By signing my name below, I affirm that I have not received assistance in completing this examination paper nor have I given assistance to another student.

Name (print):_____

Name (sign):_____

UCB Number:_____

GSI whose section you are officially enrolled in:_____

Chemical Engineering 150B
Midterm Exam 2
November 7th, 2014
8:10 - 9 am

100 Points Total

Three Problems

This examination has 10 pages

Problem 1 _____

Problem 2 _____

Problem 3 _____

Total _____

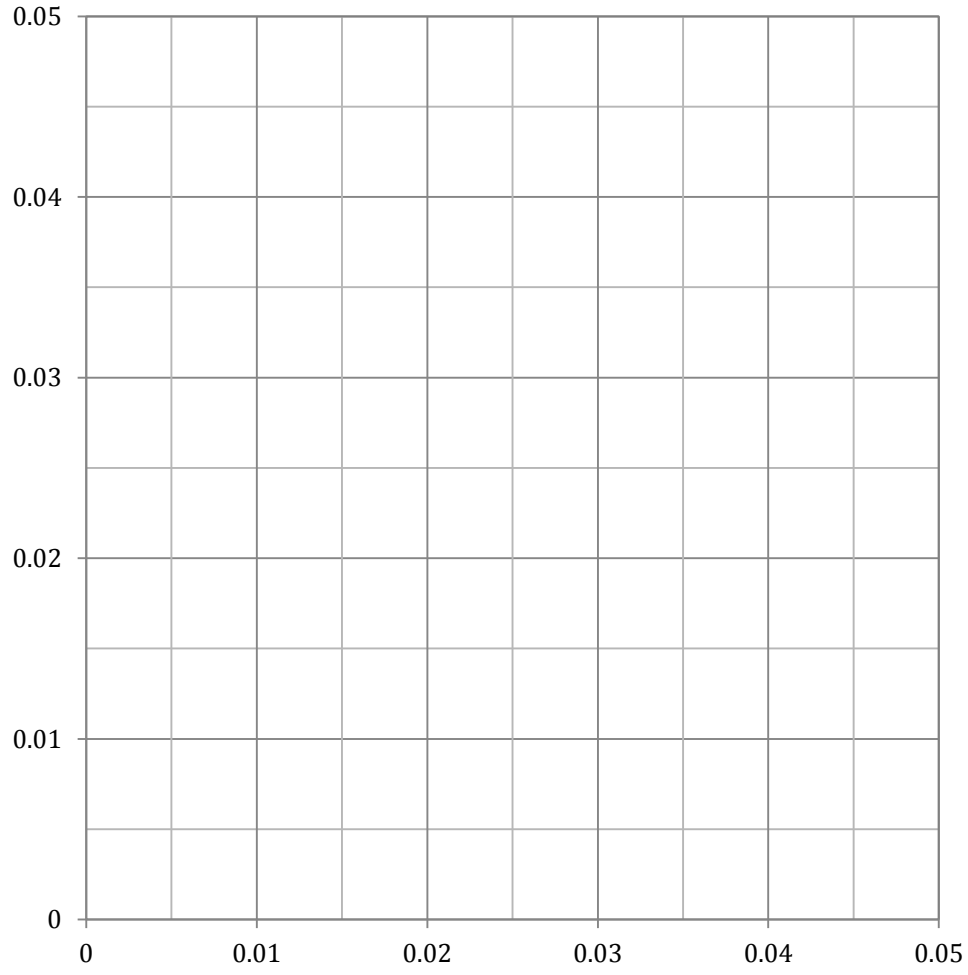
Show all work and derivations.
State all assumptions.
Write legibly.

Name _____

Problem 1 (20 points total)

A 4 mol% ammonia-gas mixture is contacted with pure water at 1atm and 20^{o}C. The film mass transfer coefficients for the gas and liquid phase are k_y and k_x, respectively (the mixture is dilute). The ratio k_x/k_y is 1.

A. (5 points) Plot the ammonia-water equilibrium on an x-y diagram (reference Table A.3-22). Use all five available data points.
B. (5 points) Label the point that corresponds to the bulk ammonia concentration in the gas phase.
C. (5 points) Plot the interface composition point on the equilibrium line.
D. (5 points) Alternatively, if the overall mass transfer coefficients, K_x and K_y, are known, plot the points on the equilibrium line that now define the driving force for mass transfer.



