PRINCE OF SONGKLA UNIVERSITY

FACULTY OF ENGINEERING

Midterm Examination: Semester I | Academic Year: 2009

Date: 26 July 2009 | Time: 9.00 - 12.00

Subject: 230 - 432 Chemical Engineering Plant Design | Room: S102

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

Number of questions : 4

Time : 3 hours

Total marks : 100

Books and notes are not allowed

Calculator and writing in pencil are allowed.

Question	Full Marks	Marks Received
1	35	
2	20	
3	20	
4	25	
Total	100	

ทุจริตในการสอบโทษขั้นต่ำคือ ปรับตกในรายวิชาที่ทุจริต และพักการเรียน 1 ภาคการศึกษา

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

1. a) A plant-design project consists of a series of stages before a complete plant is ready for operation. Give a list of steps in developing a project.

(4 marks)

b) Give two names of large Thai operating companies and two names of international contractors with active business in Rayong province.

(4 marks)

c) Give name of an international chemical company with large investment in R&D. How would you compare the amount of investment paid in R&D among chemical companies? What is the range of this figure?

(4 marks)

d) In the nitric acid process learned in class, nitrogen gas flows in large amount throughout the process. What heuristics for process design should be applied to this stream component? At which point in the process? How? Explain.

(4 marks)

e) Methyl tertiary butyl ether (MTBE) is used as an anti-knock in petrol. It is manufactured by the reaction of isobutene with methanol. The reaction is highly selective and practically any C_4 stream containing isobutene can be used as feed stock.

$$CH_2=C(CH_3)_2 + CH_3OH \dashrightarrow (CH_3)_3\text{-}C\text{-}O\text{-}CH_3$$

Isobutene methanol MTBE

A 10 per cent excess of methanol is used to suppress side reactions.

In a typical process, the conversion of isobutene in the reactor stage is 97 per cent. The product is separated from the unreacted methanol and any C4's by distillation. The essentially pure, liquid, MTBE leaves the base of the distillation column and is sent to storage. The methanol and C4's leave the top of the column as vapor and pass to a column where the methanol is separated by absorption in water. The C4's leave the top of the absorption column, saturated with water, and are used as a fuel gas. The methanol is separated from the water solvent by distillation and recycled to

the reactor stage. The water, which leaves the base of the column, is recycled to the absorption column. A purge is taken from the water recycle stream to prevent the build-up of impurities.

Draw a flow sheet for the process.

Treat the C4's other than isobutene, as one component.

(7 marks)

f) Cyclohexane is produced by catalytic hydrogenation of benzene at high temperature and pressure by the following reaction.

$$C_6H_6 + 3H_2 \rightarrow C_6H_{12}$$

Benzene hydrogen Cyclohexane

The process flowsheet shows that there are two reactors in series. The catalyst in the first reactor is Raney nickel dispersed in reactants, while the second contains a fixed bed of alumina-supported nickel catalyst. Hydrogen is supplied in excess to the first reactor. Hydrogen is partly recycled from the separator V3304. Conversion of benzene is 99.9%. The reaction is highly exothermic and the heat is recovered by making plant steam at the heat exchanger E3303 which acts as a waste heat boiler. The first reactor operates at 200°C, 34 bar while the second reactor operates at 175°C, 15 bar. Cyclohexane is kept in product tank T3601.

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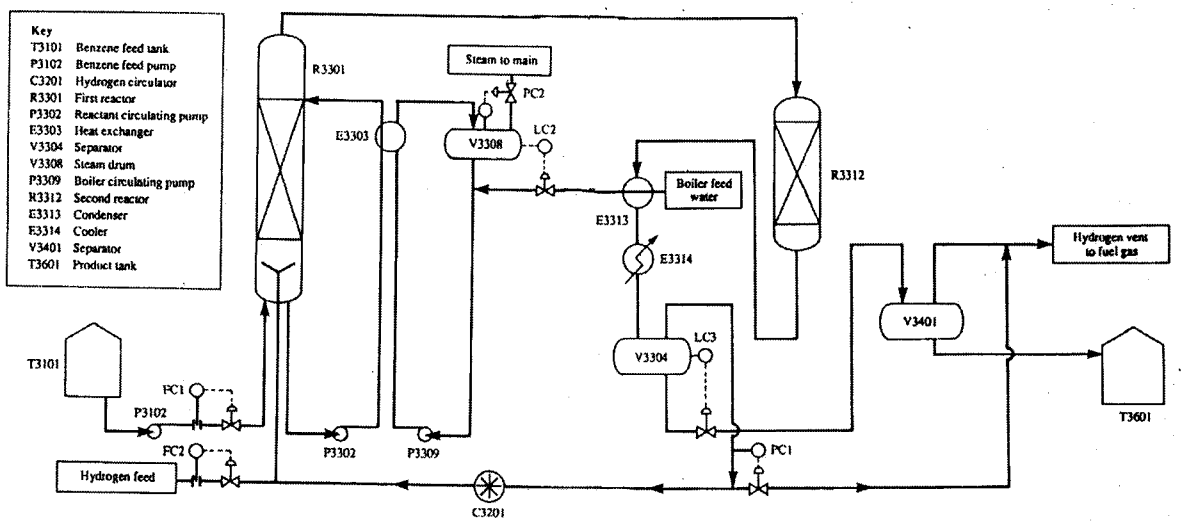

