淡江大學 99 學年度轉學生招生考試試題

系別：化學工程與材料工程學系三年級　科目：物　理　化　學

本試題共　4　大題，　2　頁

1. One mol of air is compressed from an ideal state of 1 bar and 25°C to a final state of 5 bar and 25°C by three different mechanically reversible processes in a closed system:
   (a) Heating at constant volume followed by cooling at constant pressure.
   (b) Isothermal compression.
   (c) Adiabatic compression followed by cooling at constant volume.
   Assume air to be an ideal gas with the constant heat capacity, $C_V = (5/2)R$ and $C_P = (7/2)R$, in which R is gas constant and $R = 8.314$ J/mol·K. Calculate the work required, heat transferred, and the changes in internal energy and enthalpy of the air for each process. (30 points)

2. An ideal gas with constant heat capacities, C_V and C_P, undergoing a reversible adiabatic process from State 1 of T_1 and P_1 to State 2 of T_2 and P_2. Prove that

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{(\gamma-1)/\gamma}$$

   where $\gamma = C_P/C_V$. (20 points)

3. The decomposition of urea in 0.1 M HCl occurs according to the reaction

$$NH_2CONH_2 + 2H_2O \rightarrow 2NH_4^+ + CO_3^{2-}$$

   The first-order rate constant for this reaction was measured as a function of temperature, with the following results:

Exp. No.	Temperature (°C)	Rate constant k (min^{-1})
1	61.0	7.13×10^{-6}
2	71.2	2.77×10^{-5}

   Calculate the activation energy and derive an expression of the rate constant as function of temperature. (30 points)

4. The eigenvalue solutions of Schrödinger equation can be expressed as

$$E_n = \frac{h^2 n^2}{8ma^2}$$

   Where h is Planck's constant (6.626×10^{-34} J s), n is the quantum number, m is the rest mass of electron (9.11×10^{-31} kg), and a is the dimension of box.
   (a) Calculate the energies of the two states of lowest energy for an electron in a one-dimensional box of

length 2.0 Å . (10 points)

(b) What is the probability that the electron is within 0.5 Å of the center of the box in the lowest energy state? (10 points)

[Hint] The probability of finding the electron in a finite volume of space is obtained by integration over the volume:

$$\int [\psi_n(x,y,z)]^2 \, dv$$

and the wavefunction for a particle in a box is:

$$\psi_n = \sqrt{\frac{2}{a}} \sin \frac{n\pi x}{a}$$