PRINCE OF SONGKLA UNIVERSITY

FACULTY OF ENGINEERING

Midterm Examination : Semester II — Academic Year : 2005

Date : 13 December 2005 — Time : 13.30 - 16.30

Subject : 230 - 432 Chemical Engineering Plant Design — Room : R201

Student Name: ..... Code : .....

Number of questions : 4

Time : 3 hours

Total marks : 90

Books and notes are not allowed

Calculators and writing in pencil are allowed.

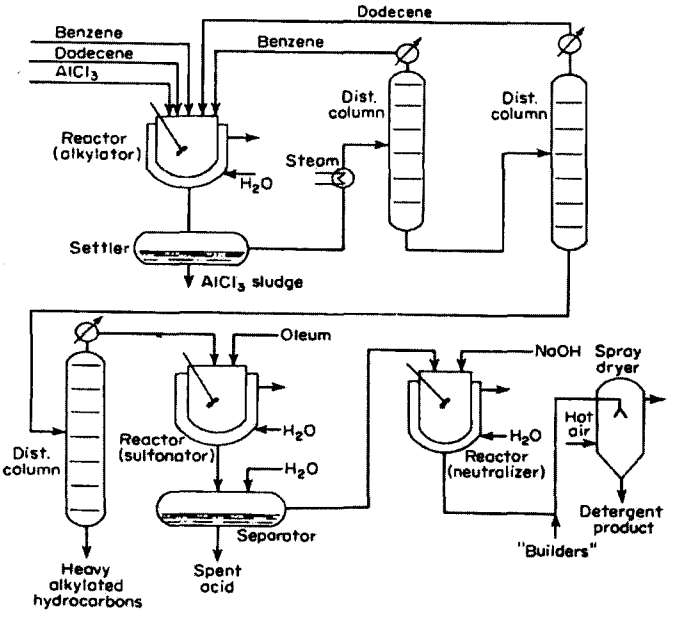
Question	Full Marks	Marks Received
1	20	
2	30	
3	20	
4	20	
Total	90	

ทุจริตในการสอบโทษขั้นต่ำคือ ปรับตกในรายวิชาที่ทุจริต และพักการเรียน 1 ภาคการศึกษา

1. a) Sodium dodecylbenzene sulfonate detergent can be produced by the process shown on next page. There are three basic reactions: alkylation, sulfonation and neutralization. Describe the preliminary process design for this process step-by step. List your answer in steps from step 1, step 2 to the last step. The process design should provide necessary information for plant investment.

(10 marks)

Student Name: ..... Code : .....



b) What is "heuristics" for process design? Give one heuristic for a process where there are by-products produced in reversible reactions in small quantities.

(10 marks)

Answer to Q1.

Student Name: ..... Code : .....

2. a) Vinyl chloride can be produced from two reaction steps:

chlorination of ethylene at 90 °C, 1.5 atm.

$$C_2H_4 + Cl_2 \longrightarrow C_2H_4Cl_2$$

Ethylene dichloroethane

and thermal cracking at 500 °C, 26 atm

$$C_2H_4Cl_2 \longrightarrow C_2H_3Cl + HCl$$

dichloroethane vinyl chloride

Assume that both reactions are complete with 100% conversion.

