BITS, PILANI – DUBAI CAMPUS

FIRST SEMESTER 2011 – 2012

FINAL YEAR

Course Code: CHE C432 **COMPREHENSIVE** Date: 09.01.12

Course Title: Computer Aided Process Plant Design Max Marks: 80

Duration : 3 Hr (Closed Book) Weightage: 40%

Note:Attempt ALL questions. Mention appropriate units in your answers. Without units, the answer will not be deemed as correct, even if the numerical value is correct. Make suitable design decisions wherever necessary, and mention them clearly.

1.(a) Mention how common types of vessels are classified according to their geomentry? (4 m)

1.(b) Discuss briefly the types of reboilers. (3 m)

2. A distillation unit consists of a partial reboiler, a column with seven equilibrium plates, and a total condenser. The feed consists of a 50 mol% mixture of benzene in toluene. It is desired to produce a distillate containing 96 mol% benzene, when operating at 101 kPa. With saturated-liquid feed fed to the fifth plate from the top, calculate: The bottoms Composition and moles of product per 100 moles of feed. (15 m)

y	0.21	0.37	0.51	0.64	0.72	0.79	0.86	0.91	0.96	0.98
x	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95

3. In petro chemical plant a gas (mw: 28) containing 4% cyclo hexane and 96% inerts has to be treated with non absorption oil (mw: 200) in packed tower at room temperature. It is required to remove 98% of cyclo hexane of the feed gas. The feed is solvent free from cyclo hexane. The equilibrium relation is given as (22 m)

$$Y = \frac{0.2X}{1+0.8X}$$

Make a preliminary design (column area, column diameter, column height, check flooding percentage and Height of overall gas phase transfer by Cornell's method) for the absorption column for the feed gas rate is 80 kmol/hr.

Given data:

$D_V = 2 \times 10^{-5}$ m^2/s

ρ_g @ 20°C = 1.21 kg/m^3

$\mu_g = 0.02 \times 10^{-3}$ N s/ m^2

ρ_L = 990 kg/m^3

$\mu_L = 1 \times 10^{-3}$ N s/ m^2

$D_L = 2 \times 10^{-9}$ m^2/s

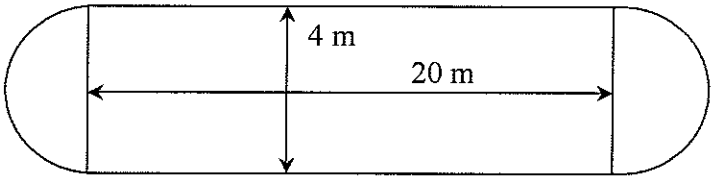
Consider

- pressure drop of 20 mm H_2O /m packing
- packing materials : 38 mm ceramic intalox saddles

4. Design an exchanger (using Kern's method) to sub-cool methanol from 95°C to 40°C. Flow-rate of methanol 100,000 kg/h. Brackish water will be used as the coolant, with a temperature rise from 25° to 40°C. Use one shell pass and two tube passes and a split-ring floating head type. (22 m)
Make suitable decisions (wherever required) and mention them clearly.

Design data:
Heat capacity methanol = 2.84 kJ/kg°C
Heat capacity water = 4.2 kJ/kg°C
Thermal conductivity of cupro-nickel alloys = 50 W/m°C.
Viscosity of water = 0.8mN/m^2
Thermal conductivity water = 0.59 W/m°C
Thermal conductivity methanol = 0.19 W/m°C
Methonal density = 750 kg/m^3
Methonal viscosity = 0.34 m Ns/m^2
Choose 20 mm o.d., 16 mm i.d., 4.88-m-long tubes, cupro-nickel.
Use 1.25 triangular pitch

5.(a) A horizontal, cylindrical tank, with hemispherical ends, is used to store liquid chlorine at 10 bar. Estimate the minimum wall thickness required to resist this pressure, for the cylindrical section and the heads. Take the design pressure as 12 bar and the allowable design stress for the material as 110 MN/m^2. A corrosion allowance of 2 mm should be used. (8 m)



5.(b) A storage tank for concentrated nitric acid (ρ =1520 kg/m^3) will be constructed from aluminium to resist corrosion. The tank is to have an inside diameter of 6 m and a height of 17 m. The maximum liquid level in the tank will be at 16 m. Estimate the plate thickness required at the base of the tank. Take the allowable design stress for aluminium as 90 N/mm^2 and the joint factor as 0.7. (6 m)

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FIRST SEMESTER 2011 – 2012

FINAL YEAR

Course Code: CHE C432 **TEST 2** Date: 11.12.11

Course Title: Computer Aided Process Plant Design Max Marks: 15

Duration : 50 minutes (Open Book) Weightage: 15%

Note : Permitted to use "only prescribed Text book and original hand written notes" for the open book evaluation component. No photocopies of any sought shall be permitted other than data book.

