Final Exam

(Open Book, 3 hours) Name _____

INSTRUCTIONS: Please read the following before beginning the exam.

- *Please show all work for each problem in the space provided. If there is insufficient space provided, use the back of the page. Be sure to indicate in the space provided that additional work is on the back.*
- *Circle your answers. Be sure to include units!*
- *A teaching assistant or the instructor will be in the room at all times. Feel free to ask questions.*
- *First answer those questions which require no calculation. Trial-and-error should not be necessary.*
- *If a subsequent question requires a numerical answer from a previous question (which you are unable to answer), take any reasonable value for the previous question or assign a variable name to the previous answer; then proceed with the subsequent question. You will not be penalized twice for missing the previous question.*

Code Number for Posting Grades

After the exam is graded, I will post a tabulation of all grades using your current 4-digit indentification number (PIN). If you wish to change your number, please write it below.

Numerical Code: | | | | |

Enter a number only if you want to change it.

1.) A dilute aqueous solution containing 1 mole% ammonia is being stripping of the ammonia by contact with fresh air (no ammonia) in a tower packed with one-inch Raschig rings. At the operating temperature and pressure (1 atm, 25°C) of the stripper, the equilibrium curve for dilute ammonia mixtures in air or water is given by

$$y^* = 1.1x$$

You may assume both operating line and equilibrium curve are straight on mole fraction coordinates.

10% a. Find the minimum air flowrate (in moles of air per mole of water) required to remove 99.9% of the ammonia from the water.

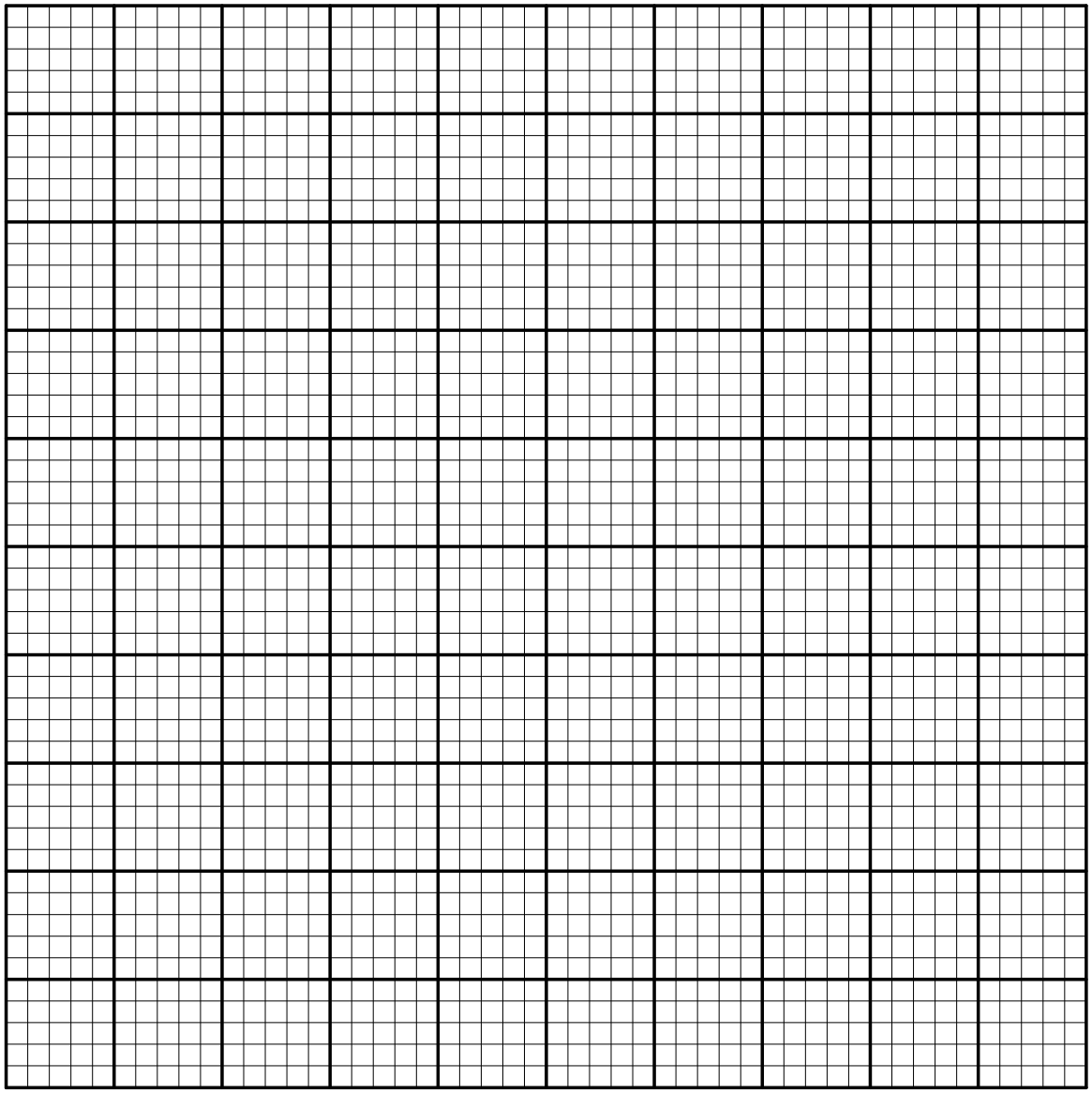
15% b. Using an air flowrate of 1 mole of air per mole of water, how many overall gas-phase transfer units are required to accomplish the desired separation.