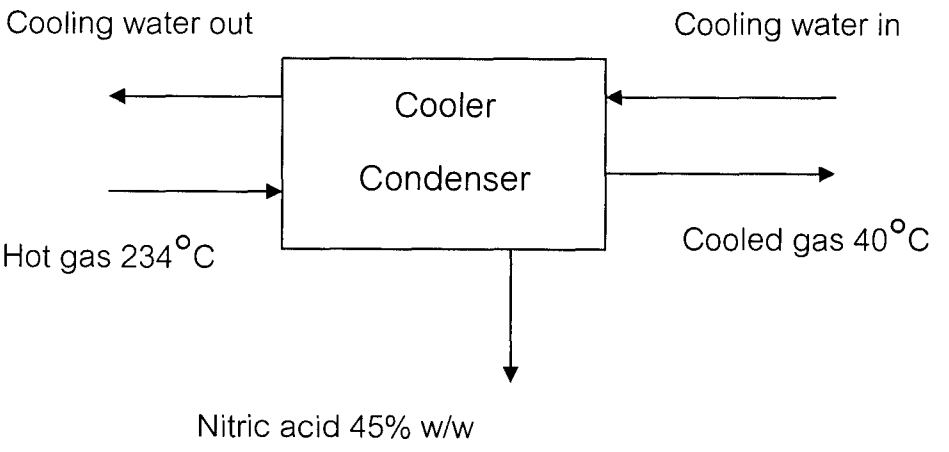
Data for boiling points:

Chemicals	Normal Boiling Point	Boiling Points (°C)		
	(°C) at 1 atm	4.8 atm	12 atm	26 atm
HCl	-84.8	-51.7	-26.2	0
C_2H_3Cl	-13.8	33.1	70.5	110
$C_2H_4Cl_2$	83.7	146	193	242

Design and draw a process flowsheet manually for production of vinyl chloride.

(15 marks)

b) In a nitric acid process the 45%w/w acid is partly produced at the cooler condenser. The heat flows and other heat sources around the cooler condenser are given below.



Student Name: .... Code : .....

Hot gas inlet	4.22×10^9	J/h
Cooled gas outlet	0.23×10^9	J/h
Nitric acid 45% w/w outlet	0.12×10^9	J/h
Oxidation of NO	2.96×10^9	J/h
Condensation of water	4.53×10^9	J/h
Nitric acid 100% w/w formation	1.29×10^9	J/h
Dilution of nitric acid	0.33×10^9	J/h

b.1) Calculate the amount of heat removed by the cooling water in J/h.

b.2) Describe design procedure for the shell-and-tube type cooler condenser from the above information.

(15 marks)

Answer to Q2 a).

Student Name: ..... Code : .....

3. Synthesis of ammonia from nitrogen and hydrogen follows the reaction

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

The process flowsheet is shown on next page. The Feed 1 stream contains N_2 100 mol/h, H_2 300 mol/h and impurity argon Ar 5 mol/h.

Reactor conversion on N_2 is 60%.

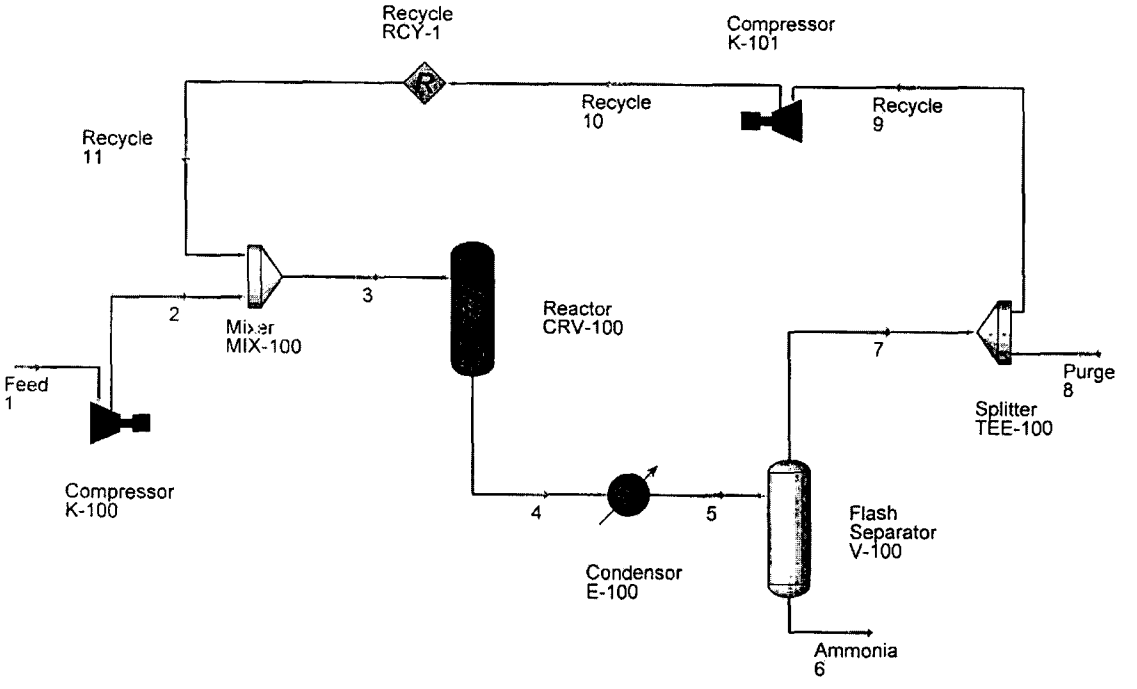
The flash separator gives perfect separation for ammonia product.

