

PRINCE OF SONGKLA UNIVERSITY
FACULTY OF ENGINEERING

Midterm Examination: Semester II

Academic Year: 2007

Date: 28 December 2007

Time: 13.30 - 16.30

Subject: 230 - 432 Chemical Engineering Plant

Room: Robot Head

Design

Student Name: Code:

Number of questions : 4

Time : 3 hours

Total marks : 110

Books and notes are not allowed

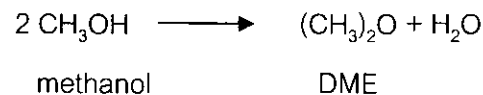
Calculators and writing in pencil are allowed.

Question	Full Marks	Marks Received
1	30	
2	25	
3	35	
4	20	
Total	110	

ทฤษฎีในการสอบโทษขั้นต่ำคือ ปรับตกในรายวิชาที่ทฤษฎี และพักการเรียน 1 ภาคการศึกษา

Student Name: Code :

1. a) Describe the job responsibilities and relationships for licensor and contractor in chemical process industries. (3 marks)
- b) List the steps in designing a chemical process plant from the project inception to plant startup. (3 marks)
- c) List the steps in total purchased-equipment cost estimation. (3 marks)
- d) List major components for total capital investment estimation for a new chemical plant. (3 marks)
- e) From the "heuristics" for process design, what are criteria used in introducing a purge stream in the process? (3 marks)
- f) From the "heuristics" for equipment design, what are criteria used to determine the sequence or order of distillation columns for separating multi-component mixtures? (3 marks)
- g) Dimethyl ether (DME) is produced by catalytic dehydration of methanol. The main reaction is as follows:



Chemicals	Boiling Point (°C) @ 1 bar	Mol Wt
Methanol	64.7	32.04
DME	-23.7	46.07
Water	100	18.01

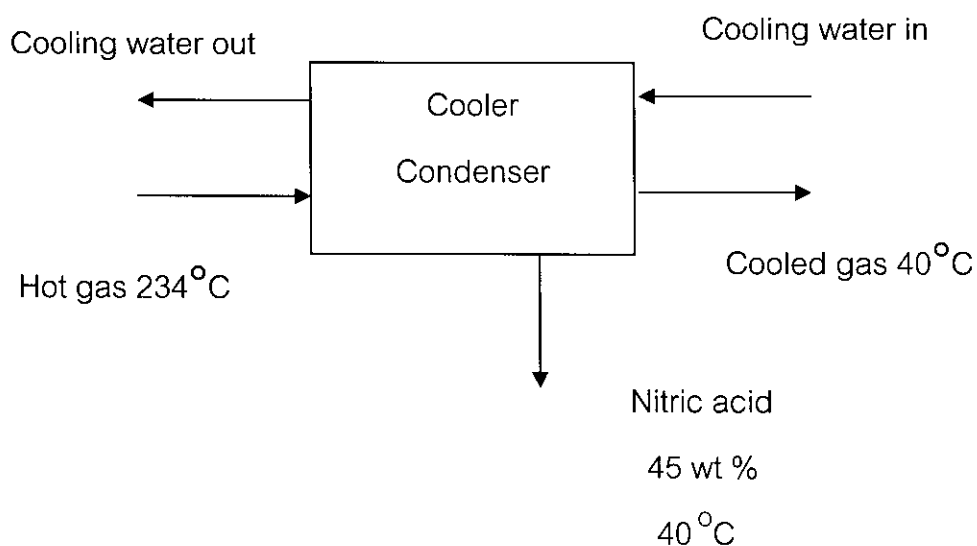
A fixed-bed reactor is used and operating at 15 bar, 250-365 °C. The reactor conversion is 80%. High purity of 95% is required for DME product. Draw a process flow diagram for a DME process. Give reasons for sequence or order of position of equipment.

(12 marks)

Student Name: Code :

2.a) From the nitric acid process you have learned in details in class, the hot inlet gas mixture to the cooler condenser consists of NO, H₂O, O₂ and N₂. The reactions that occur are oxidation of NO to NO₂ and the formation of HNO₃. Both reactions are exothermic. Write all names of heat components necessary for performing heat balance around the cooler condenser.

(5 marks)



b) From the names of heat components in Question 2a), write heat balance equation for heat removed from the condenser.

(5 marks)

c) If 20 kgmol/h of pure nitric acid is condensed into the nitric acid steam in the above figure, calculate heat of dilution in kJ/h at datum temperature of 25 °C. An enthalpy-concentration diagram is provided on next page.

Conversion factors:

$$1 \text{ Btu}/(\text{lb } ^\circ\text{F}) = 4.186 \text{ kJ}/(\text{kg K})$$

$$1 \text{ Btu}/\text{lb} = 2.326 \text{ kJ}/\text{kg}$$

. Mol.wt. of HNO₃ is 63 g/gmol.

