CHEMICAL ENGINEERING

SOLUTION THERMODYNAMICS

1. Which of the following is true regarding the summability relations?
   a. Partial properties of an ideal solution are independent of one another.
   b. Mixture properties of an ideal solution cannot be calculated from partial properties.
   c. Partial properties of a real mixture are independent of one another.
   d. Mixture properties of a real mixture cannot be calculated from partial properties.

2. Which of the following estimation methods is best applicable to calculate the fugacity coefficient of a saturated polar gas?
   a. Redlich-Kwong equation
   b. virial equation
   c. ideal gas equation
   d. Lee-Kesler equation

3. Which of the following methods is best applicable to calculate the activity coefficient of a nonpolar liquid in a ternary, immiscible solution?
   a. Wilson equation
   b. Margules equation
   c. NRTL equation
   d. van Laar equation

4. Which of the following is false regarding the gamma-phi approach for VLE?
   a. The Poynting factor is negligible at low pressure.
   b. The gammi-phi approach is simplified to Raoult's law for ideal gas and ideal solution.
   c. Modified Raoult's law can be derived from the gamma-phi approach for an ideal gas and real solution.
   d. Lewis-Randall rule transforms the gamma-phi approach into mvodified Raoult's law.

5. An excess property is
   a. the difference in property value of a real gas and an ideal gas at the same conditions
   b. the difference in property value of a real solution and an ideal solution at the same conditions
   c. the difference in property value of an ideal gas and an ideal solution
   d. the difference in property value of a real pure species and an ideal pure species

6. In a binary solution, what happens to the other species (B) if a species (A) approaches Henry's law?
   a. The other species' (B) fugacity coefficient equates to Henry's constant.
   b. Lewis-Randall rule becomes valid for the other species (B).
   c. Gibbs-Duhem equation is invalid for both species (A and B).
   d. The other species' (B) activity coefficient equates to Henry's constant.

7. Which of the following is false regarding fugacity?
   a. Fugacity replaces chemical potential as an equilibrium criterion.
   b. The fugacities of a species in all phases are equal at the same conditions.
   c. The fugacity of an ideal gas in a mixture is equal to total pressure.
   d. Fugacity has the same unit as pressure.

8. Why does Gibbs energy serve as a generating function?
   a. It can generate energy needed for chemical reactions and mass transfer.
   b. It gives means to derive other thermodynamic relations.
   c. It provides calculation of all other thermodynamic properties.
   d. It can extrapolate values of other state functions.

9. Determine the number of degrees of freedom of partially decomposing $CaCO_3$ to CaO and CO_2 into an evacuated space.
   a. 1   c. -1
   b. 0   d. 2

10. The enthalpy of a binary liquid system of species 1 and 2 at fixed T and P is represented by the equation: $H = 400x_1 + 600x_2 + x_1x_2(40x_1 + 20x_2)$ in J/mol. Determine the partial enthalpies at infinite dilution $\hat{H}_1^\infty$ and $\hat{H}_2^\infty$ in J/mol.
    a. 640 & 420   c. 240 & 460
    b. 420 & 640   d. 460 & 240

11. Determine the fugacity coefficients for nitrogen (1) and methane (2) in a binary mixture at 200 K and 30 bar if the mixture contains 40 mol-% N_2. Experimental virial-coefficient data in cm^3/mol are $B_{11} = -35.2$, $B_{22} = -105.0$, and $B_{12} = -59.8$.
    a. 0.425 & 0.167   c. 0.238 & 0.591
    b. 0.823 & 0.159   d. 0.951 & 0.832

12. The thermodynamic properties of n-butane gas at 500 K and 50 bar is given by the Redlich/Kwong equation. Determine its residual entropy in J/mol·K.
    a. -6.5   c. 6.5
    b. 5.6   d. -5.6

13. The hydrogenation of benzene to produce cyclohexane: $C_6H_6 + 3 H_2 = C_6H_{12}$ is carried out over a catalyst at 600 K and 15 bar. The feed contains 3 mol H_2 for each 1 mol C_6H_6. Determine the conversion of benzene to cyclohexane with K = 0.02874.
    a. 0.473   c. 0.815
    b. 0.374   d. 0.743

14-15. A feed stock of pure n-butane is cracked at 750 K and 1.2 bar to produce olefins. Only two reactions have favorable equilibrium conversions at these conditions: (I) $C_4H_{10} = C_2H_4 + C_2H_6$; (II) $C_4H_{10} = C_3H_6 + CH_4$. The of K_I and K_{II} are 3.856 and 268.4, respectively.

14. Assume a basis of 1 mol of n-butane feed. What are the values of the reaction coordinates in mol?
    a. 0.107 & 0.891   c. 0.170 & 0.819
    b. 0.223 & 0.469   d. 0.322 & 0.496

15. What is the mole fraction of methane at equilibrium?
    a. 0.446   c. 0.001
    b. 0.053   d. 0.728