Name _____

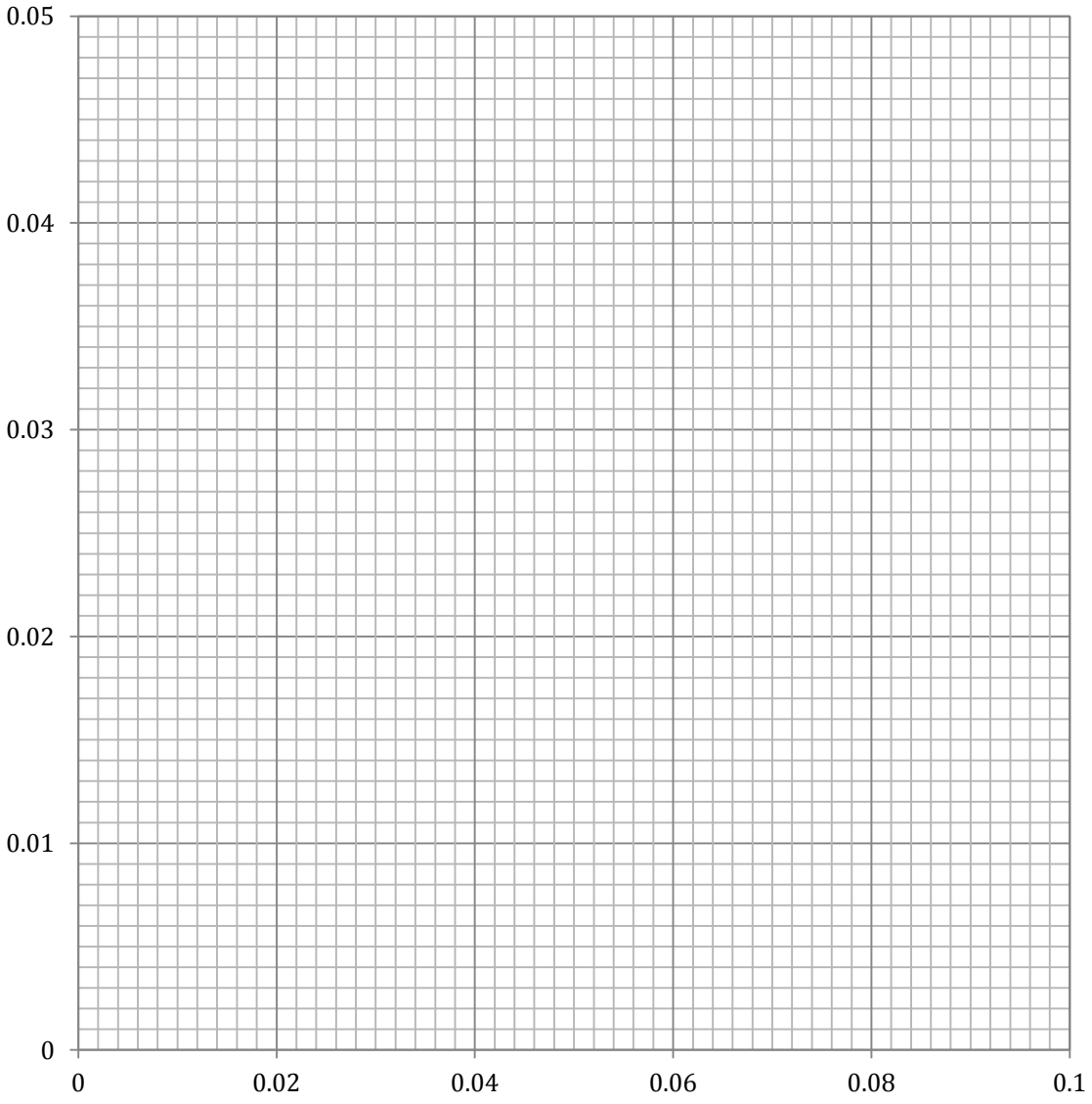
Problem 2 (40 points total)

An oil is to be stream-stripped in a tray column to recover the benzene impurity contaminating the oil. The oil feed to the stripper contains 8 mol% benzene, 75% of which is to be recovered. The steam leaving contains 3 mol% benzene.
Equilibrium data for the operating temperature and the operating pressure (101 kPa) were obtained from a bench-scale experiment on an oil sample; the experiment produced a benzene vapor pressure of 5.07 kPa over an oil sample containing 10 mol% benzene. The oil showed negligible vapor pressure in the experiment.

