

# CE407 Exam 01

06/18/2020

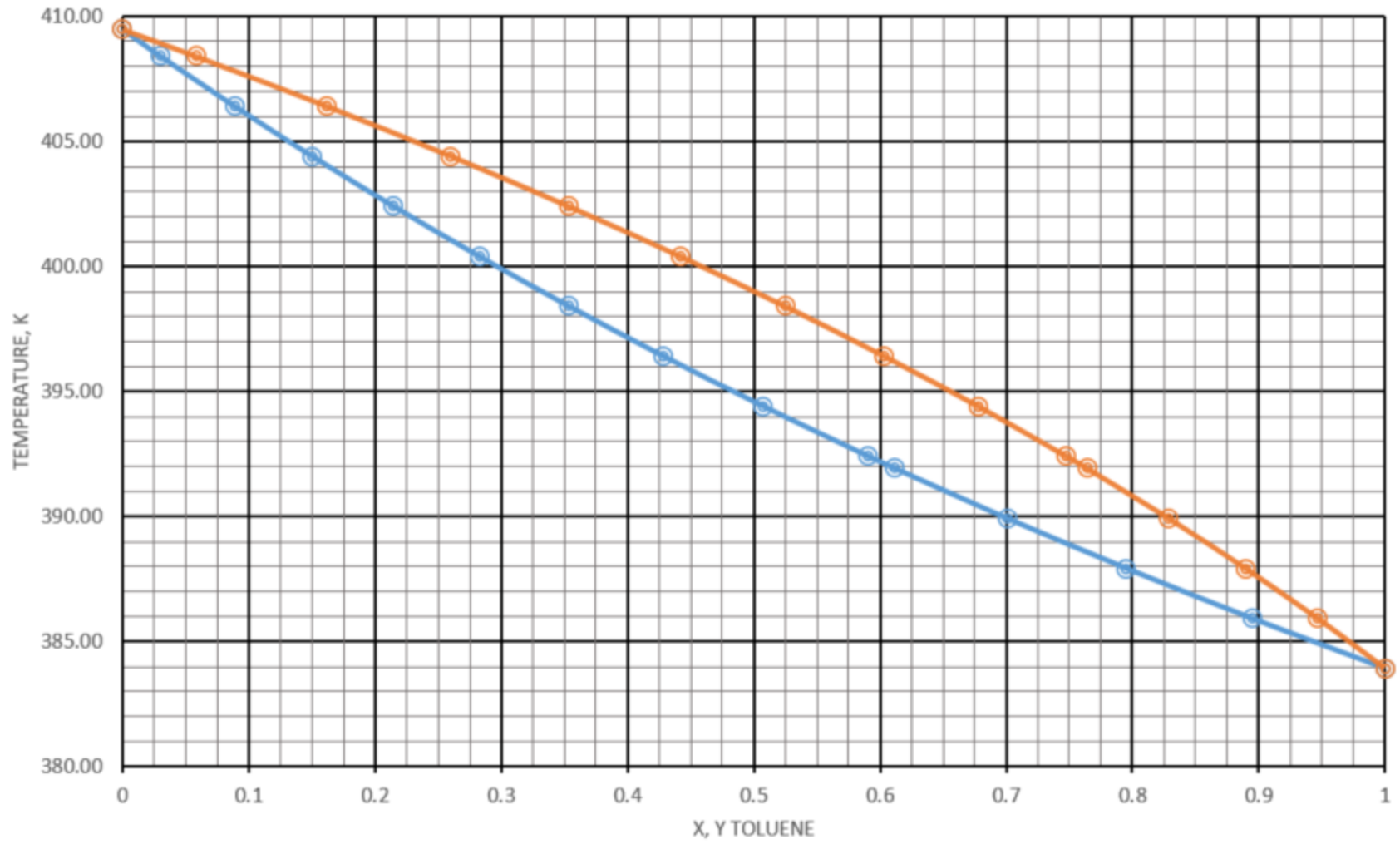
1. (50 points) A 100 mol/minute feed of saturated liquid with a composition of 0.6 mole fraction toluene and 0.4 mole fraction ethylbenzene is fed to a fractionating column. There is a 95% recovery of toluene in the distillate and a 93% recovery of the ethylbenzene in the bottom product. The column is equipped with a total condenser. The column is to operate with a reflux ratio  $R = 2.5$ .
  - a. What are  $x_D$  and  $x_B$ ?
  - b. How many stages are required for this separation?
  - c. What is optimal feed stage?
  - d. What is the required rate of cooling at the condenser ( $q_c$ ) and the required rate of heating ( $q_r$ ) to the reboiler? **Give answers in kJ/hr**
  - e. What are the required rates of cooling water and steam? **Give answers in kg/hr**
  - Equilibrium data provided via the attached  $T_{xy}$  diagram and Vapor Liquid Equilibrium Chart
  - Define reference states such that the liquid enthalpy is zero for each pure component at 383.9 K.
  - Heat capacity of Water 4.186 kJ/kg C. Allow for a 10 C temperature rise in the cooling water.
  - Steam: use 159 psig steam, which has a latent heat of evaporation of 1986 kJ/kg
  - $H_x(T, x) = 10,750 x + 185 T - 28 xT - 71,022 \text{ J/mol}$
  - $H_y(T, y) = 27,060 y + 169 T - 65.3 yT - 28870 \text{ J/mol}$ 
    - **T is in K for these enthalpy formulas**
  
