Answer Sheets for CHE654 Homework Set #4
(100 Points)

Note: For all problems, submit a copy of your process flow diagram and a copy of your input summary of the process.

27. (20 points) *Quick Property Analysis, I*

Answer the following questions:

(a) The values of the retrieved binary parameters in °C for the 3 binary systems are

Binary System	Interaction Parameters	Range of Temperature (°C)
Acetonitrile-Water		
Ethanol-Butylamine		
Acid-Pyridine		

If a pair has no interaction parameters, why?

_____

_____

(b) Description of a minimum-boiling azeotrope:

_____

_____

Description of a maximum-boiling azeotrope:

_____

_____

Classification:

Acetonitrile-Water : ☐ Minimum ☐ Maximum boiling-point azeotrope

Ethanol-Butyl-amine : ☐ Minimum ☐ Maximum boiling-point azeotrope Acetic acid-Pyridine : ☐ Minimum ☐ Maximum boiling-point azeotrope

(c) UNIQ-RK property method is not appropriate for the Acetic acid-Pyridine system because _____

_____

Two alternate property methods better suited to predict the azeotrope for the acetic acid-pyridine system are: _____

(d) Don't forget to submit the *T-xy* plots of each system!

Summary Table:

Binary System	**Azeo. Temp.**	**% Err.**	**Azeo. X**	**% Err.**
Acetonitrile-Water				
Ethanol-Butylamine				
Acetic acid-Pyridine				

(e) Don't forget to submit the vapor pressure profile (in psia) of all components as a function of T from 0 to 100 °C.

Rearrange the relative volatility in increasing order:

_____

29. (20 points) ***Choosing Appropriate Property Methods, I***

(a) Activity coefficient γ of ethanol in an equimolar liquid solution of ethanol and cyclohexane at 60 °F and 20 psia.

Property Method: _____ O With O Without Henry's Law

Activity coefficient of ethanol = _____

(b) Critical temperature of a mixture with a composition of 30 mol% benzene, 30 mol% cyclohexane, 30 mol% *n*-hexane, and 10 mol% N_2.

Property Method: _____ O With O Without Henry's Law

Critical temperature of the mixture = _____ °C

(c) Vapor fugacity coefficient φ^V of formic-acid in an equimolar mixture of formic-acid and water at 20 psia in which 50 mol% of the mixture is vapor.

Property Method: _____ O With O Without Henry's Law

Vapor fugacity coefficient of formic-acid = _____

(d) Which gas has higher solubility in the liquid solution and by how much: 1 lbmol of helium or 1 lbmol of argon in a liquid solution of 10 lbmol of ethanol at 70 °F and 14.7 psia? (Special note: you are not allowed to pick an equation of state for this problem).

Property Method: _____ O With O Without Henry's Law

Gas with higher solubility is _____ and by more than _____ ppm (mole)

(e) Energy required to vaporize 1 gmol (i.e. heat of vaporization) of a saturated liquid containing 40 mol% aniline, 40 mol% acetol, and 20 mol% cyclohexene at 1 bar.

Property Method: _____ O With O Without Henry's Law

Energy required = _____ cal

(f) Vapor compressibility factor *Z* of a mixture containing 40 mol% formaldehyde, 40 mol% chloroform, and 20 mol% acetylene at 150 °C and 20 bar.

Property Method: _____ O With O Without Henry's Law

Vapor compressibility factor = _____

(g) Solubility of water in the organic phase in a mixture containing 45 mol% water, 45 mol% 1-methylcyclohexanol, and10 mol% O_2 at 20 °C and 1 bar.

Property Method: _____ O With O Without Henry's Law

Solubility of water = _____ mol%

(h) What temperature increase is required to produce a vapor stream containing 30 mol% acetone from a one-lbmole saturated liquid mixture with an overall composition of 40 mol% water, 40 mol% benzene, and 20 mol% acetone at 14.7 psia, assuming there is no pressure change in the vaporization? (You must save this problem and email the file to me at the end of the exam.)

Property Method: _____ O With O Without Henry's Law

Temperature increase = _____ °F

30. (20 points) ***Choosing Appropriate Property Methods, II***

(a) Which of the following 3 components has the lowest volatility at T = 80 °F: cyclobutane, 1,2-butadiene, or ethyl-chloride?

Property Method: _____ O With O Without Henry's Law

Component with the lowest volatility = _____

(b) The K-value of ethanol in a binary mixed-phase (30 mole% vapor) mixture of 50 mole% water and 50 mole% ethanol at 200 psia.

Property Method: _____ O With O Without Henry's Law

K-value of ethanol = _____

(c) Solubility (mole ppm) of CO_2 in water in a mixture of 20 mole% CO_2 and 80 mole% water at 5 psia and 80 °C.

Property Method: _____ O With O Without Henry's Law

Solubility of CO_2 = _____ ppm

(d) Solubilities (mole%) of acetic-acetone in the aqueous phase and alcohol phase of a mixture of 20 mole% *n*-butanol, 20 mole% acetone, and 60 mole% water at 14.7 psia and 50 °F.

Property Method: _____ O With O Without Henry's Law

Solubility in aqueous phase = _____ %; Solubility in alcohol phase = _____ %

(e) Heat of mixing (excess enthalpy) when 1 lbmol of acetol is mixed with 1 lbmol of acetonitrile at 20 psia and 100 °F.

Property Method: _____ O With O Without Henry's Law

Heat of mixing = _____ Btu/lbmol

(f) Vapor fugacity coefficient of acetic-acid in a vapor-liquid mixture (with 30 mole% vapor) containing 30 mole% acetic-acid, 30 mole% acetone, and 40 mole% ethanol at 20 psia.

Property Method: _____ O With O Without Henry's Law

Vapor fugacity coefficient of acid = _____

(g) Bubble-point pressure of a mixture of 30 mole% *n*-pentane, 30 mole% benzene, and 40 mole% cyclohexane at 30 °C.

Property Method: _____ O With O Without Henry's Law

P_{BUBBLE} = _____ bar

32. (20 points) ***Waste Stream Purification Using Multiple Property Methods***

(a) SR-POLAR property method is appropriate for the high pressure section of the process because

_____

_____

Suitable method for the LP section: _____

(b) Don't forget to submit input summary!

Molar vapor fraction in the LP-partial condenser: _____

Operating parameters of the 2 columns:

	Reflux ratio	Actual # of stages
LP-Column	_____	_____
HP-Column	_____	_____

Mole fractions of acetone, water, and acetic acid in their respective purified streams:

Acetone from LP-column: _____

Water from HP-column: _____

Acetic acid from HP-column: _____

33. (20 points) ***Toluene-Benzene Recovery Process with Multiple Property Methods***

(a) Mole fraction of benzene in the 2nd-Column overhead stream: _____

Molar ratio toluene: hydrogen in reactor feed: _____

(b) Hydrogen molar feed flow rate: _____ gmol/min

Mole fraction of benzene in the 2nd-Column overhead stream: _____