The molar flow ratio of purge-to recycle is 0.2.

Write a spreadsheet program by filling in formulas in cells on the provided spreadsheet to estimate the molar flow rates of N_2, NH_3 and Ar in streams 3, 4, 6, 7, 8 and 9 for iteration 1. Explain criteria used for performing other iterations.

(20 marks)

Student Name: ..... Code : .....



Answer to Q3

	A	B	C	D	E
1	Reaction	$N_2 + 3H_2$	$\longrightarrow$	$2NH_3$	
2	Fractional Conversion	0.6	Ratio: Purge8/Recycle7	0.2	
3	Stream Feed 1or 2 (mol/h)	N_2	NH_3	Ar	H_2
4		100	200	5	300
5					
6					
7					
8	Molar Flow mol/h	N_2	NH_3	Ar	H_2
9	Stream 3				
10	Stream 4				
11	Stream 6				
12	Stream 7				
13	Stream 8				
14	Stream 9				

Student Name: ..... Code : .....

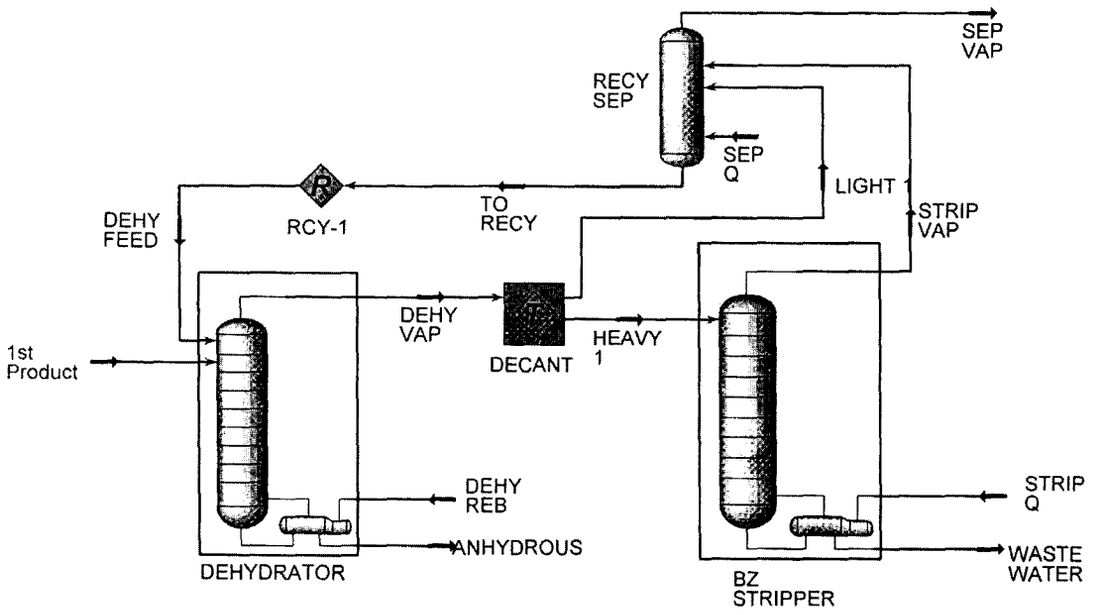
4. Ethanol can be produced from fermentation of bio-materials such as sugar cane and cassava. It must be purified in the first separation step to increase the ethanol mole fraction from about 0.2 to 0.8831 mole fraction. This ethanol is called "1st product" and has composition 0.8831 and 0.1169 mole fraction of ethanol and water respectively. It is further purified in a process shown on next page in order to produce anhydrous (ethanol) product. The simulation HYSYS workbook is also provided.

