

B.E. CHEMICAL ENGINEERING FOURTH YEAR SECOND SEMESTER - 2018**CHEMICAL PROJECT ENGINEERING & ECONOMICS**

Time: 3 hours

Full Marks: 100

Answer any four questions considering at least one (1) question from each of the COs.

CO1. *To understand, develop and analyse various types of flow diagrams.*

[1] Develop a P&ID for the Process Flow Diagram (PFD) for Benzene Distillation (adapted from Kauffman, D., *Flow Sheets and Diagrams, AIChE Modular Instruction, Series G: Design of Equipment*, series editor J. Beckman, AIChE, New York, 1986, vol. 1, Chapter G.1.5, AIChE copyright © 1986 AIChE, all rights reserved) attached herewith for either:

Zone A: V101: Toluene Feed Drum; R-101: Reactor; P-101 A/B: Toluene Feed Pumps; E-101: Feed Preheater; H-101: Heater.

OR

Zone B: T-101: Benzene Column; V104: Reflux Drum; P-102 A/B: Reflux Pumps; E-103: Feed Preheater; E-104: Benzene Condenser.

Use the following numbering for utility connections:

1. Cooling water
2. C.W. Return
3. 265 PSIA Steam
4. Condensate
5. Sample Port
6. Chemical Sewer
7. Vent to Flare
8. Clear Sewer
9. Vent to Atmosphere
10. CS: Carbon Steel

T-101: Benzene Column; V101: Toluene Feed Drum; V102: High Pressure Phase Separator; V103: Low Pressure Phase Separator; V104: Reflux Drum; R-101: Reactor; P-101 A/B: Toluene Feed Pumps; P-102 A/B: Reflux Pumps; E-101: Feed Preheater; E-102: Reactor Effluent Cooler; E-103: Feed Preheater; E-104: Benzene Condenser; E-105: Product Cooler; E-106: Benzene Reboiler; H-101: Heater; C-101 A/B: Recycle Gas Compressor.

(25)

[Turn over

CO2: To understand and analyse economics of chemical processes with particular emphasis on various methods of cost estimation for the overall project as well as for individual equipment.

[2]

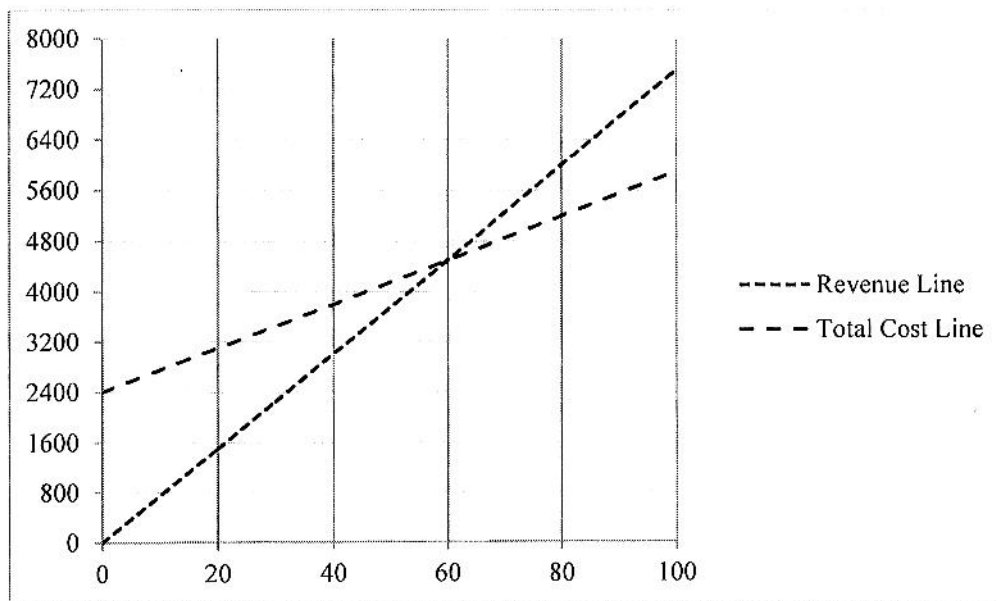
- What are the limitations of breakeven analysis?
- A central air-conditioning unit is purchased for Rs.3,00,000 and has an expected life of 12 years. The salvage value for the unit at that time is expected to be Rs.50,000. What will be the book value at the end of 7 years (*use sum-of-years digits method of depreciation*).
- A process plant has an initial investment of Rs.50 lakhs. The estimated salvage value is Rs.2 lakhs. It has a life of 8 years. Estimate the book value of the plant after 5 years by (i) Straight line depreciation method (ii) Declining balance method and (iii) Sinking fund method with a sinking fund interest rate of 10%.
- Indira Industries is a major producer of diverter dampers used in the gas turbine power industry to divert gas exhausts from the turbine to a side stack, thus reducing the noise to acceptable levels for human environments. Normal production level is 60 diverter systems per month, but due to significantly improved economic conditions in Asia, production is at 72 per month. The following information is available.