A. (15 points) How many moles of steam are required per 100 mol of oil-benzene mixture?

Name _____

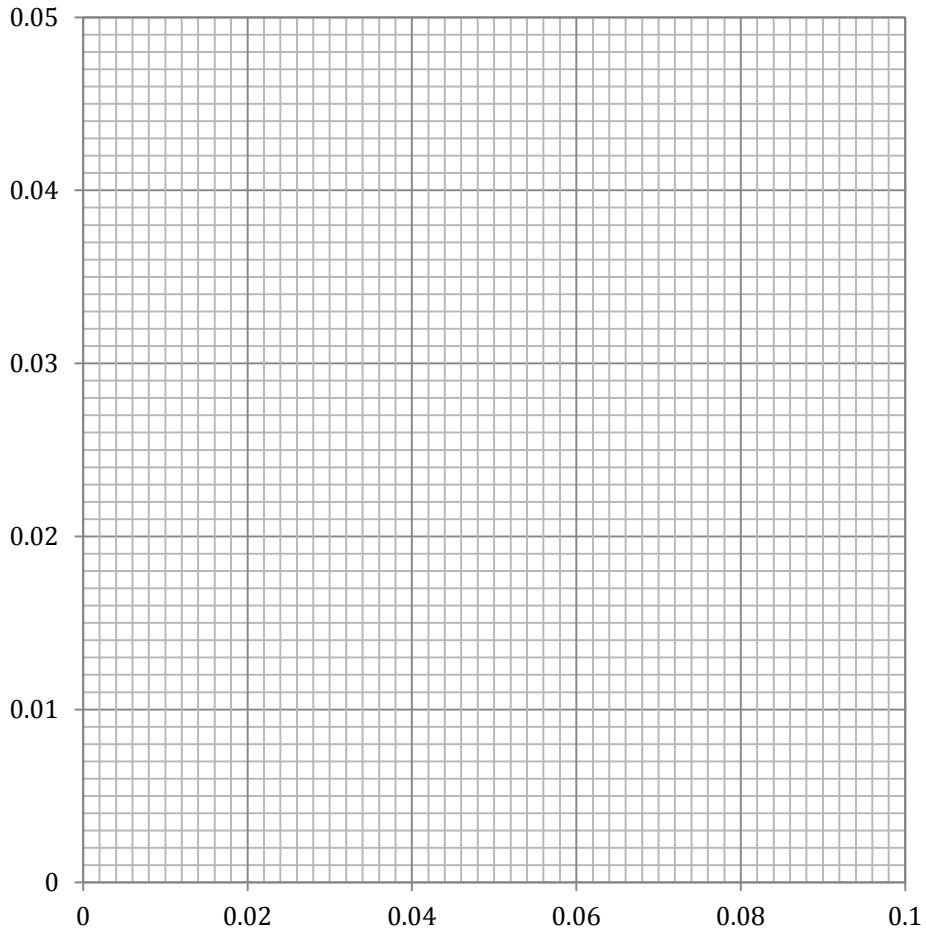
B. (10 points) How many theoretical equilibrium stages are required? Graph paper is included below if you wish to employ the graphical method.



C. (15 points) If the benzene recovery is to be increased to 85% with the same oil and steam rates, how many theoretical equilibrium stages would be required? What is the concentration of benzene in the stream leaving the column in this case?

Graph paper attached for use with the graphical method.

Name _____



Name _____

Problem 3 (40 points total)

Air containing 1.6 vol% sulfur dioxide is scrubbed with pure water in a packed column of 1.5 m^2 cross-sectional area and 3.5 m height packed with Intalux saddles at a pressure of 1 atm. The gas flow rate is 0.062 kmol/s, the liquid flow rate is 2.2 kmol/s, and the outlet gas SO_2 concentration 0.4 vol%. At the column temperature, a Henry-type equilibrium relationship is valid, viz. $y=40\ x$, where x and y are the mole fraction sulfur dioxide in water and air respectively.

A. (15 points) What is the ratio of the actual liquid flow rate to the minimum liquid flow rate required for the scrubbing duty (L/L_{min})?

B. (15 points) What is the number of transfer units (N_{OG}) for the column and how does it compare to the number of theoretical equilibrium stages (N) of the column.

C. (5 points) Determine the height of a transfer unit (H_{OG}) and the height of a theoretical equilibrium stage (HETP) from the operating data.

Name _____

D. (5 points) Determine the value of the product of the overall mass transfer coefficien and the specific surface area of the packing (K_y'a).