This examination paper contains SEVEN questions and comprises TWO printed pages.

Question 1: (25%)

Liquid water can be superheated to 105°C at 1.01325 bar. Calculate the values of w, q, ΔU, ΔH, ΔS, ΔA, and ΔG for the process of superheated water at 105°C and 1.01325 bar changing to steam at the same temperature and pressure. Is this process spontaneous? The enthalpy of vaporization is 40.58 kJ mol^{-1} at 100°C and 1.01325 bar.

Given with $C_P(H_2O, l) = 75.3$ J K^{-1} mol^{-1}, and $C_P(H_2O, g) = 33.6$ J K^{-1} mol^{-1}.

Question 2: (12%)

Two perfectly insulated tanks each having a volume of 1 m^3 are connected by means of a small pipeline containing a valve. Initially, one tank contains an ideal gas at 2 bar and 290 K, and the other is completely evacuated. The valve is opened, and the pressures and the temperatures are allowed to equalize.

(a) What is the final temperature and pressure in the tanks? **[5%]**

(b) What is the entropy change of the gas? [7%] You need to find the mole number of the gas in the system.

Given with R = 8.314 J/(mol K) = 83.14 (bar cm^3)/(mol K) = 8.314×10^{-5} (bar m^3)/(mol K)]

Question 3: (13%)

Steam enters a turbine with a pressure of 30 bars, a temperature of 400°C (H_1 = 3231 kJ/kg, S_1 = 6.921 kJ/kg·K) and a velocity of 160 m/s. Saturated vapor at 100°C (H_2 = 2676 kJ/kg, S_2 = 7.355 kJ/kg·K) exits with a velocity of 100 m/s. At steady state, the turbine develops work equal to 540 kJ per kg of steam flowing through the turbine. Heat transfer between the turbine and its surroundings occurs at an average outer surface temperature of 500 K. Determine the rate at which entropy is produced within the turbine per kg of steam flowing, in kJ/kg·K. Neglect the change in potential energy. [**13%**]

[Unit conversion: 1 m^2/s^2 = 10^{-3} kJ/kg.]

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（背面仍有題目,請繼續作答）

Question 4: (10%)

Let M denote a thermodynamic molar property as a function of temperature T, pressure P, and mole fraction of constituent x_i, which is often expressed as the mass n_i for species i to the overall masses of all constituents. Please derive its general Gibbs-Duhem equation, in which T and P may vary. **(10%)**

Question 5: (15%)

A binary system of species *1* and *2* consists of vapor and liquid phases in equilibrium at temperature T, for which

(1) $\ln \gamma_1 = 1.8\, x_2^2$ and $\ln \gamma_2 = 1.8\, x_1^2$, and (2) $P_1^{sat} = 1.24$ **bar** and $P_2^{sat} = 0.89$ **bar**,

where γ_i, x_i, and P_i^{sat} denote the activity coefficient and the liquid-phase mole fraction of species i, and vapor pressure of pure species i at the temperature of the system , respectively. If Raoult's law modified with introduction of activity coefficient is valid to describe the vapor-liquid equilibrium, please answer the following questions with your detailed calculations:

(a) For what range of values of the overall mole fraction z_1 of species *1* can this two-phase system exist with a liquid mole fraction $x_1 = 0.65$? **(8%)**

(b) What are the pressure and composition of the azeotrope at this temperature T? **(7%)**

Question 6: (10%)

Please write down (a) the excess Gibbs energy expression **(3%)**; (b) the Lewis-Randall rule and the condition valid for the rule **(2+2=4%)**; and (c) the residual Gibbs energy expression in terms of fugacity and others **(3%)**.

Question 7: (15%)

If C_P^E is a constant, independent of T, find expression for G^E, S^E, and H^E as functions of T. (9%) From the equations developed previously, find values for G^E, S^E, and H^E **(6%)**.

For an equi-molar solution of benzene(1)/n-hexane(2) at 323.15 K, given the following excess property values for an equi-molar solution at 298.15 K:

$C_P^E = -2.86$ J·mol^{-1}K^{-1}; $H^E = 897.9$ J·mol^{-1}, and $G^E = 384.5$ J·mol^{-1}.

(End of Examination Paper)