2. (35 points) A 200 mol/hr stream of contaminated air (composition 96 mole percent air, 4 mole percent toxin) must be cleaned up by countercurrent contact with water in an absorption tower operating isothermally at 25 C and atmospheric pressure. The exiting air should have toxin mole fraction no greater than 0.003. Entering water is pure.
  - a. What is the minimum flow rate of water required to achieve the desired cleanup, corresponding to an infinite number of stages? *Hint: Curvature of equilibrium line will lead to first contact occurring at the "b" (or "dirty") end of the tower.*
  - b. If the entering water flow rate is 20.0 mole/hr, how many ideal stages are required? *Calculate at least three points on the operating curve in order to capture its shape.*

As usual, you may neglect evaporation of water as well as dissolution of air in the liquid. The equilibrium curve is provided.

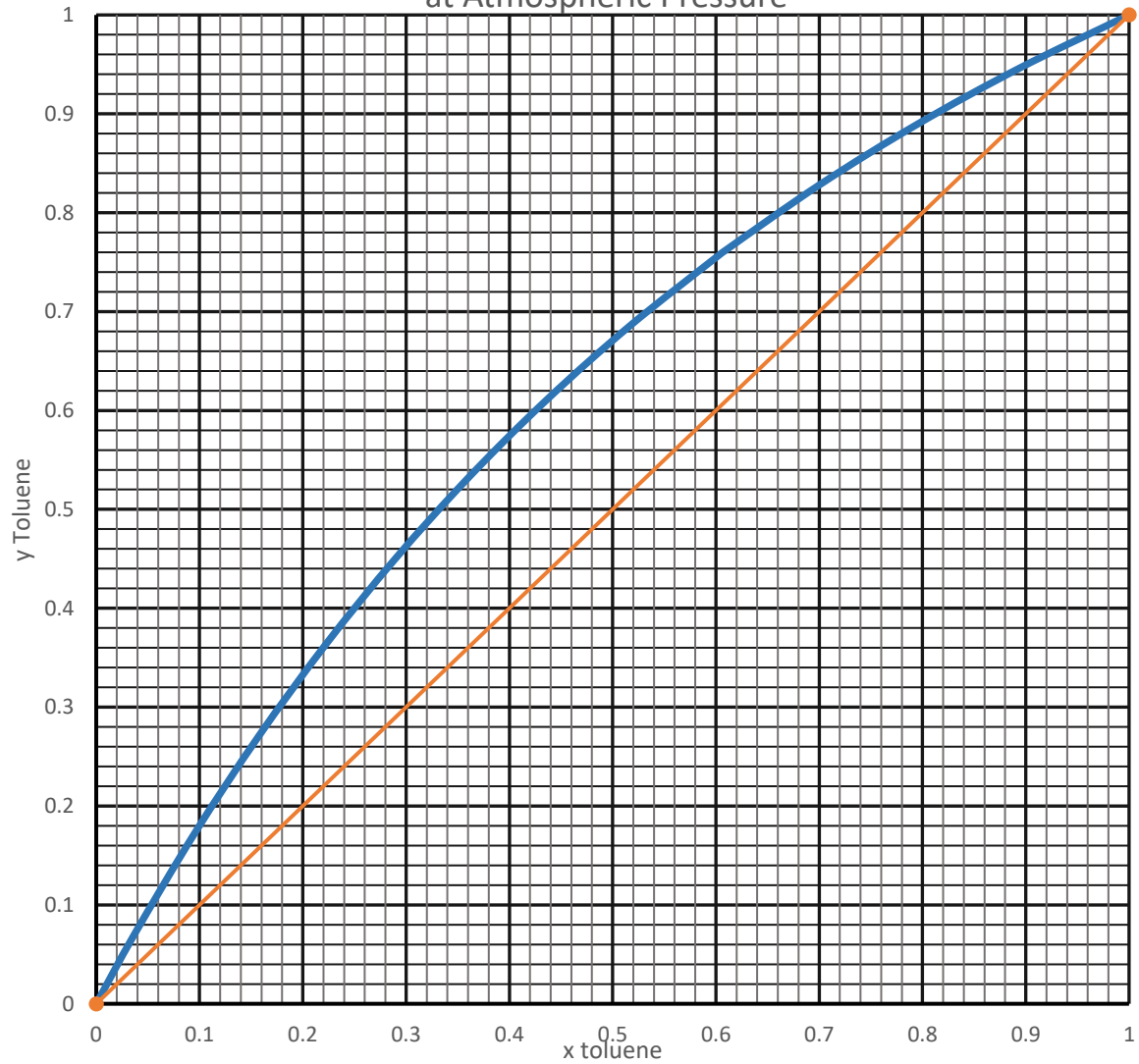
3. (15 points) A ternary mixture with the following composition is to be split into separate streams of (relatively) pure components. If each column is capable of 98% recovery of the light key in the distillate and 98% recovery of the heavy key in the bottoms, design a column sequence and calculate the final purity of each component.

Component	Mole Fraction
C3	0.25
C4	0.30
C8	0.45

# Txy Toluene - Ethylbenzene



Equilibrium Curve Binary Mixture of Toluene and Ethylbenzene  
at Atmospheric Pressure



## Problem 02

