BITS PILANI, DUBAI CAMPUS, ACADEMIC CITY, DUBAI
Second SEMESTER 2011-2012
CHE C332: Process Design Decisions
Comprehensive Examination

DATE: 14-06-2012

TOTAL DURATION: 3 hours **MAXIMUM MARKS: 40**

Note: Attempt ALL questions. Part A contains 12 questions.
Attempt Part A and Part B in separate answer sheets.

PART – A [20 Marks]

1. If an amount triples in 14 years, what is the annual compound rate of return? [1]
2. Assuming nominal annual interest rate to be 9%, find the value of $1800 invested for 5 years with interest compounding quarterly. [1]
3. You could receive AED12, 000 today or AED18, 000 after four years. If both are equivalent, what is the annual rate of interest? [1]
4. You buy a systematic income plan (SIP) for $100,000 which pays you $8500 every year for 20 years. What annual rate of interest are you earning? [2]
5. Between the Liquid Separation System and the Vapor Recovery System, which should be designed first and why? [1]
6. In Heat exchanger network (HEN) synthesis, what are the heuristics of stream-matching (a) above pinch, and (b) below pinch? [1]
7. A piece of equipment with an original cost of $7000 and no salvage value has a depreciation allowance of $1000 during its 4^{th} year of service, when depreciated by SOYD method. What recovery period has been used? [2]
8. Styrene can be produced by the reactions
   Ethylbenzene ←→ styrene + H_2
   Ethylbenzene → Benzene + Ethylene
   Ethylbenzene + H_2 → Toluene + CH_4
   The reactions take place at 1115 ^{O}F and 25 psia. We want to produce 250 mol/h of styrene. Draw the a) recycle structure of the flowsheet, and b) discuss the effect of diluents on shifting equilibrium conversion in above process. [3]
9. An equipment costs $90,000 and has 6 years' service life with no salvage value. Calculate using double declining balance (DDB) method depreciation charged in third year. [2]
10. In acetone recovery from air-acetone stream with the absorption as a selected alternative, discuss the following: [2]
    a) Advantages and disadvantages of using a solvent other than water.
    b) Discuss the pros and cons of using high flow rate of water in the absorber.
11. When it is decided to install a vapor recovery system in a process, what are the possible locations (on the flow sheet) to place it? What are the heuristics that guide this decision? [2]
12. How is coefficient of difficulty of separation is defined? What is its significance? [2]

CHE C332: Process Design Decisions
Comprehensive Examination
PART – B [20 Marks]

Note: attempt ALL questions. Part B contains 4 questions.

1. A chemical process has two hot streams to be cooled and two cold streams to be heated. Assuming HRAT = 12 ^{o}C for the stream data given below, carry out the energy integration analysis using Pinch Technology by determining the following: [4]
   (a) Minimum hot and cold utility requirements based on second law,
   (b) Hot and cold pinch temperatures,

Stream No.	Source Temperature (^{o}C)	Target Temperature (^{o}C)	Heat Capacity Flow rate (MW/^{o}C)
1	280	80	30
2	260	100	45
3	20	220	40
4	120	260	60

2. For the heat exchanger network synthesis problem given below, hot and cold utility requirements for HRAT = 8 ^{o}C are 4800 kW each. The pinch temperature is 104 ^{o}C. [5]

Stream No.	Source Temperature (^{o}C)	Target Temperature (^{o}C)	Heat Capacity Flow rate (kW/^{o}C)
1	200	100	200
2	180	60	150
3	100	140	500
4	80	170	200

   Synthesize an MER network featuring minimum number of units, and draw it on the grid diagram; clearly indicating heat exchanger loads and intermediate stream temperatures.

3. In the final design stage of a project, the question has arisen as to whether to use a water-cooled exchanger or an air-cooled exchanger in the overhead condenser loop of a distillation tower. The information available on the two pieces of equipment is provided below: [6]

	Initial Investment	Yearly Operating Cost
Air-cooled	$35, 000	$1, 500
Water-cooled	$22, 000	$3, 500

   Both pieces of equipment have service lives of 18 years. For an internal rate of return of 10% p.a., *which piece of equipment represents the better choice*? At what internal rate of return, both equipments will be equally attractive?

4. Selectivity data for a process to produce B from A are given below:

S	0.644	0.572	0.514	0.446	0.384
x	0.50	0.60	0.70	0.80	0.90

   Where Selectivity, S = mol B at reactor exit/ mol A converted.
   Develop a linear correlation for the data. Use your results to estimate the conversion corresponding to the maximum yield. [5]

BITS PILANI, DUBAI CAMPUS
Second SEMESTER 2011 – 12
CHE UC332: Process Design Decisions
Test - 2 (CLOSED Book)

DATE: 20 MAY 2012

DURATION: 50 MINUTES **MAXIMUM MARKS: 20**

Note: Attempt ALL questions. Show the calculation steps and formula used clearly. Make suitable design decisions wherever necessary, and mention them clearly. Do not alter any given data.

1. Write any FOUR heuristics for distillation sequencing in a multi-component separation. Give one justification for each heuristic. [4]
2. When it is decided to install a vapor recovery system in a process, what are the possible locations (on the flow sheet) to place it? What are the heuristics that guide this decision? [4]
3. In the table below, there are 10 components with their destination codes listed in order of their boiling points. Calculate how many product streams will be there? What will be their composition? [3]

Component	Destination Code	Component	Destination Code
A	Recycle	F	Fuel
B	Waste	G	Recycle and Purge
C	Recycle	H	Primary Product
D	Fuel	I	Recycle
E	Recycle and Purge	J	Recycle

4. Ethylene oxide (EO) is produced by the catalytic oxidation of ethylene over a silver-containing catalyst. A side-reaction oxidizes ethylene to carbon dioxide and water.

