國立臺灣科技大學 112 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 %) multiple choice question: ($R = 8.3145\ J\ K^{-1}mol^{-1}$)

(1) (4 %) When phosphorus pentachloride, PCl_5, is heated at a constant pressure of exactly 1 bar to a temperature of 1400 K, the amount of phosphorus pentachloride decreases by 20.7% because of dissociation to phosphorus trichloride, PCl_3, and chlorine, Cl_2. $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$. Determine the equilibrium constant at this temperature.

a. 42.8×10^{-3}　　b. 87.7　　c. 0.207　　d. 0.045

(2) (4 %) The constant pressure molar heat capacity of nitrogen gas, N_2, is 29.125 J K^{-1} mol^{-1} at 298.15 K. Calculate the change in the internal energy when 2.00 mol of nitrogen gas is heated so that its temperature increases by 25.0°C. You may assume that the value of the heat capacity does not vary with temperature.

a. 1.04 kJ　　b. 1.46 kJ　　c. 1.87 kJ　　d. 520 J

(3) (4 %) A sample of liquid butan-1-ol, C_4H_7OH was brought to the boil in an open calorimeter. An electric current of 289 mA from a 12.0 V source was then passed through a resistive heater coil which was immersed in the liquid. The current was allowed to flow for a period of 245 s, during which time the temperature remained constant and 1.416 g of butan-1-ol was found to have evaporated. Calculate the molar enthalpy of vaporization of butan-1-ol.

a. 86.8 kJ mol^{-1}　　b. 850 J mol^{-1}　　c. 16.7 kJ mol^{-1}　　d. 43.3 kJ mol^{-1}

(4) (4 %) The mean bond enthalpy of a P–Cl bond is 331 kJ mol^{-1} and of a Cl–Cl bond is 242 kJ mol^{-1} at 298 K. If the mean standard enthalpy of atomization of white phosphorus is 315 kJ mol^{-1}, estimate the standard enthalpy of formation of gaseous phosphorus trichloride, PCl_3, at this temperature.

a. –315 kJ mol^{-1}　　b. +226 kJ mol^{-1}　　c. +1671 kJ mol^{-1}　　d. –1041 kJ mol^{-1}

(5) (4 %) Calculate the change in the standard molar entropy of sulfur trioxide gas, SO_3, when it is cooled from a temperature of 100°C to 10°C at a constant pressure of 1 bar. The standard molar constant-pressure heat capacity of sulfur trioxide is 50.1 J K^{-1} mol^{-1}.

a. +7.81 J K^{-1} mol^{-1}　　b. –13.8 J K^{-1} mol^{-1}　　c. –115 J K^{-1} mol^{-1}　　d. –6.01 J K^{-1} mol^{-1}

(6) (4 %) For hydrogen sulfide, H_2S, the standard enthalpy of formation is –20.2 kJ mol^{-1} and the standard entropy of formation is +43.0 J mol^{-1} at 298 K. Calculate the standard Gibbs energy of formation at this temperature.

a. –33.0 kJ mol^{-1}　　b. +12.8 kJ mol^{-1}　　c. –20.5 kJ mol^{-1}　　d. –7.4 kJ mol^{-1}

(7) (4 %) The density of liquid carbon disulfide, CS_2, is 1293 kg m^{-3}. Calculate the change in the molar Gibbs energy of carbon disulfide when it is compressed by a change in pressure from 1.00 bar to 2.00 bar.

a. +17.0 kJ mol^{-1}　　b. +77.3 J mol^{-1}　　c. +5.89 J mol^{-1}　　d. +76.1 J mol^{-1}

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(8) (4 %) The molar Gibbs energy of tribromomethane, $CHBr_3$, decreases by 4.44 kJ mol^{-1} when the temperature is increased from 288 to 308 K. Determine the molar entropy of tribromomethane.

a. –222 J K^{-1} mol^{-1}　b. 222 J K^{-1} mol^{-1}　c. 0.222 J K^{-1} mol^{-1}　d. 22.2 J K^{-1} mol^{-1}

(9) (4 %) An ideal solution is prepared by mixing 15.6 g of toluene, $C_6H_5CH_3$, and 136.2 g of butan-1-ol, C_4H_9OH at 25°C. The vapor pressure of pure butan-1-ol is 885 Pa at this temperature. Calculate the partial pressure of butan-1-ol in the vapor above the mixture.

a. 885 Pa　b. 811 Pa　c. 74.6 Pa　d. 90.9 Pa

(10) (4 %) Determine the molar Gibbs energy of mixing for the formation of an equimolar mixture of two perfect gases at a temperature of 298 K.

a. –0.745 kJ mol^{-1}　b. –0.372 kJ mol^{-1}　c. 0 kJ mol^{-1}　d. –1.72 kJ mol^{-1}

2. (10 %) At a temperature of 214 K, carbon disulfide, CS_2, and acetone, CH_3COCH_3, are not fully miscible and, instead, form separate liquid phases with mole fractions of carbon disulfide of 0.403 and 0.833. Use the lever rule to calculate the relative amounts of the two phases when 10.0 g of carbon disulfide and 10.0 g of acetone are mixed together at this temperature.

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3. (15%) Please determine the heat of vaporization of acetonitrile with a normal boiling point of 80 °C, given that acetonitrile has a vapor pressure which is changing at the rate of 0.030 atm/deg K around the boiling point.

4. (20 %) The rate of a first order reaction increases from $r = 1.5 \times 10^{-2}$ sec^{-1} to $r_c =$ 4.6 sec^{-1} at 260 °C when a catalyst is added to the reaction. Calculate the decrease in the activation enthalpy. Assuming the activation entropy is not affected by the catalyst.

5. (7 %) Explain why colloids are translucent and are able to scatter light, but solutions are transparent.

6. (8 %) In the following series of compounds, including ZnS, SrO, and $CdBr_2$, which metal would you expect to have the highest actual positive charge? Explain.