b) the internuclear distance. (4%)