國立清華大學 104 學年度碩士班考試入學試題

系所班組別：生醫工程與環境科學系乙組 (化學組)

考試科目（代碼）：物理化學(2303)

Fundamental constants

$c = 3.0\times10^{8}$ m/s, $e = 1.6\times10^{-19}$ C, $N_A = 6.02\times10^{23}$ mol^{-1}, $R = 0.082$ atm L/(K mol) = 8.314 J/(K mol), $k = 1.38\times10^{-23}$ J/K, $h = 6.626\times10^{-34}$ Js, $m_e = 9.11\times10^{-31}$ kg

1. Describe the major topics of physical chemistry and what you learned in the course. Name the author of physical chemistry textbook you used. (10%)

2. Below is a list of five of the most important scientists. Describe the significance of their contributions to physical chemistry field. (20%)

(1) Robert Boyle (January 25, 1627 – December 31, 1691)

(2) James Prescott Joule (December 24, 1818 – October 11, 1889)

(3) Rudolf Julius Emanuel Clausius (January 2, 1822 – August 24, 1888)

(4) William Thomson 1st Baron Kelvin (June 26, 1824 – December 17, 1907)

(5) Johannes Diderik van der Waals (November 23, 1837 – March 8, 1923)

3. The composition of the atmosphere is approximately 80% N_2 and 20% O_2 by volume. At what height above the surface of the Earth would the atmosphere become 90% N_2 and 10% O_2 by volume? Assume that the temperature of the atmosphere is constant at 25 °C. What is the pressure of the atmosphere at that height? (10%)

4. An ideal gas of 5.0 mol CO_2 is originally confined in 15 L at 300 K. Assume it undergoes isothermal expansion against a constant pressure of 1.0 atm until equilibrium is reached. Assume the heat capacity of CO_2 at constant pressure, $C_{p,m}$, is 37.11 J/mol K. Calculate the final volume, q, w, ΔU, and ΔH for the process. (15%)

5. Calculate the minimum work needed to freeze 250 g of water originally at 0°C standing in a room at 20°C. What would be the minimum time required in a refrigerator operating ideally at 100W? The molar heat of fusion of water is 6.01 kJ/mol. (15%)

6. You have collected a tissue specimen that you would like to preserve by freeze drying. To ensure the integrity of the specimen, the temperature should not exceed -5.0 °C. The vapor pressure of ice at 273.16 K is 624 Pa. What is the maximum pressure at which the freeze drying can be carried out? The molar enthalpy changes of fusion of ice and vaporization of water are 6.01 and 40.66 kJ/mol, respectively. (10%)

7. Consider the equilibrium $N_2O_4(g) \leftrightarrows 2NO_2(g)$, which can be easily studied in the laboratory through a measurement of the vapor density of the equilibrium mixture.

(a) Derive the equilibrium constant with the degree of dissociation, α, of dinitrogen tetroxide and the pressure.

(b) The measured density of an equilibrium mixture of N_2O_4 and NO_2 at 15 °C and 1.013 bar is 3.62 g/L, and the density at 75 °C and 1.013 bar is 1.84 g/L. What is the enthalpy change of the reaction $N_2O_4(g) \leftrightarrows 2NO_2(g)$? (20%)