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1. In the manufacture of methyl ethyl ketone (BP: 99°C) from butanol (BP: 80°C), the product is separated from unreacted butanol by distillation. The feed to the column consists of a mixture of 0.90 mol fraction MEK, 0.10 mol fraction 2- butanol, with a trace of trichloroethane. The feed rate to the column is 20 kmol/h and the feed temperature 35°C. The specifications required are: top product 0.99 mol fraction MEK; bottom product 0.99 mol fraction butanol. Design a column for this separation. The column will operate at essentially atmospheric pressure. Use a reflux ratio 1.5 times the minimum. Total actual plates are 20. (15 m)

   (a) determine the minimum reflux ratio,
   (b) determine the number of theoretical stages below the feed plate.
   (c) design a suitable sieve plate for conditions below the feed point. (flow rates, base pressure, bottom column diameter, liquid flow pattern, provisional plate design, check weeping and plate pressure drop)

   Equilibrium data for the system MEK 2-butanol, mol fractions MEK:

liquid phase	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95
vapour phase	0.23	0.41	0.53	0.64	0.73	0.80	0.86	0.92	0.96	0.98
boiling point°C	97	94	92	90	87	85	84	82	80	79

Properties

Latent heats: MEK 31284 kJ/kmol, 2-butanol 40821 kJ/kmol

Specific heats: MEK 164 kJ/kmol, 2-butanol 228 kJ/kmol

Mol mass: MEK 72.11, 2-butanol 74.12

Liquid viscosity's at the average column temperature:

MEK 0.038 Nm^{-2} s, Butanol 0.075 Nm^{-2} s

Column top pressure = 100 kN/m^2

Column bottom conditions: ρ_v =2.9 kg/m^3; ρ_L = 725 kg/m^3,

Surface tension = 9.6×10^{-3} N/m

BITS PILANI – DUBAI CAMPUS
FIRST SEMESTER 2011 – 2012
FINAL YEAR

Course Code: CHE C432 **Test 1** Date: 16.10.11
Course Title: Computer Aided Process Plant Design Max Marks: 15
Duration : 50 minutes (Closed Book) Weightage: 15%

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1. Propane (MW:44) is separated from propylene (MW:42) by distillation. The compounds have close boiling points and the relative volatility will be low. For a feed composition of 10 percent w/w propane, 90 per cent w/w propylene, estimate the number of rectifying section theoretical plates needed to produce propylene overhead with a minimum purity of 99 mol per cent. The column will operate with a reflux ratio of 20. The feed will be at its boiling point. Take the relative volatility as constant at 1.1. (6 m)

2. Acetic acid is to be separated from s process stream containing 80% acetic acid and 20% water (by mass) by continuous distillation at atmospheric pressure. Concentration of water in bottom product (pure acetic acid) should not be greater than 50 ppm. Find the number of theoretical stages for the stripping section required to purify the bottom product – acetic acid from the following data.
   Slope of the stripping section operating line = 1.2, slope of the equilibrium line = 2.5 and 0.02 is the mole fraction of more volatile component at the reference point. (6 m)

3. Mention the factors which influence for selection of the type of vessels for any process plant. (1.5 m)

4. What are the varieties of formed heads are used for closing the ends of cylindrical vessels? (1.5 m)

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Course Code: CHE C432 **QUIZ 2** Date: 28.11.11

Course Title: Computer Aided Process Plant Design Max Marks: 07

Duration : 20 minutes (Closed Book) Weightage: 7%

Name: ..... **ID No:** ..... **Prog:** .....

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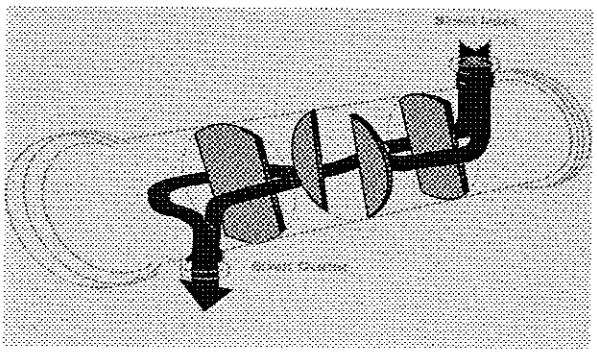
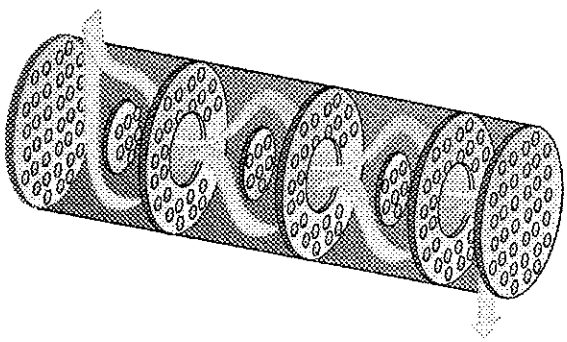
1. What are the assumptions and limitations of LMTD for shell and tube heat exchanger design? (2 m)

