國立臺灣科技大學
113學年度碩士班招生
試題

系所組別：0410材料科學與工程系碩士班甲組

科　　目：物理化學

<<504101>>

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(總分為100分；所有試題務必於答案卷內頁依序作答)

1. (40 %) multiple choice question: ($R = 8.314\ J\ K^{-1}mol^{-1}$)

(1) (4 %) In the calibration step of a thermochemistry experiment, a current of 117 mA, from a 24.0 V source was allowed to flow through the electrical heater for 247 s and was found to result in an increase in the temperature of the calorimeter and its contents of +1.25 K. Calculate the heat capacity of the calorimeter and its contents.

a. 694 $J\ K^{-1}$　　b. 277 $J\ K^{-1}$　　c. 555 $J\ K^{-1}$　　d. 867327 $J\ K^{-1}$

(2) (4 %) Use the following data to determine the standard enthalpy change for the reaction

$$K(g) + \tfrac{1}{2}Cl_2(g) \rightarrow K^+(g) + \tfrac{1}{2}Cl^-(g)$$

at a temperature of 298.15 K. The values refer to standard enthalpy changes at this temperature.

Ionization enthalpy of potassium $\Delta_{ion}H° = +418\ kJ\ mol^{-1}$

Enthalpy of formation of atomic chlorine $\Delta_fH° = +121\ kJ\ mol^{-1}$

Electron gain enthalpy of atomic chlorine $\Delta_{eg}H° = -349\ kJ\ mol^{-1}$

a. +190 $kJ\ mol^{-1}$　　b. +888 $kJ\ mol^{-1}$　　c. − 52 $kJ\ mol^{-1}$　　d. +646 $kJ\ mol^{-1}$

(3) (4 %) Calculate the standard molar entropy of vaporization of phosphorus trichloride, PCl_3, at its boiling temperature, 74°C, given that the standard molar enthalpy of vaporization of phosphorus trichloride is 30.5 $kJ\ mol^{-1}$.

a. +2.43 $J\ K^{-1}\ mol^{-1}$　　b. +109 $J\ K^{-1}\ mol^{-1}$　　c. +412 $J\ K^{-1}\ mol^{-1}$　　d. +87.9 $J\ K^{-1}\ mol^{-1}$

(4) (4 %) Calculate the change in the molar Gibbs energy of a perfect gas when it is compressed isothermally at a temperature of 25°C from a molar volume of 10.00 dm^3 to a molar volume of 1.00 dm^3. (ln10 = 2.3)

a. +479 $J\ mol^{-1}$　　b. +5.71 $kJ\ mol^{-1}$　　c. +2.48 $kJ\ mol^{-1}$　　d. +208 $J\ mol^{-1}$

(5) (4 %) Estimate the change in the normal boiling temperature of an aqueous solution made by dissolving 12.6 g of phenol, C_6H_5OH, in 250 cm^3 of water. The ebullioscopic constant of water is 0.51 $K\ kg\ mol^{-1}$.

a. +0.27 K　　b. +0.068 K　　c. –1.6 K　　d. –0.65 K

(6) (4 %) Calculate the standard reaction Gibbs energy for the reaction

$$2\ N_2O_5(g) \rightleftharpoons 4\ NO_2(g) + O_2(g)$$

at a temperature of 298 K. The standard Gibbs energies of formation of the components at this temperature are given in the table below.

	$\Delta_fG°$ (298 K) / $kJ\ mol^{-1}$
N_2O_5	+118.0
NO_2	+51.8
O_2	0

a. –66.2 $kJ\ mol^{-1}$　　b. –89.2 $kJ\ mol^{-1}$　　c. –28.8 $kJ\ mol^{-1}$　　d. –169.8 $kJ\ mol^{-1}$

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(7) (4 %) The pKb of the base cyclohexamine, $C_6H_{11}NH_2$, is 3.36. What is the pKa of the conjugate acid, $C_6H_{11}NH_3^+$?

a. 3.36　　b. 7.64　　c. 10.64　　d. 14.00

(8) (4%) The perfect gas model assumes that the average separation between the atoms or molecules is so great that they move independently of one another. Use the perfect gas equation to calculate the average volume per atom or molecule for a gas at a temperature of 298 K and a pressure of 1.00 bar.

a. 41.1 μm^3　　b. 41.1 $Å^3$　　c. 41.1 mm^3　　d. 41.1 nm^3

(9) (4 %) The rate constant for the reaction

$$2\,N_2O_5(g) \rightleftharpoons 4\,NO_2(g) + O_2(g)$$

is reported in units of s^{-1}. What is the overall order of the reaction?

a. Zeroth order　　b. First order　　c. Second order　　d. Third order

(10) (4 %) For a solution-phase dimerization reaction, the rate constants for the second-order forward reaction is 2×10^7 dm^3 mol^{-1} s^{-1} and for the first-order backward reaction is 4×10^5 s^{-1}. Determine the equilibrium constant.

a. 1×10^{-4}　　b. 0.2×10^{-2}　　c. 50　　d. 1×10^9

2. (10 %) Assume that the equation of state for a gas can be written in the form $P(V_m\text{-}b(T)) = RT$. Derive an expression for $\beta = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_P$ and $\kappa = -\frac{1}{V}\left(\frac{\partial V}{\partial P}\right)_T$ for such a gas in terms of $b(T)$, $db(T)/dT$, P, and V_m. Show that $T\beta = 1 + T\left(\frac{\partial \ln z}{\partial T}\right)_P$ and $P\kappa = 1 - P\left(\frac{\partial \ln z}{\partial P}\right)_T$

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3. (15 %) A solution is prepared by dissolving 1.23 g of C_{60} (buckminsterfullerene) in 100.0 g of toluene (methylbenzene). Given that the vapor pressure of pure toluene is 5.00 kPa at 30 °C, what is the vapor pressure of toluene over the solution?

4. (20%) The concentration of fructose 6-phosphate (F6P) and fructose 1,6-biphosphate (F16bP), ATP, and ADP in muscle tissue are measured as 0.089, 0.012, 12.0, and 1.2 mmol/L, respectively. For the reaction F6P(aq) + ATP(aq) → F16bP(aq) + ADP(aq) at 37 °C, the standard Gibbs energy (at pH=7) is –18.3 kJ/mol.
   (1) (15 %)Please calculate the reaction quotient and the reaction Gibbs energy for the reaction in the muscle tissue environment.
   (2) (5 %)Is the reaction spontaneous? Why?

5. (15 %) Potassium has a standard boiling point of 773 °C and a molar enthalpy of vaporization $\Delta_{vap}H = 84.9$ kJ/mol. Estimate the saturation vapor pressure of liquid potassium at 400 °C.