(3 Hours) **Total Marks: 80**

N.B.: (1) Question No.1 is compulsory.
(2) Attempt any **Three** out of remaining questions.
(3) Assume any suitable data if necessary and indicate it clearly.
(4) Draw neat sketches wherever required.
(5) Answer to the sub-questions of an individual question should be grouped and written together i.e. one below the other.

Q.1. (a) Write and explain general material balance over: **04**
(i) Mixer (ii) Splitter

(b) What are the applications of "vacuum" and "nitrogen" as utility in chemical industries? **04**

(c) Based upon degree of freedom analysis, how the number of controllers required in any process are decided? What are the general thumb rules to be followed while designing control structure for process? **04**

(d) What are the design heuristics for selecting between Batch and Continuous process? **04**

(e) Explain the concept of "fire triangle" and different types of fire **04**

Q.2. (a) What are the common features of sulphonation process? Draw PPS for manufacture of linear alkyl benzene sulphonate from linear alkyl benzene and SO_3 as raw materials. Also explain why hot dry air is mixed with SO_3 vapours used for sulphonation. **(10)**

(b) What can be various types of feed impurities and according to characteristic of each type of impurity, what feed purification guidelines, will you suggest? **(10)**

Q.3. (a) A feed mixture containing 70 moles of component 1, 100 moles of component 2 and 90 moles of component 3 is to be separated in flash column. Pressure and temperature for this flash operation is 1400 mm Hg and 300 K respectively. The overhead recovery of key component is 60%. Then calculate the component flow rates in overhead and bottom stream from flash column. The component with intermediate volatility can be selected as key component. **(10)**

Data:

Component	Antoine Constants		
	A	B	C
1	15.84	2480	- 40
2	15.82	2200	- 36
3	15.68	2150	- 34

TURN OVER

(b) Consider the reactor where the following reactions are occurring. Methane and Ethane are the limiting reactants in the 1st and 2nd reaction respectively. Conversion per pass is 70% and 80% for the 1st and 2nd reaction respectively. Then develop the general model of material balance equations for each of the components involved in this process. **(10)**

$$CH_4 + 2\,O_2 \longrightarrow CO_2 + 2\,H_2O$$

$$C_2H_6 + 3.5\,O_2 \longrightarrow 2\,CO_2 + 3\,H_2O$$

Q.4. (a) 900 gmol/s of 60/40 mole% mixture of benzene and xylene are separated at 2 atm in distillation column. The overhead recoveries of light and heavy key components are 0.8 and 0.15 respectively. Then find the theoretical number of trays, reflux ratio and column height if 24" tray spacing and disengagement space of 2 m each at top and bottom is used (ignore support height). **(10)**

Data:

Component	P_{vap} (kPa)	T_{boil} (K)
Benzene	91.5	353.3
Xylene	11.17	417.6

(b) A counter current heat exchanger is used to cool the air from 386 K to 305 K with cooling water entering at 300 K and leaving at 322 K. The overall heat transfer coefficient for this heat exchanger is 120 W/m^{2}K. Heat duty for this HEx is 30 kW. Then calculate updated bare module cost for this HEx. **(10)**

$\mathbf{S_o}$ = 5.5 ft^2, $\boldsymbol{\alpha}$ = 0.024, $\mathbf{C_o}$ = Rs. 20400, **MF** = 1.83, $\mathbf{F_m}$ = 1.78, $\mathbf{F_p}$ = 0.25, $\mathbf{F_d}$ = 0.85, **CI** in base year = 395, **CI** in present year = 1125.

Q.5. (a) Discuss in detail, the role of Process engineer in process industries. **(10)**

(b) Explain in detail about "Fault Tree Analysis", risk assessment methodology. **(10)**

Q.6. (a) For the process stream data given below, determine $\mathbf{Q_{H,min}}$, $\mathbf{Q_{C,min}}$ and pinch temperature for $\mathbf{\Delta T_{min}}$ = 10 °C. **(10)**

Streams	MCp (kW/°C)	Tin (°C)	Tout (°C)
1	6	60	180
2	5.2	30	130
3	4	180	40
4	8	150	40

(b) Discuss about PFD in detail. **(10)**