2. Mention the types of the baffles used in the following shell and tube heat exchanger. (2 m)



a)

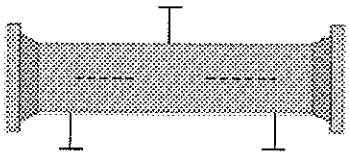


b)

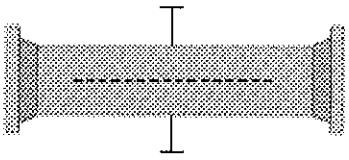
3. What are the advantages of floating-head heat exchanger and explain with an application? (1 m)

4. Mention the shell types for the following shell and tube heat exchangers. (2 m)

a) cross flow
b) kettle type reboiler
c) divided flow
d) double split flow
e) split flow
f) two pass shell with longitudinal baffle
g) one pass shell



(i)_____



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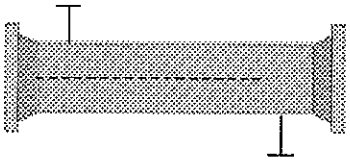
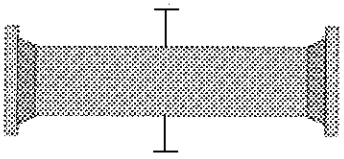


(iii) _____



(iv) _____

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FIRST SEMESTER 2011 – 2012

FINAL YEAR

Course Code: CHE C432 **QUIZ 1** Date: 31.10.11

Course Title: Computer Aided Process Plant Design Max Marks: 08

Duration : 20 minutes (Closed Book) Weightage: 8%

Name: ..... **ID No:** ..... **Prog:** .....

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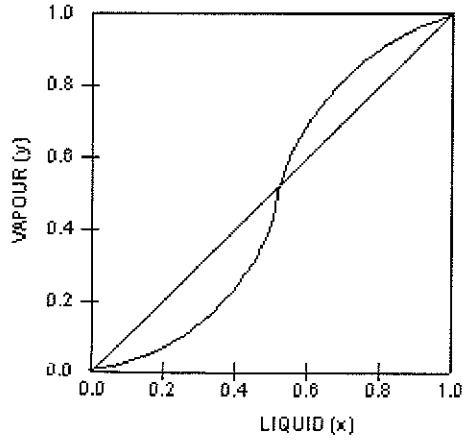
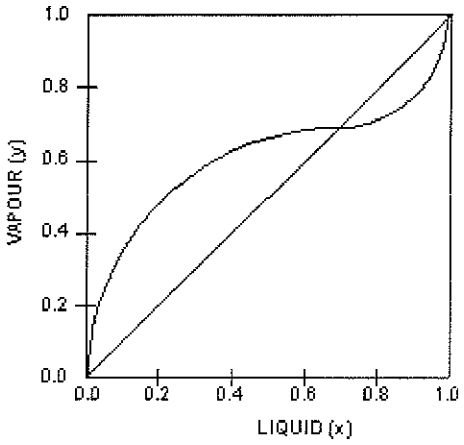
1. In batch distillation with constant reflux, the overhead product purity (1 m)
   a. increases with time
   b. decreases with time
   c. does not vary with time
   d. none of the above
2. At total reflux in continuous distillation the number of plates is (1 m)
   a. maximum
   b. minimum
   c. infinite
   d. none of the above
3. When saturated vapor is fed to a distillation column, the slope of the feed line is
   a. one (1 m)
   b. zero
   c. between zero and one
   d. infinity
4. As the pressure increases in the fractionators the relative volatility (1 m)
   a. decreases
   b. increases
   c. does not vary
   d. none of the above

5. The most intriguing VLE curves are generated by azeotropic systems. Name the categories of the two VLE plots shown below, which shows two different azeotropic systems. (2 m)





a) _____ b) _____

7. What are the limitations of McCabe and Theile method? (2 m)