

B.Tech. (Chemical Engineering) Eighth Semester (C.B.S.)
Elective-III : Chemical Process Synthesis and Design

P. Pages : 3

NRT/KS/19/3810

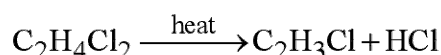
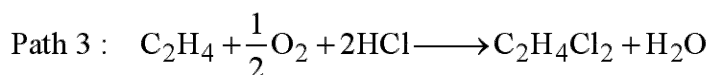
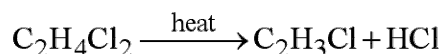
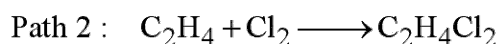
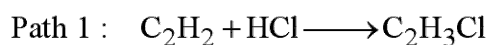
Time : Three Hours



Max. Marks : 80

- Notes :
- All questions carry marks as indicated.
 - Diagrams and chemical equations should be given whenever necessary.
 - Illustrate your answers whenever necessary with the help of neat sketches.
 - Answer **any five** questions.

- Discuss the hierarchy of chemical process design & integration with the help of onion model. **8**
 - Explain how the market, into which the chemical products are being sold, influences the objectives & priorities in the design. **8**
- Given objective is to manufacture vinyl chloride, there are atleast three reaction paths that can be readily exploited. **8**



The market values & molar masses of the materials involved are given below.

Material	Molar Mass (kg/kmol)	Value (\$/kg)
Acetylene	26	1.0
Chlorine	71	0.23
Ethylene	28	0.53
Hydrogen Chloride	36	0.39
Vinyl chloride	62	0.46

Oxygen is considered to be free at this stage, coming from atmosphere. Which reaction path makes most sense on the basis of raw material cost, product & by-product values ?

- Explain types of reaction systems with proper examples. **8**
- Explain the concept of separation of azeotropic mixture with the help of triangular diagram & lever rule. **8**
 - Write notes on absorption & stripping with labelled diagrams. **8**

4. a) A heat recovery problem consists of two streams given in following table. 8

Stream	Type	Supply Temp. (°C)	Target Temp (°C)	Enthalpy (MW)
1	Hot	100	40	12
2	Cold	10	150	7

Steam is available at 180°C & cooling water at 20°C. For minimum permissible temperature difference (ΔT_{\min}) of 10°C, calculate the minimum hot & cold utility requirements. Also draw the flowsheet of heat exchange with hot & cold streams.

- b) Explain the heat integration characteristics of dryer with evolving dryer design to improve heat integration. 8

5. a) Each component for the mixture of alkanes is to be separated into relatively pure products. 8

Component	Flowrate (kmol/hr)	Boiling Point (k)	Relative Volatility	Relative volatility between adjacent components
A : Propane	45.4	231	5.78	
B : i-Butane	136.1	261	2.98	1.94
C : n-Butane	226.8	273	2.36	1.26
D : i-Pentane	181.4	301	1.21	1.95
E : n-Pentane	317.5	309	1.00	1.21

Use the heuristics to identify the potentially good sequence that are candidates for further evaluation.

- b) Explain the sequencing of distillation column using thermal coupling for the separation of 3-component mixture. 8

6. a) Explain intensification & attenuation of hazardous materials. 8

- b) Compare the flammability hazard of storing 1000 kmol of cyclohexane at 100°C & 200°C, using catastrophic failure of the vessel as a basis for comparison. The atmospheric boiling point of cyclo-hexane is 81°C, its latent heat of vaporization is 30,000 kJ/kmol, liquid heat capacity is 210 kJ/kmol.k, & its heat of combustion is 3.95×10^6 kJ/kmol. How much theoretical heat of combustion would be released in the event of an explosion ? 8

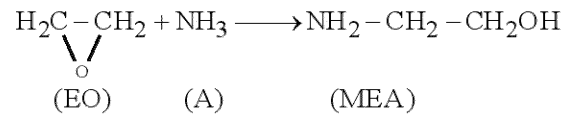
7. a) A company manufactures two products (Product-1 & Product-2) in a batch plant involving two steps (Step-I & Step-II). The value of product 1 is 3 \$/kg & of Product 2 is 2 \$/kg. Each batch has same capacity of 1000 kg/batch, but batch cycle time differs between the products, given below. 8

	Step - I (hr)	Step - II (hr)
Product - 1	25	10
Product - 2	10	20

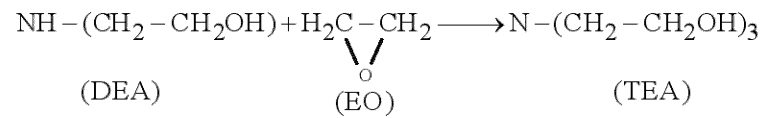
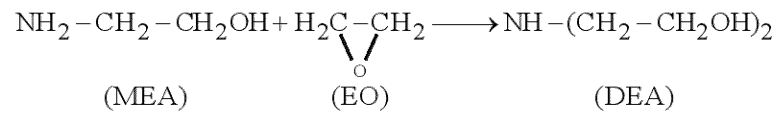
Step - I has the maximum operating time of 5000 hr/year & Step - II has 6000 hr/year. Determine the operation of the plant to obtain the maximum annual revenue.

- b) Write notes on adsorption & liquid-liquid extraction. 8

8. a) Monoethanol amine (MEA) is a desired product. It can be produced from ethylene oxide (EO) & ammonia (A). 8



Two secondary reactions occur to form diethanol amine (DEA) & triethanol amine (TEA) as follows :



Secondary reactions are parallel with respect to ethylene oxide, but are in series with respect to MEA. Monoethanol amine is more valuable than di- & tri-ethanol amine. Make an initial choice of reactor.

- b) Write notes on toxic release in chemical process industry. 8