Fixed costs FC = INR 2.4 million per month

Variable cost per unit v = INR 35,000

Revenue per unit r = INR 75,000

- How does the increased production level of 72 units per month compare with the current breakeven point?
- What is the current profit level per month for the facility?
- What is the difference between the revenue and variable cost per damper that is necessary to break even at a significantly reduced monthly production level of 45 units, if fixed costs remain constant?



Y Axis in INR 1000; X Axis in number of units per month

(3+5+9+8=25)

[3]

- a. Explain:
- i) Single Factor Sensitivity Analysis
 - ii) Strauss Plot
 - iii) Tornado Chart
- b. Describe briefly Order-Of-Magnitude (**OOM**) estimates of fixed Capital Cost. Recently a cast iron leaf-filter with 100 ft² area was purchased for clarifying an inorganic liquid stream for INR 10,50,000. In a similar application, the company will need a 450 ft² (area) cast iron leaf pressure filter. The size exponent for this type filter is 0.6. Estimate the purchased price of the 450 ft² unit.
- c. How equipment costs are corrected for inflation? In a desalination plant, an evaporator of area 200 m² was purchased in 1996 at a cost of INR 210,00,000. In 2002, another evaporator of area 50 m² was added. What was the cost of the second evaporator (in INR)? Assume that the cost of evaporators scales as (capacity)^{0.54}. The Marshall land Swift index was 1048.5 in 1996 and 1116.9 in 2002.
- d. Describe briefly estimation of fixed capital cost using Lang Factor method with delivered cost and the factor as applicable to the industry type.
- e. The Capital Cost of a pipeline of exotic material is estimated as $3D^{1.5}$ Rs/m. where D is the pipe diameter in mm. The annual maintenance cost is estimated as 10% of the total capital cost. Annual operating cost of the pipe is given as follows:

$$\text{Annual operating cost} = 3 \times 10^{15} / D^5 \text{ Rs/ (m. year)}$$

Estimate the most economic pipe diameter based on the least annual cost approach to the nearest multiple of 10mm. Estimated amortization period is 10years.

(6+4+4+3+8=25)

CO3. *To understand and apply profitability and financial analysis, methods for decision making among alternatives for chemical processes including incremental analysis for retrofitting facilities.*

[4]

- a. Explain two each of the causes and effects of inflation.
- b. Profitability index of a company X is 1.3 and that of company Y is 1.6. Which company has economic dependence?
- c. A furnace installation 'A' costs Rs.1.2 lakhs with operating cost at Rs.48,000 per annum. It has a life of 10 years. The installation 'B' guarantees same performance with an operating cost of Rs.38,000 with an initial cost of Rs.2.5 lakhs. Salvage value for both is Rs.10,000. What increase in life would be required for plan 'B' to warrant its selection if money is worth 10%.
- d. The following proposals are under consideration:

[Turn over

Proposal	A	B	C	D	E
Initial outlay, Rs.	25,000	23,000	12,000	20,000	45,000
Annual cash flow, Rs.	3,000	4,000	2,000	4,000	9,000
Life, years	10	6	7	9	12

Rank these proposals

- in the order of profitability after payback period, and
- using Net Present Value method¹ assuming an interest rate of 10%.