Unit Operation type:	Dehydrator:	Reboiled absorber
	BZ Stripper:	Reboiled absorber
	Recysep	Separator
	Decant	Sub-flowsheet T containing condenser and settler
	RCY-1	Recycle (operator for HYSYS)

Describe steps for drawing and simulation of this process flow diagram by HYSYS simulation program.

(20 marks)

Student Name: ..... Code : .....



Material Streams Fluid Pkg: All

Name		1st Product	DEHY FEED	ANHYDROUS	LIGHT 1	HEAVY 1
Vapour Fraction		0.0000	0.0000	0.0000	0.0000	0.0000
Temperature	(C)	78.10 *	55.00 *	78.17	25.00	25.00
Pressure	(kPa)	101.3 *	101.3 *	101.3	101.3	101.3
Molar Flow	(kgmole/h)	68.84 *	221.0 *	60.89	220.0	8.992
Mass Flow	(kg/h)	2946	1.414e+004	2805	1.411e+004	173.2
Liquid Volume Flow	(m3/h)	3.664	16.55	3.524	16.51	0.1781
Heat Flow	(kJ/h)	-1.866e+007	-1.933e+007	-1.643e+007	-1.997e+007	-2.557e+006
Name		STRIP VAP	WASTE WATER	SEP VAP	TO RECY	DEHY VAP
Vapour Fraction		1.0000	0.0000	1.0000	0.0000	1.0000
Temperature	(C)	87.43	99.97	55.00	55.00 *	66.29
Pressure	(kPa)	101.3	101.3	101.3	101.3	101.3
Molar Flow	(kgmole/h)	0.9425	8.049	0.0000	220.9	228.9
Mass Flow	(kg/h)	28.15	145.0	0.0000	1.414e+004	1.428e+004
Liquid Volume Flow	(m3/h)	3.275e-002	0.1453	0.0000	16.54	16.69
Heat Flow	(kJ/h)	-2.195e+005	-2.247e+006	0.0000	-1.930e+007	-1.315e+007

Compositions Fluid Pkg: All

Name	1st Product	DEHY FEED	ANHYDROUS	LIGHT 1	HEAVY 1
Comp Mole Frac (Ethanol)	0.8831 *	0.4202 *	1.0000	0.4200	0.0425
Comp Mole Frac (H2O)	0.1169 *	0.0109 *	0.0000	0.0084	0.9566
Comp Mole Frac (Benzene)	0.0000 *	0.5689 *	0.0000	0.5716	0.0009
Name	STRIP VAP	WASTE WATER	SEP VAP	TO RECY	DEHY VAP
Comp Mole Frac (Ethanol)	0.4047	0.0001	0.4044	0.4199	0.4052
Comp Mole Frac (H2O)	0.5871	0.9999	0.0218	0.0109	0.0456
Comp Mole Frac (Benzene)	0.0082	0.0000	0.5738	0.5692	0.5492

Energy Streams Fluid Pkg: All

Name		DEHY REB	STRIP Q	SEP Q		
Heat Flow	(kJ/h)	8.416e+006	8.967e+004	8.859e+005		

Unit Ops