國立臺灣科技大學 111 學年度碩士班招生試題

系所組別：材料科學與工程系碩士班甲組

科　　目：物理化學

(總分為 100 分；所有試題務必於答案卷內頁依序作答，否則不予計分)

物理化學研究所考題

1. (40 points) multiple choice question: ($R = 8.3145\ J\ K^{-1}mol^{-1}$)

(1) Calculate the expansion work done on the system when exactly 1 mol of solid ammonium chloride, NH_4Cl, decomposes completely to yield gaseous ammonia, NH_3 and hydrogen chloride, HCl at a temperature of 1250 K. Treat the expansion as irreversible and the gases formed as perfect. (4 points)

a. –15.4 kJ　　b. –4.96 kJ　　c. –16.6 kJ　　d. –20.8 kJ

(2) The molar heat capacity of solid aluminium is 24.4 $J\ K^{-1}\ mol^{-1}$ at 25°C. Calculate the change in internal energy when 1.00 mol of solid aluminium is heated from a temperature of 20 °C to 30 °C. (4 points)

a. 244 J　　b. 24.4 J　　c. 171 J　　d. 327 J

(3) Calculate the heat transferred to the system when 1.00 mol of a perfect gas expands reversibly at a constant temperature of 25 °C so that its volume doubles. (4 points)

a. –144 J　　b. –746 J　　c. –1.72 kJ　　d. 2.48 kJ

(4) The standard enthalpy of formation of benzoic acid, C_6H_5COOH, is –385 $kJ\ mol^{-1}$ at 298 K. Calculate the standard enthalpy of combustion of benzoic acid at this temperature, given that the standard enthalpy of formation of liquid water, H_2O is –285.8 $kJ\ mol^{-1}$ and gaseous carbon dioxide, CO_2, is –393.51 $kJ\ mol^{-1}$. (4 points)

a. –294.3　　b. –3997　　c. –3227.0　　d. 2282.2　($kJ\ mol^{-1}$)

(5) Calculate the change in the molar entropy of a perfect gas when it is compressed isothermally to 10 % of its initial volume. (4 points)

a. –19.1　　b. –16.6　　c. +0.813　　d. –8.31　($J\ K^{-1}\ mol^{-1}$)

(6) Use the following data to calculate the standard reaction entropy at 298 K for the thermal decomposition of ammonium chloride, $NH_4Cl(s) \rightarrow NH_3(g) + HCl(g)$. $Sm°_{NH4Cl(s)}/Jmol^{-1} = 94.85$; $Sm°_{NH3(g)}/Jmol^{-1} = 192.77$; $Sm°_{HCl(g)}/Jmol^{-1} = 186.90$. (4 points)

a. +474.52　　b. +284.82　　c. –100.72　　d. +88.98　($J\ K^{-1}\ mol^{-1}$)

(7) The molar entropy of 1,3-dioxane, $C_4H_8O_2$, is 196.6 J K–1 mol–1. What is the change in the molar Gibbs energy of 1,3-dioxane when it is heated from 298 K to 348 K? (4 points)

a. –3.93　　b. –9.83　　c. –196.6　　d. –63.5　($kJ\ mol^{-1}$)

(8) For the equilibrium $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$, how many phases are present? (4 points)

a. 1　　b. 2　　c. 3　　d. 4

(9) Calculate the change in the chemical potential of a perfect gas when its partial pressure doubles at a temperature of 200°C. (4 points)

a. +2.73　　b. +1.15　　c. +0.50　　d. +0.30　($kJ\ mol^{-1}$)

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(10) The critical point of ammonia, NH_3, occurs at a pressure of 11.3 MPa, temperature of 406 K and molar volume of 72.5 cm^3 mol^{-1}. Determine the compression factor of ammonia at the critical point. (4 points)

a. 0.243　　b. 1　　c. 4.12　　d. 0.741

2. (10 points) When 15.0 cm^3 of benzene, C_6H_6, is added to 125 cm^3 of water, H_2O, at 20°C, the final volume of the liquid mixture is 137 cm^3. Calculate the partial molar volume of benzene in dilute aqueous solutions given that the density of benzene and of water are 0.879 g cm^{-3} and 0.998 g cm^{-3} respectively, and the partial molar volume of water is 17.8 cm^3 mol^{-1} at this temperature.

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3. (20 points) The equation for the hydrogenation of ethylene may be written as:

$$C_2H_4(g) + H_2(g) \rightleftarrows C_2H_6(g)$$

(1) Calculate the heat of hydrogenation using free energies of formation. (10 points)

(2) Determine the equilibrium constant at 200 °C. (10 points)

The following information are given: Gibbs energies of formation at 298 K ($\Delta G_f°$) of $C_2H_4(g)$ and $C_2H_6(g)$ are 16.282 kcal mol^{-1} and −7.860 kcal mol^{-1}, respectively. The enthalpy of formation at 298 K ($\Delta H°$) for the combustion of $C_2H_4(g)$, $H_2(g)$ and $C_2H_6(g)$ are −337.23 kcal, −68.317 kcal and −372.82 kcal, respectively.

4. (15 points) The melting point of monoclinic sulfur at a pressure of 1 atm is 119.3 °C. The change in volume during fusion is 41 $cm^3\ kg^{-1}$ and enthalpy of fusion is 422 cal mol^{-1}. Find the melting point of sulfur when the pressure is raised to 1000 atm.

5. (15 points) Define the following terms:

(1) Entropy (5 points)

(2) Raoult's law (5 points)

(3) Activity coefficient (5 points)