(4+1+5+15=25)

[5]

- What are the advantages of cost flow analysis?
- Ministry of Steel, Government of India, is considering four independent projects [VSP (Vishakhapatnam), BSP (Bhilai), RSP (Rourkela), IISCO (Burnpur)] having different useful lives. The cash flow profile for each project x consists of an initial cost $C_{0,x}$, a stream of uniform annual operating and maintenance costs \bar{C}_x , and a stream of uniform annual benefits \bar{B}_x for years $t = 1, 2, \dots, N_x$ where N_x is the useful life of project x . The salvage value at $t = N_x$ for project x is $S_{N,x}$. There will be no replacement when the useful life of a project expires. The numerical data for these projects are given in the following Table. Ministry of Steel, Government of India intends to adopt a planning horizon of 10 years and specifies a MARR (Minimum Attractive/Acceptable Rate of Return²) of 10%. Determine whether these projects are economically feasible on the basis of the benefit-cost ratio using
 - The given time streams of costs and benefits.
 - The net annual cash flows resulting from the given data.

Project x	Useful Life N_x	Initial Cost $C_{0,x}$ INR	Uniform Annual costs \bar{C}_x , for years $t = 1, 2, \dots, N_x$ INR	Uniform Annual benefits \bar{B}_x for years $t = 1, 2, \dots, N_x$ INR	Salvage Value at $t = N_x$ $S_{N,x}$ INR
1	10	35,00,000	4,20,000	17,82,200	9,80,000
2	4	31,50,000	2,10,000	9,29,600	3,50,000
3	10	28,00,000	2,80,000	11,92,800	7,00,000
4	6	21,00,000	2,45,000	10,58,400	0

(3+2+20=25)

¹ Net present value method (also known as discounted cash flow method) is a popular capital budgeting technique that takes into account the time value of money. It uses net present value of the investment project as the base to accept or reject a proposed investment in projects like purchase of new equipment, purchase of inventory, expansion or addition of existing plant assets and the installation of new plants etc.

² The minimum acceptable rate of return, often abbreviated MARR, is the minimum rate of return on a project a manager or company is willing to accept before starting a project, given its risk and the opportunity cost of forgoing other projects. Discounted Cash Flow Methods may be adopted to calculate MARR.

- For a pure investment opportunity, accept if $IRR > MARR$; reject otherwise.
- For a pure borrowing opportunity, accept if $IRR < MARR$; reject otherwise.

[6]

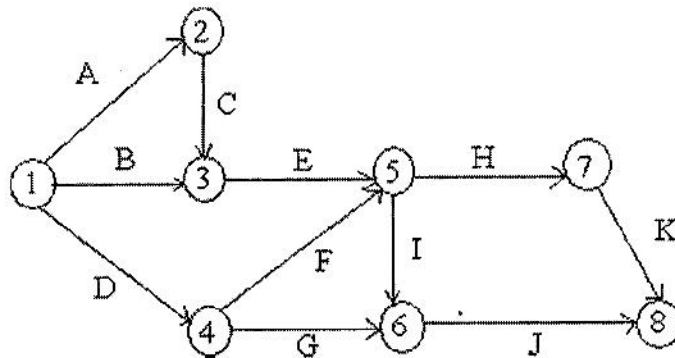
- If one year planning horizon is used, the total annual cost of inventory can be expressed as:_____.
- Estimate the optimum order quantities (Q^*) as per Economic Order Quantity (EOQ) Model and Economic Production Quantity (EPQ) Model.
- ABC manufacturers produces 1,25,000 oil seals each year to satisfy the requirement of their client. They order the metal for the bushing in lot of 30,000 units. It cost them INR 2800 to place the order. The unit cost of bushing is INR 8.4 and the estimated carrying cost is 25% unit cost. Find out the economic order quantity? What percentage of increases or decrease in order quantity is required so that the ordered quantity is an Economic Order Quantity ?
- Name any three methods of Quantitative Approaches of Forecasting.
- One of the two wheeler manufacturing companies experienced irregular but usually increasing demand for three products. The demand was found to be 420 bikes for June and 440 bikes for July. They use a forecasting method which takes average of past year to forecast future demand. Using the simple average method demand forecast for June is found as 320 bikes (Use a smoothing coefficient 0.7 to weight the recent demand most heavily) and find the demand forecast for August.