Chemicals	Boiling Point (°C) @ 1 bar	Mol Wt
benzene	80.1	78.11
hydrogen	-252.7	2.016
cyclohexane	80	84.16

Try to understand the flowsheet and answer the following questions.

f.1) How is the heat of reaction removed?

f.2) What is the equipment type and function of V3401?

f.3) If hydrogen feed is supplied from a reciprocating compressor, will the arrangement of FC2 as shown be satisfactory? Sketch an acceptable arrangement.

(12 marks)

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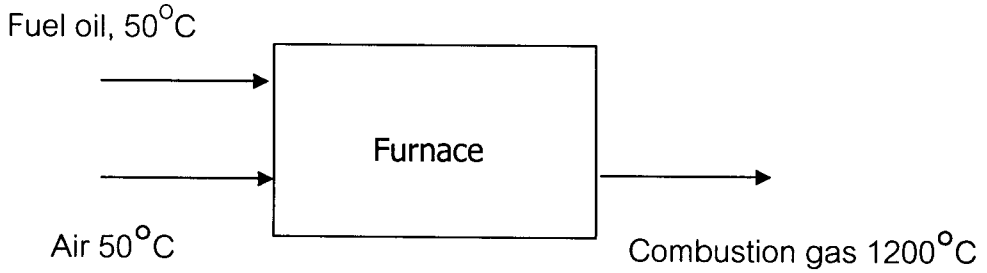
2. Fuel oil and air are fed to a furnace and burned to produce combustion gas as shown in the figure below. The air contains O_2 and N_2.The product gas consists of O_2, N_2, CO_2 and H_20.



Properties of the fuel oil are:

Calorific value	39540	kJ/kg
Latent heat of vaporization	350	kJ/kg
Heat capacity	1.6	kJ/kg K

Fuel oil feed rate is 250 kg/h.

Air and combustion gas component flow rates and temperature constant values for C_p are:

Component Flow rates, k mol/h Constant values for C_p

COMP	Inlet Gas Excluding Fuel Oil(Kmol/h)	Outlet Gas (Kmol/h)	a	b	c	d
O_2	27.88	4.925	a1	b1	c1	d1
N_2	104.88	104.95	a2	b2	c2	d2
CO_2	0	18.225	a3	b3	c3	d3
H_2O	0	10.00	a4	b4	c4	d4

The C_P values for all components change with temperature according to equation

$C_p = a + bT + cT^2 + dT^3$ kJ/kgmol K where T is temperature, K.

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Write a spreadsheet for Excel program on the provided sheet for calculation of cooling rate required at the furnace in kJ/h. Show the cell formula for the heat content of O_2 component in the feed stream in kJ/kg mol. Use datum temperature $25^{o}C$.

(20 marks)

Answer to Q2.

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Answer to Q2 (continued)

	A	B	C	D	E	F	G	H	I	J	K
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3. From Question 2 if the constant values for C_p are as shown in the table below, calculate the cooling rate required at the furnace in kJ/h. Again use datum temperature 25^{O}C. Note that E means 10th power as in Excel program. Use all other information from question2.

(20 marks)

COMP	Inlet Gas excluding fuel oil (Kmol/h)	Outlet Gas (Kmol/h)	a	b	c	d
O_2	27.88	4.925	28.06	-3.670E-06	1.743E-05	-1.060E-08
N_2	104.88	104.95	31.099	-1.354E-02	2.675E-05	-1.170E-08
CO_2	0	18.225	19.763	7.330E-02	-5.520E-05	1.713E-08
H_2O	0	10.00	32.19	1.921E-03	1.054E-05	-3.590E-09

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4.a) Hot gas produced from reactor in the process are recovered by producing steam for plant use. If only the hot gas inlet composition and its temperature are known, how would you design the boiler or heat exchanger for energy recovery?

(5 marks)

b) Suggest the factors that should be considered in the layout of a condenser in the process plant.

(3 marks)

c) In selecting the plant site or location for a new process plant, a number of factors must be considered. Write short comments on

1) Taxation and legal restrictions

2) Site characteristics

(4 marks)

d) Explain the meanings of LC and NIOSH

(4 marks)

e) Explain the meaning of Tray Sizing.

(3 marks)

f) Compare the operating temperatures and pressures for Preflash column and Crude column in Aspen Plus petroleum processing plant,

(3 marks)

g) Explain the function of pumparounds at the Crude column.

(3 marks)

---------- END of last question