

CHEM ENG 3D3

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DURATION OF EXAMINATION: 2 Hours

Dr. Shiping Zhu

McMaster University Midterm Examination

Thursday Oct 27 2005, 7:30-9:30 pm

THIS EXAMINATION PAPER INCLUDES 1 PAGE AND 4 QUESTIONS. YOU ARE RESPONSIBLE FOR ENSURING THAT YOUR COPY OF THE PAPER IS COMPLETE. BRING ANY DISCREPANCY TO ATTENTION OF INVIGILATOR.

Instruction: You may use any calculators (no laptop and desktop), course notes and text books. 25 marks for each question.

- 1 The solution of acetonitrile(1) and nitromethane(2) conforms closely to Raoult's law. The vapor pressures of acetonitrile and nitromethane at 75 °C are 83.21 and 41.98 kPa, respectively. Given 100 moles of the solution with 30 mol% acetonitrile, calculate
 - (a) the vapor pressure of the solution at 75 °C, and
 - (b) the amount of vapor at 75 °C and 60 kPa
- 2 (a) Air contains approximately 78% N₂, 21% O₂ and 1% Ar. What is the change in Gibbs energy in separating 100 moles of the air at 25 °C and 1 atm? Is this separation process "automatic"? Why?
 - (b) The PVT behavior of air at a certain temperature T follows the truncated virial expansion: $PV/RT = 1 - 0.16P + 0.04P^2$. Calculate its fugacity at 100 bar and the change in Gibbs energy ($\Delta G/RT$) in pressuring the air from 1 bar to 100 bar.
- 3 The molar volume (cm^3/mol) of a binary mixture at $T = 25^\circ\text{C}$ and $P = 1 \text{ atm}$ is given by $V^E = (13x_1 + 5x_2)x_1x_2 \text{ cm}^3/\text{mol}$. The molar volumes of the pure components are 108 and 72 cm^3/mol , respectively.
 - (a) Calculate the molar volume V of the mixture and the partial molar volume \bar{V}_1 at $x_1 = 0.5$.
 - (b) Calculate the partial molar volume \bar{V}_1^∞ of the infinite dilute solution. Discuss the differences among V_1 , \bar{V}_1 and \bar{V}_1^∞ .
- 4 (a) The liquid solution of 25 moles of methanol(1) and 75 moles of methyl acetate(2) at 45 °C starts to bubble when pressure is reduced to 73.50 kPa. The saturated pressures of methanol and methyl acetate at 45 °C are 44.51 and 65.64 kPa, respectively. Is this an ideal solution that follows Raoult's law? Verify your answer by calculation.
 - (b) The vapor at the bubble point contains 28.2 mol% methanol. Is the system positively deviated or negatively deviated from an ideal solution? Show your calculation.

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