5% c. Suppose the answer to part b) is greater than the number of transfer units available in the existing stripper. How would you change the gas flowrate (increase or decrease?) to reduce the number of transfer units required for the separation?

20% 2.) Suppose the stripping operation of Problem 1 were performed in a tray tower instead of a packed tower. How many ideal trays would be required? The air flowrate is that given in part 1b.

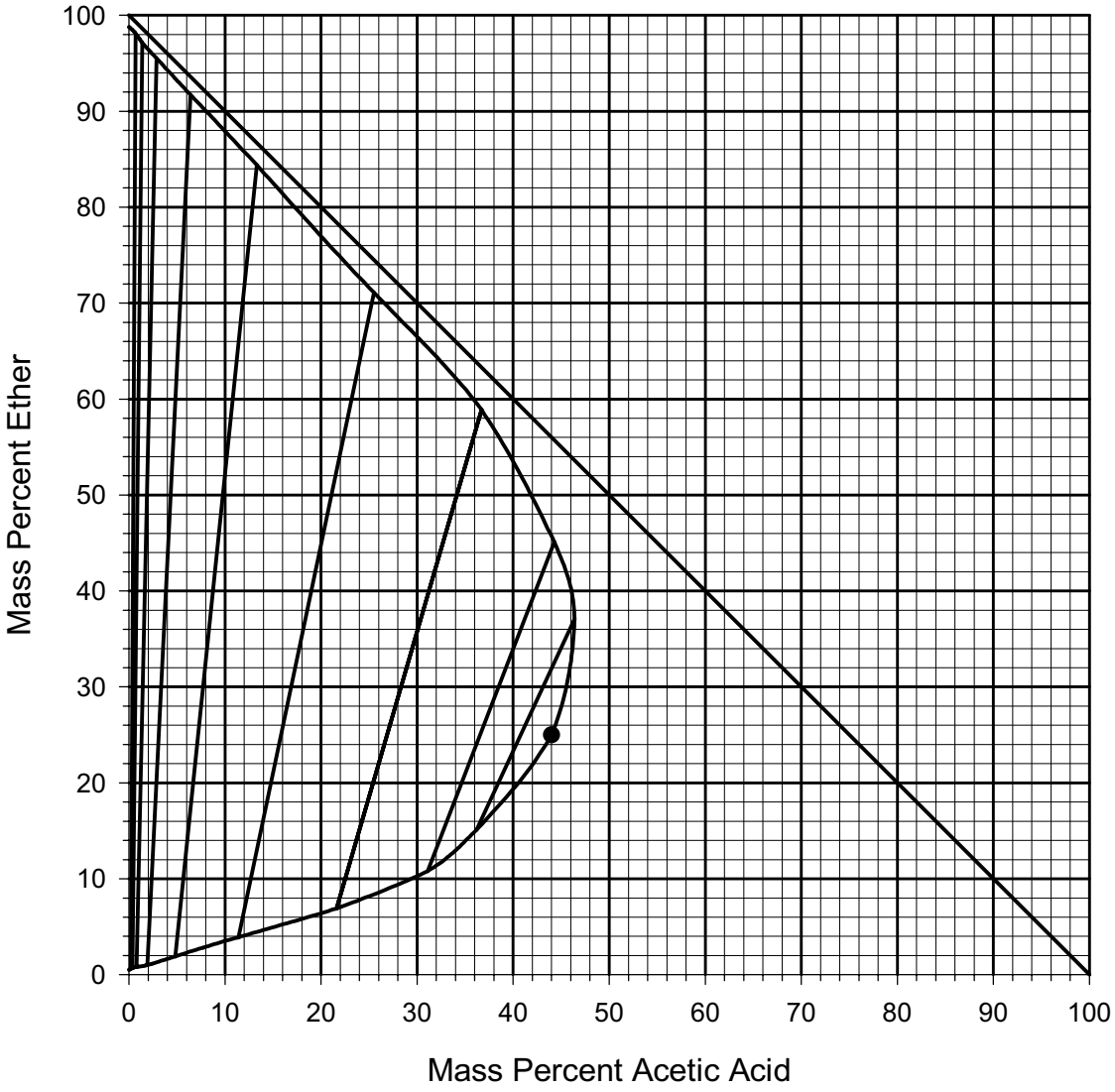
The "tower" consists of one countercurrent cascade of stages with the aqueous ammonia solution fed to the top stage and the fresh (ammonia-free) air fed to the bottom stage.

Hint: this problem can be solved without the use of graphs, but a sheet of graph paper is included below for your use.



20% 3.) A hollow-fiber membrane cartridge is being considered to produce a gas containing at least 95 mole% nitrogen using air (79 mole% nitrogen, 21 mole% oxygen) as the feed. Previous experiments have shown that the available membrane is ten times more permeable to oxygen than nitrogen. Is it possible to produce the desired nitrogen-rich gas using the available membrane in a single cartridge and air as the feed? Multiple stages are not permitted (for economic reasons).

Although a simple "yes" or "no" answer is finally required, you must include some calculations and an explanation to support your answer.



5% 4.) One kilogram of acetic acid is mixed with 0.5 kilogram each of isopropyl ether and water and allowed to equilibrate at 25°C. Use the rectangular diagram above to determine how many liquid phases are formed at equilibrium.

5.) One hundred kilograms per hour of a 30wt% acetic acid solution (no ether) is contacted with pure isoproply ether in a single mixer-settler. Use the phase diagram on the previous page.

20% a. What flowrate of ether is needed to reduce the acetic acid concentration to 5wt% in the raffinate (water-rich) stream using a single stage?

5% b. What is the corresponding concentration of acetic acid in the extract (solvent rich) stream?