(15 marks)

Student Name: Code :

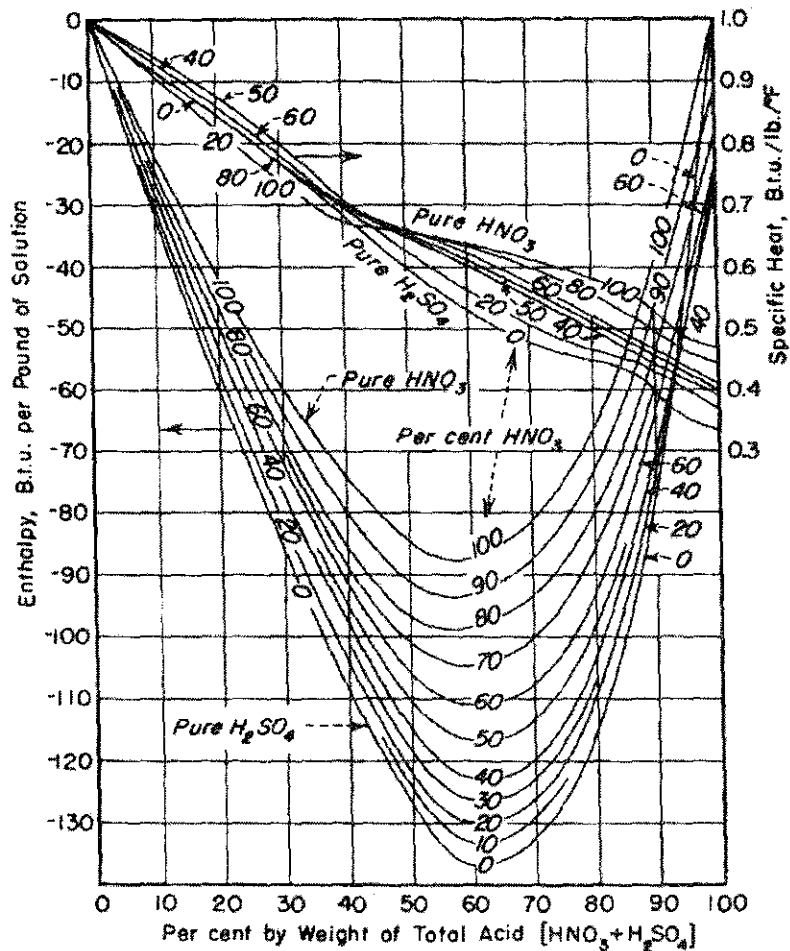


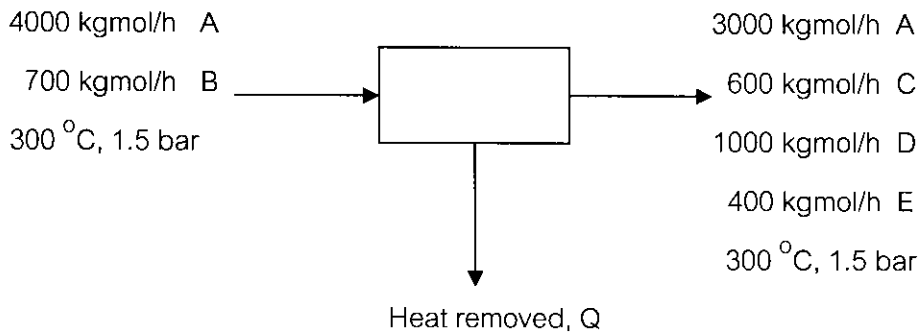
FIG. Enthalpy-concentration diagram for aqueous sulfuric and nitric acids at 32°F. Reference states: enthalpy of pure components at 32°F is zero. **NOTE:** The percent HNO₃ is computed on a water-free basis. Enthalpies at temperatures other than 32°F may be computed by utilizing the specific-heat data given, which may be assumed to be independent of temperature as a first approximation. [McKinley and Brown, Chem. Metall. Eng., 49, 142 (1942).]

Student Name: Code :

3.a) The required chemical product C is produced by reaction (3.1). A and B are raw materials. Product C can further reacts to form by-product E according to reaction (3.2). Both reactions are exothermic and heat must be removed from the reactor in order to keep the reaction temperature constant at 300°C. Feed and product mixtures are vapors. Conversion of A is 25%.



The block flow diagram is shown below.



Standard enthalpy of reaction at 25 °C for reaction (3.1) is -173.1 kJ/kgmol

Standard enthalpy of reaction at 25 °C for reaction (3.2) is -266.6 kJ/kgmol

Chemicals	C_p J/kgmol °C
A	65.5
B	29.3
C	54.7
D	33.6
E	66.5

At datum temperature 25 °C, calculate the heat that must be removed, Q to keep the reaction temperature at 300 °C in kJ/h. Assume that C_p are constant over the working temperature range. (15 marks)

Student Name: Code :

b) From the information in question 3a), if C_p values for all components change with temperature according to equation $C_p = a + bT + cT^2 + dT^3$ J/kgmol K where T is temperature, K write a spreadsheet for Excel program on the provided sheet for heat that must be removed from the reactor.

The values for temperature constants are:

a_1, b_1, c_1 and d_1 for component A,

a_2, b_2, c_2 and d_2 for component B

a_3, b_3, c_3 and d_3 for component C

a_4, b_4, c_4 and d_4 for component D

a_5, b_5, c_5 and d_5 for component E

Specify the cell name and cell formula for calculation of heat content of component A in the inlet stream in kJ/kgmol h.

Specify the cell name and cell formula for calculation of heat removed in kJ/kgmol h .

(20 marks)

Answer to Q3 a).

Student Name: Code :

- 4.a) In selecting the plant site or location for a new process plant, a number of factors must be considered. Write short comments on
- 1) Water supply
 - 2) Community factors
- b) Plant layout depends on many factors. What is the meaning of minimum distance between equipment? What are considerations used in specifying them?
- c) What are the major factors used for setting the plant layout?
- d) What is pipe rack? What are important factors in pipe rack design?
- e) Explain the meaning of Tray Sizing.
- f) Explain the meaning of Tray Rating.
- g) Explain the meaning of LD_{50} .
- h) Explain the meaning of TLV.
- i) In Aspen Plus petroleum processing plant, give comments on the function and size of a stripper located on the side of a main column.
- j) In Aspen Plus petroleum processing plant, give comments and compare the preflash column and the crude column on operating conditions and products.

(20 marks)