22/05/2025 TE CHEMICAL SEM-VI C-SCHEME PEE QP CODE: 10085751

Time: 3 Hours **Total marks: 80**

N.B.: (1) Question No 1 is compulsory
(2) Attempt any three questions out of remaining five questions
(3) Assume suitable data if necessary and indicate it clearly.
(4) Figures to the right indicate full marks.

Q.1. Solve the following (Any four) **20**

a) Discuss different roles & responsibilities of process engineer.
b) Differentiate between Piping and Instrumentation Diagram (P&ID) and Process Flow Diagram (PFD).
c) Discuss significance of different types of trays used in distillation column.
d) Differentiate between physical and functional depreciation.
e) Draw tree diagram showing cash flow in an industrial operation.
f) Explain the various types of costs.

Q.2. a) Find out area of heat exchanger according to the following specifications and calculate its total installed cost (Updated bare module cost) in year 2015. **12**

Heat Exchanger specifications:
Identification: Condenser;
Function: to condense vapors of methanol;
Overall HTC, U= 975.7w/m^2K;
Type: Horizontal fixed tube sheet;
F_p=0.2;
Heat duty= 1250 kW;
Type of flow: Counter current flow;
Tube side specifications: Fluid: Cooling water, T_{in}= 25^{0}C, T_{out}= 45^{0}C;
Shell side specifications: Fluid: Methanol, T=80^{0}C (Constant);
Tube material: Stainless Steel (SS); Shell material: Stainless Steel (SS).

Design Type	Kettle reboiler	U tube	Fixed tube sheet
F_d	1.35	0.80	0.85

Surface area (m^2)	Shell & Tube material, F_m	
	Carbon steel (CS) / CS	SS / SS
0-10	1.0	2.50
10-50	1.0	3.10

Equipment type	Co (Rs.)	So (m^2)	Range (s) m^2	α	MF
Heat exchanger	25x10^4	37.18	10-900	0.65	4.12
	1.5x10^4	0.51	0.1-10	0.024	183

Cost index (CI)	Year
453	2015
128	Base year

b) A tray dryer was purchased in 2020 of the cost of Rs. 55000 has total 10 trays, each tray has size 45 cm x 28 cm, used in food processing unit. Now, production capacity is increased which require 10 trays of size 2m x 2m. Using six tenth rule, what is the expected cost of new dryer in 2023, if cost index in 2020 is 198 & in 2023 is 205? **08**

Q.3. a) Design an absorber for the following feed stream at 10 bar & 300K to recover 90% of the Diethyl ether in the liquid stream. Find the flow rate of solvent required, theoretical number of trays, Flow rates of liquid & vapour streams leaving the absorber & its composition. **15**

Data:

Component	Flow rate (gmole/s)	Vapour pressure (bar)
n-butane	100	3.4503
Di ethyl ether	5	1.09
n-butanol	2	0.019
water	16	0.061

b) Write 12 steps design process for distillation column. **05**

Q.4. a) A manufacturing plant require an initial fixed capital investment (FCI) of Rs. 50000000 and working capital investment (WCI) of Rs. 7500000. It is estimated that the annual income will be Rs. 45000000 and annual expenses including depreciation will be Rs. 24000000 before income taxes. A minimum annual return of 16% before income taxes is required, before the investment is worthwhile. Income taxes amount to 25% of all pretax profits. Determine the following: **12**

i) Annual % returns on total initial investment before income taxes
ii) Annual % returns on total initial investment after income taxes
iii) Annual % returns on total initial investment before income taxes based on capital recovery with minimum profit.

b) Discuss the following: **08**

i) Payout period method of profitability analysis
ii) Replacement analysis

Q.5 a) Hexane at 37.80 ^{0}C is pumped through the system at a rate of 9.09 m^3 /h. The tank is at atmospheric pressure. Pressure at the end of discharge line is 345 kPa g. The discharge head is 3.05 m and the suction lift is 1.22 m above the level of liquid in the tank. 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 hexane is 659 kg/m^3 and its vapour pressure at 37.8 ^{o}C is 33.71 kPa. Calculate $(NPSH)_A$ **10**

b) A 3 stage reciprocating compressor is used to compress 320 m^3/h of methane from 1 atm to 60 atm. Inlet temperature of methane gas is 28 ^{o}C. Specific heat ratio of methane is 1.31. Calculate: **10**

i) Power required for compression if mechanical efficiency of compressor is 80%
ii) Discharge temperature of gas after 1st stage.

Q.6. a) In order to make it worth-while to purchase a new piece of equipment, the annual depreciation costs for the equipment cannot exceed Rs. 3000 at any time. The original cost of the equipment is Rs. 30000, and it has zero salvage & scrap value. Determine the length of service life necessary if the equipment is depreciated by: **10**

i) Sum of the years digits method
ii) Straight line method

b) For the case of a nominal annual interest rate of 10% for capital of Rs. 5000, determine: **10**
i) Total amount accumulated after one year (365 days) with daily compounding.
ii) Total amount accumulated after 5 years with continuous compounding.
iii) The effective annual interest rate if compounding is continuous.

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