系所班組別：生醫工程與環境科學系乙組 (環境與分子科學組)

考試科目（代碼）：物理化學 (2402)

Fundamental constants

$c = 3.0 \times 10^8$ m/s, $e = 1.6 \times 10^{-19}$ C, $N_A = 6.02 \times 10^{23}$ mol^{-1}, $R = 0.082$ atm L/(K mol) = 8.314 J/(K mol), $k = 1.38 \times 10^{-23}$ J/K, $h = 6.626 \times 10^{-34}$ Js, $m_e = 9.11 \times 10^{-31}$ kg

1. Below is a list of five of the most important scientists. Describe the significance of their contributions to physical chemistry field. Please mention it if he(she) won a Nobel Prize. (20%)

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

(2) Jacobus Henricus van't Hoff (August 30, 1852 – March 1, 1911)

(3) Svante August Arrhenius (February 19, 1859 – October 2, 1927)

(4) Gilbert Newton Lewis (October 23, 1875 – March 23, 1946)

(5) Peter Joseph William Debye (March 24, 1884 – November 2, 1966)

2. Find the change in Gibbs energy if 1.0 mol of liquid water is pressurized at 0.0 °C from 1.0 atm to 10.0 atm. State any assumptions. (20%)

3. Consider an ideal refrigerator operating between 0°C and 25°C.　The refrigerator is to produce 1.0 g of ice each second from water at 0°C.　How much work must be done per second?　The molar heat of fusion of water is 6.0095 kJ/mol. (20%)

4. Suppose that the enzyme E and substrate S combine to form a complex ES, which then dissociates into product P and free enzyme E.　The product rate follows Michaelis-Menten form:

$$v = \frac{dp}{dt} = \frac{V_{\max}[S]}{K_m + [S]}$$

In competitive inhibition, the inhibitor I binds only to the active site of the enzyme and thereby inhibits the attachment of the substrate S.

(a) Give a schematic representation of the model for the competitive inhibition.

(b) If the dissociation constant of EI is K_I, please derive a rate expression for P formation with $V_{\max}$, [S], K_m, [I], and K_I, by assuming quasi-steady state for [ES] and for [EI].　Draw a plot with 1/v against 1/[S] by varying [I]. (20%)

5. Answer the following questions, using the accompanying figure. (20%)

a. A liquid mixture consists of 33 g of component A and 99 g of component B. At what temperature would the mixture begin to boil?

b. Under the conditions in (a), what is the composition of the vapor when boiling first occurs?

c. If the distillation is continued until the boiling point is raised by 2 °C, what would be the composition of the liquid left in the still?

d. If fractional distillation is used in the experiment and the efficiency of the fractionating column is 100%, under the conditions in (c), what are the composition and mass of the two components collected over the initial 2 °C interval?