(3+8+5+3+6=25)

CO4. To understand, apply and integrate the basis of optimum design and scale-up of major and auxiliary chemical equipment.

[7]

- Explain 'Cellular Type Layout'. Enumerate two of the advantages and disadvantages of this type of layout.
- For the following chemical engineering project, find the earliest and latest expected time to each event and also critical path in the network.



Task:	A	B	C	D	E	F	G	H	I	J	K	A
Least time:	4	5	8	2	4	6	8	5	3	5	6	4
Greatest time:	8	10	12	7	10	15	16	9	7	11	13	8
Most likely time:	5	7	11	3	7	9	12	6	5	8	9	5

(7+18=25)

[Turn over

[8]

- a. Enumerate any three steps in a layout design procedure.
- b. Explain briefly a 'Product-Quantity' Chart.
- b. Explain: (a) Geometric Similarity and (b) Dynamic similarity.
- c. A sphere of diameter 1 ft is to be dragged at a speed of 8.45 ft/s in seawater at . To predict the drag, we want to conduct an experiment on a 6" diameter sphere in air flowing past the model sphere. The drag on the model is to be kept at 6 lb-f. Determine the drag on the prototype. Ignoring any cavitation or compressibility effects, expression for drag is :



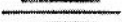

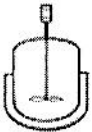






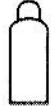











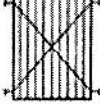
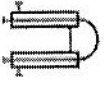



$$\frac{F}{\rho v^2 d_p^2} = f\left(\frac{\rho v d_p}{\mu}\right)$$

















- d. Chemical engineers are involved in scaling up a laboratory scale reaction to the pilot plant scale or full-scale reactor. If one knows the volume of the pilot-scale CSTR required to achieve X_A , how is this information used to achieve X_A in a larger CSTR? How are (a) Space Time and (b) Damkohler No. utilized in scaling-up CSTRs.

(3+2+5+7+8=25)

Symbols of chemical apparatus and equipment

Below are listed some symbols of chemical apparatus and equipment normally used in a P&ID, according to ISO 10628 and ISO 14617

	<u>Pipe</u>		Thermally insulated pipe		Jacketed pipe		Cooled or heated pipe
	Jacketed mixing vessel (autoclave)		Half pipe mixing vessel		Pressurized horizontal vessel		Pressurized vertical vessel
	<u>Pump</u>		<u>Vacuum pump</u> or compressor		Bag		<u>Gas bottle</u>
	Fan		Axial fan, MK, ,		Radial fan		<u>Dryer</u>
	<u>Packed column</u>		<u>Tray column</u>		<u>Furnace</u>		<u>Cooling tower</u>
	<u>Heat exchanger</u>		<u>Heat exchanger</u>		Cooler		<u>Plate & frame heat exchanger</u>
	<u>Double pipe heat exchanger</u>		<u>Fixed straight tubes heat exchanger</u>		U shaped tubes heat exchanger		<u>Spiral heat exchanger</u>

	Covered gas vent		Curved gas vent		(Air) filter		Funnel
	<u>Steam trap</u>		Viewing glass		<u>Pressure reducing valve</u>		<u>Flexible pipe</u>
	<u>Valve</u>		<u>Control valve</u>		Manual valve		<u>Back draft damper</u>
	<u>Needle valve</u>		<u>Butterfly valve</u>		<u>Diaphragm valve</u>		<u>Ball valve</u>