$C_2H_4 + 0.5\ O_2 \rightarrow C_2H_4O$

$C_2H_4 + 3\ O_2 \rightarrow 2\ CO_2 + 2\ H_2O$

The reaction selectivity data are given below.

x	0.1	0.2	0.3	0.4	0.5	0.6	0.7
S	0.953	0.943	0.929	0.909	0.879	0.827	0.725

Where Selectivity, S = mol EO at reactor exit/ mol ethylene converted.
Develop a linear correlation between conversion x and selectivity S from above data. The correlation will have following form: $S = 1 - \frac{a}{(1-x)^b}$. Use your results to estimate the conversion corresponding to the maximum yield.

[7 + 2 = 9]

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BITS, PILANI, DUBAI CAMPUS, ACADEMIC CITY, DUBAI

Second SEMESTER 2011 – 2012

CHE C332: process Design Decisions

Test – 1 (Open Book)

DATE: 1 April 2012

DURATION: 50 MINUTES **MAXIMUM MARKS: 20**

Note: Attempt ALL questions. *Make suitable design decisions wherever necessary, and mention them clearly. Do not alter any given data.*

1. You could receive AED15, 000 today or AED17, 550 after four years. If both are equivalent, what is the annual rate of interest? [2]

2. Compare two pension fund schemes: Investment scheme A requires you to deposit $1000 per year for fifteen years, and then pays you $3000 per year forever. Investment scheme B requires you to deposit $2000 per year for 9 years, and then pays you $3000 per year forever. Which investment scheme you consider to be better? Justify. [6]

3. A piece of equipment with an original cost of AED84000 and no salvage value has a depreciation allowance of AED15000 during its third year of service, when depreciated by SOYD method. What recovery period has been used? [3]

4. In acetone recovery from air-acetone stream with the absorption as a selected alternative, discuss the following: [6]

   a) Advantages and disadvantages of using a solvent other than water.

   b) Discuss the pros and cons of using high flow rate of water in the absorber.

   c) The effect of decreasing solvent flow rate to the absorber on the utilities requirement and reflux ratio in the subsequent distillation column.

5. Consider a condensation process for recovering acetone from an air stream. Describe the economic trade-offs involved in the design of a condensation process (both low temperature and high-pressure). [1.5 + 1.5 = 3]

*** END OF PAPER ***

BITS, PILANI - DUBAI CAMPUS
Second SEMESTER 2011-2012
CHE UC332: Process Design Decisions
Quiz - 2 (Closed Book)

DATE: 1 May 2012

DURATION: 20 MINUTES **MAXIMUM MARKS: 5**

Note: Attempt ALL questions. Do rough calculations on the back of this question paper. Questions 1 to 6 carry ½ marks each; question 7 carries 2 marks.

Student's Name: I.D.

1. We process the inerts rather than eliminating them before reaction when

   a) Catalyst is adversely affected by the inerts

   b) Large exothermic heat must be removed

   c) Nearly pure products are required

   d) all of the above

2. The gas recycle and purge stream is used in a process, if the light reactant is boiled at boiling point lower than the boiling point of:

   a) ethylene, b) propylene, c) propane, d) ethane.

3. In deciding between batch versus continuous process, which of the following favor the choice of a batch process?

   a) Large production rate, seasonal product, fast reactions

   b) Small production rate, multi-product plant, slow reactions

   c) Small production rate, fast reactions, long product life

   d) Large production rate, multi-product plant, fouling material

4. Which of the following group of streams is not included in counting number of product streams?

   a) Recycle and reactants b) recycle and purge

   c) Vent and waste d) primary and secondary products

5. Consider the reaction system, A →B →C where B is the desired product. The selectivity is given by,

   a) $S = \frac{\text{moles of C produced}}{\text{moles of B consumed}}$ c) $S = \frac{\text{moles of B produced}}{\text{moles of C produced}}$

   b) $S = \frac{\text{moles of B produced}}{\text{moles of A fed to reactor}}$ d) $S = \frac{\text{moles of B produced}}{\text{moles of A consumed}}$

6. Byproducts from reversible side reactions are

   a) Purged b) recycled

   c) Recovered in separators d) all of the above 3 can be considered

7. The selectivity versus conversion relationship for a particular reaction system is given as: S = 1 – 0.8 x. Find out the conversion corresponding to maximum yield.

BITS, PILANI, DUBAI CAMPUS
DUBAI INTERNATIONAL ACADEMIC CITY, DUBAI
Second SEMESTER 2010-2011
CHE UC332: Process Design Decisions
Quiz - I

DATE: 13.03.2012

DURATION: 20 MINUTES **MAXIMUM MARKS: 5**

Note: Attempt ALL questions. Do rough calculations on the back of this question paper.

Student's Name: I.D.

1. For the heat exchanger network synthesis problem given below, hot and cold utility requirements for HRAT = 10 ^{O}C are 360 MW and 60 MW, respectively. The pinch temperature is 165 ^{O}C.

Stream No.	Source Temperature (^{O}C)	Target Temperature (^{O}C)	Heat Capacity Flow rate (MW/^{O}C)
1	190	40	3.0
2	170	50	4.0
3	20	230	6.0

The heat exchanger network featuring minimum number of units is given below. On this network, fill in heat exchanger loads and intermediate stream temperatures. [Q_1, Q_2, Q_3, T_1, and T_2]