International Master's Programs of Chemical Engineering in the Graduate School of Engineering, Kyushu University (Academic Year from October, 2026)

Subject： Chemical Thermodynamics（1 sheet）

1. (25 points)
Answer the following questions. The gas constant is $R = 8.314\ \mathrm{J\ K^{-1}\ mol^{-1}}$.

(1.1) A 5.00 mol sample of a perfect gas is taken as the system. The gas has a molar heat capacity at constant pressure $C_{p,\mathrm{m}} = \frac{5}{2}R$ and is initially at 240 kPa and 325 K. It undergoes a reversible adiabatic expansion until its pressure reaches 150 kPa. For this expansion, calculate the final volume, the final temperature, the change in internal energy ΔU, and the work w done on the gas.

(1.2) Calculate the amount of heat released by the complete combustion of 10.0 $\mathrm{dm^3}$ of octane at 298 K and 1.00 bar. The density of octane is 0.703 $\mathrm{g\ cm^{-3}}$, and its standard enthalpy of combustion is given by $-5471\ \mathrm{kJ\ mol^{-1}}$.

2. (25 points)
Answer the following questions. The gas constant is $R = 8.314\ \mathrm{J\ K^{-1}\ mol^{-1}}$.

(2.1) The vapor pressures of a pure substance A, whose melting point is 70 ℃, were 1.5 kPa at 80 ℃ and 6.0 kPa at 120 ℃. Determine the enthalpy of vaporization of substance A.

(2.2) Determine the ideal solubility of a pure substance B in a pure solvent C at 25 ℃. The molar mass, enthalpy of fusion, and melting point of substance B are $180\ \mathrm{g\ mol^{-1}}$, $30\ \mathrm{kJ\ mol^{-1}}$, and 220 ℃, respectively. The molar mass of substance C is $80\ \mathrm{g\ mol^{-1}}$.

(2.3) For a certain chemical reaction, the standard Gibbs energy of reaction at 1200 K is $40\ \mathrm{kJ\ mol^{-1}}$. Determine the equilibrium constant of this reaction at 1200 K. Furthermore, determine the temperature at which the equilibrium constant exceeds 1. The standard reaction enthalpy of the reaction is $250\ \mathrm{kJ\ mol^{-1}}$.