Uva Wellassa University, Sri Lanka
End Semester Examination – June 2010
ENG 324-2 Chemical Engineering Science

Time: Two (02) hour

Total 04 questions
Answer **all** questions
Clearly state any assumptions made
You can assume any missing data
Tables of properties are provided in the exam hall

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01) A petroleum fraction containing 40% benzene, 24% toluene and 36% xylenes (all by volume) is to be separated by fractional distillation at the rate of 1000 kmol/hr. The feed stock is processed successively in two distillation columns, the bottom product from the first column being fed to the second column. The overhead product (distillate) from the first column containing 98.5% benzene is discharged at 390 kmol/hr and that from the second column containing 92.5% toluene is discharged at 230 kmol/hr. If no xylenes are lost in the overhead from the first column and no benzene lost in the bottom residue from the second column, compute the volumetric composition of all product streams.

(100 marks)

02) I. Briefly explain the three modes of heat transfer.

(30 marks)

II. An experimental double pipe heat exchanger consists of a horizontal copper pipe (ID = 15.06 mm, OD = 19.05 mm, length = 2.75 m) inside (tube) and concentric with a 0.1 m OD steel pipe (Shell). The outside of the 0.1 m pipe is well insulated with 85 percent magnesia. The temperature of the outer surface of the copper pipe is measured by means of fine copper – constantan thermocouples attached to the surface. Condensing steam is used on the outside surface of the copper pipe, while the fluid under investigation flows through the copper pipe. The results from a run in which water was flowing through the copper pipe are given below:

Inlet water temperature	= 73.4 ^{0}C
Outlet water temperature	= 91.8 ^{0}C
Temperature of condensing steam	= 105.8 ^{0}C
Heat given up by steam	= 13.98 kW
Mean temperature of outer surface of copper pipe	= 99.5 ^{0}C

Calculate the heat transfer coefficient (h_i) between water and the inside of copper pipe. Thermal conductivity of copper = 379 W/mK.
Hint: Use mean temperature of outer surface of copper pipe to calculate the heat transfer coefficient (h_o) between steam and the outside of copper.

(70 marks)

03) A methanol-water mixture is separated using continuous distillation column operating at 1 atm. The feed which is at its boiling point enters the column with a rate of 300 kmol/hr. A reflux ratio of 2.5Rmin is used. Compositions of 0.9 and 0.1 (both in mole fractions) are desired for the top and bottom streams respectively when the feed composition is 0.4 (mole fraction). Equilibrium curve for methanol-water system at 1 atm is given in Figure1.
Determine:

a) The amounts of distillate and bottoms produced by the column.
(20 marks)

b) The minimum reflux ratio for the column.
(10 marks)

c) The operating line equation for the rectifying section at the given reflux ratio.
(15 marks)

d) The equation of the q-line.
(10 marks)

e) Locate the top and bottom operating lines on the x-y plot.
(30 marks)

f) The number of theoretical plates required for the column.
(15 marks)

04) I. Ammonia from a mixture of air is to be removed by absorbing into fresh water at 1 bar in a counter-current absorption column. The solute free gas and water flow rates are 1000 kmol/hr and 1664 kmol/hr, respectively. If the mole fraction of ammonia in the gas stream is to be reduced from 0.3 to 0.01, determine the followings,

a) The composition of used water stream. Write down your assumptions.
(20 marks)

b) Determine the operating line equation for the desired separation.
(10 marks)

c) What happens to the operating line and the desired compositions if you reduce the liquid flow rate continuously?
(15 marks)

d) Give three major differences between the distillation and absorption processes.
(15 marks)

II. Filtration is a very useful method of separation that is widely used in the industry.

a) State the fundamental equation for filtration, explaining all the notations.
(10 marks)

b) Starting with the fundamental equation, derive the equation for constant pressure filtration.
(20 marks)

c) What are the uses of the equation that you derived, in the industrial level?
(10 marks)

