(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) Describe criteria of selection between tray tower and packed tower. **(05)**

(b) Explain the characteristics of process flow diagram. **(05)**

(c) Draw and explain the onion diagram representing hierarchy of chemical process design. **(05)**

(d) What are the basic functions of process engineer? **(05)**

Q.2. (a) Benzene at 37.8^0 C is pumped through the system at a rate of 9.09 m^3 /h with the help of Centrifugal pump. The reservoir is at atmospheric pressure. Pressure at the end of discharge line is 345 Kpa g. The discharge head is 3.05 m and the pump suction head is 1.22 m above the level of liquid in reservoir. The friction loss in suction line is 3.45 kPa and that in the discharge line is 37.9 kPa. The mechanical efficiency of the pump is 0.6. The density of benzene is 865 Kg/m^3 and its vapour pressure at 37.8 ^{0}C is 26.2 kPa. Calculate: **(12)**
(i) $(NPSH)_A$ of the pump
(ii) Power required by centrifugal pump

(b) The fluid density is 1200 kg/m^3 and is being pumped at the rate of 800 m^3/day. The inlet and exit pressures for the pump are 300 and 600 kPa respectively. The efficiency of pump and associated motor are 75% and 85% respectively. Then calculate, break horse power of the pump and its bare module cost in present year. **(08)**
Data: $\mathbf{C_o}$ = Rs. 45000; $\mathbf{S_o}$ = 2000 watt; α = 0.36; $\mathbf{F_m}$ = 1; $\mathbf{F_o}$ = 1.5; **MF** = 3.38; **CI** in present year = 1200; **CI** in base year = 390

Q.3. (a) Design an orifice meter based on the following data: **(12)**
Name of fluid = water; Flow rate= 100000 kg/h;
β = 0.5; Y = expansion factor for liquid = 1; $L_1 = L_2 = 1$;
Inside diameter of pipe = 154 mm
Operating temp 32 ^{O}C
Density of water at 32 ^{O}C = 995.026 kg/m^3
Viscosity of water at 32 ^{O}C = 0.765 cP
Manometric fluid = Mercury
Density of mercury at 32 ^{O}C = 13516.47 kg/m^3.

(b) Explain catalyst degradation process in detail. **(08)**

Q.4. (a) A distillation column is to separate 4750 mol/h of feed composed of 37% n-butane, 32% iso-pentane, 21% n- pentane and 10% n-hexane. The column operates at an average pressure of 2 atm a and will produce a distillate product containing 95 % n- butane and 5% iso pentane. The bottom product is allowed to contain no more than 570 mol/h of n- butane. Feed is 25% vapour. Assume ideal vapour liquid equilibrium. All compositions are mole %. Find: **(12)**

(i) Residue and distillate compositions
(ii) q (Feed at 25% vap)
(iii)Use Underwoods method to determine the minimum reflux for required separation
Data: ν (constant used in Underwood equation) = 1.6045

	n-butane	iso pentane
α_{av}	2.567	1

(b) Explain common types of reactor configuration. **(08)**

Q.5. (a) Explain design and working of short path distillation unit along with its application **(12)**

(b) Explain role and responsibilities of process and chemical engineering profession towards society, and environment along with its ethical aspects and safety concerns. **(08)**

Q.6. Explain the following **(any four)**

(a) Sizing of compressor and turbine **(05)**

(b) Algorithm for Design of Absorber **(05)**

(c) Product life cycle **(05)**

(d) Equation of bare module cost of an equipment **(05)**

(e) Optimum pipe size **(05)**

****