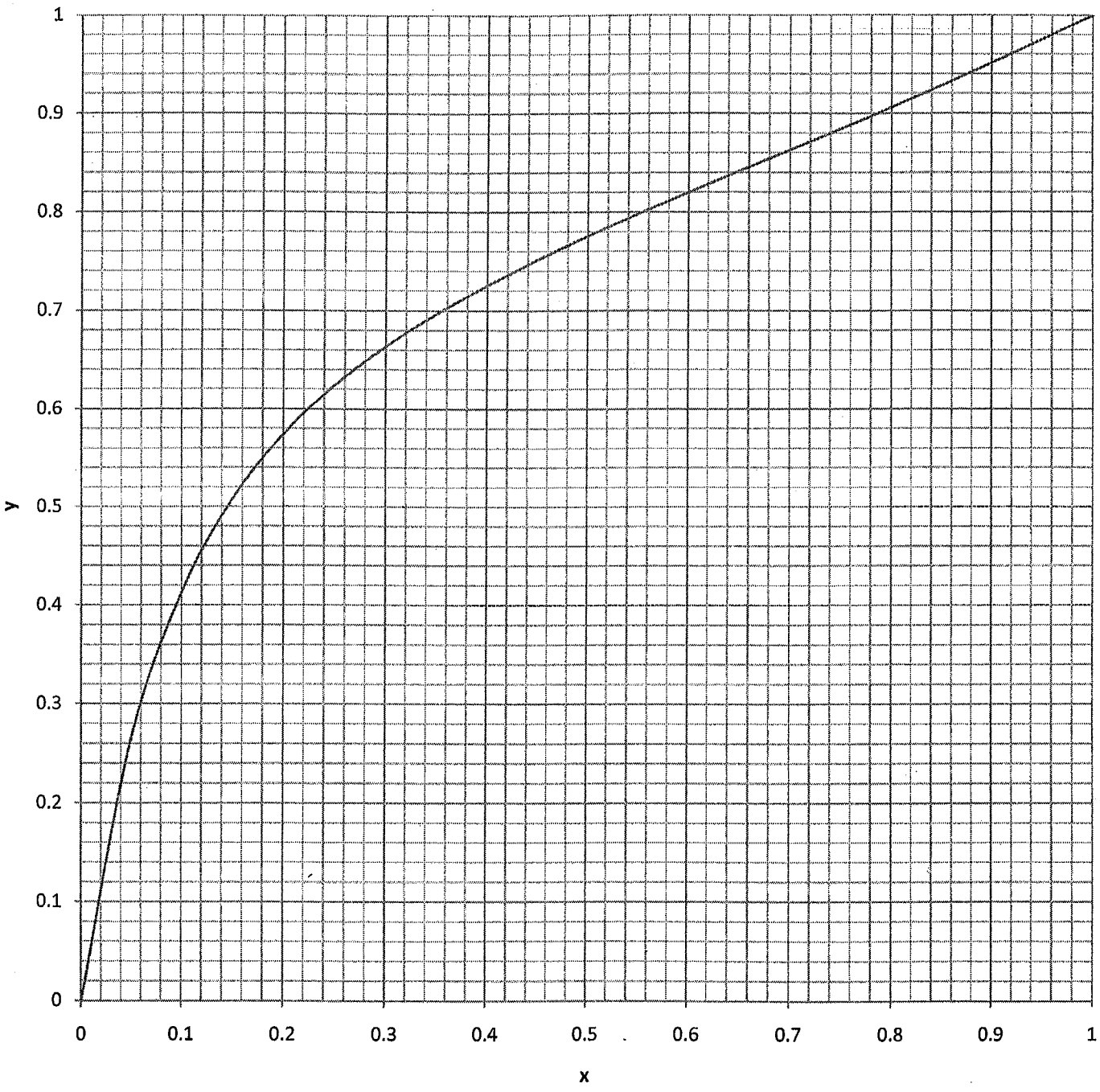

Figure 1: Equilibrium curve for methanol-water system at 1 atm.