

B.E. CHEMICAL ENGINEERING FOURTH YEAR SECOND SEMESTER - 2019
4th Year, 2nd Semester

CHEMICAL PROJECT ENGINEERING & ECONOMICS

Time: Three Hours

Full Marks: 100

Answer any four questions, taking at least one (1) from each of the COs
All the questions carry equal marks.

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

[1]

- What are the three models of a Block Flow Diagram (BFD). Explain each in a line.
- State four conventions followed in a BFD.
- Propane is dehydrogenated to propene, which is oxidized to acrolein first and then further oxidized to acrylic acid. The products are separated in the end to give acrylic acid and various by-products. The by-products are further separated to yield a propane recycle stream. Draw a BFD for this process.
- Name four items to be excluded from a Process Flow Diagram (PFD).
- Explain PFD in the light of a P&ID.
- Enlist four attributes of a P&ID w.r.t process piping, sizes and identification.
- According to ISO 10628 and ISO 14617, what do the following symbols indicate for a P&ID:

(3+4+3+2+2+4+7=25)

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]

- Define: Time value of money; Book value; Service life; Salvage value; Scrap value.
- Name two accelerated depreciation methods. Explain any one of them.
- The initial cost of an evaporator is Rs.40,00,000 having a useful life of 8 years. The estimated salvage value of the equipment at the end of the useful life is Rs.3,50,000. Find out the book value of the evaporator at the end of 5th year using (i) Straight-line method; (ii) Double-declining balance method; (iii) Sum-of-the-years-digits method and (iv) Sinking fund method, if the interest rate is 8.2 % per year?

(5+4+16=25)

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[3]

- (a) Name any four uses of Capital Cost Estimates.
- (b) Name any four factors contributing to the increase of Capital Cost.
- (c) Elaborate Order-Of-Magnitude (OOM) Estimates as a method for estimation of Fixed Capital Cost.
- (d) Recently a cast iron leaf pressure filter with 1 m^2 was purchased for clarifying an inorganic liquid stream for INR 10,00,000/-. In a similar application, the company will need a 42 m^2 cast iron leaf pressure filter. The size exponent for this type filter is 0.6. Estimate the purchased price of the 42 m^2 unit.
- (e) In a desalination plant, an evaporator of area 20 m^2 was purchased in 1996 at a cost of INR 20,00,000/-. In 2002, another evaporator of area 50 m^2 was added. What was the cost of the second evaporator (in INR)? Assume that the cost of evaporators scale as (capacity)^{0.54}. The Marshall and Swift index was 1048.5 in 1996 and 1116.9 in 2002.
- (f) Explain Turnover Ratio method for estimating fixed capital investment.
- (g) What are the main steps involved in preparing a capital cost estimation based on design.
- (h) Name a factorial method for estimating Fixed Capital Cost and explain it.
- (i) A company is considering an investment in an acetone facility. The engineering department has estimated that the battery-limits fixed capital investment to be INR 13000,00,000/-. Land allocated for the project is INR 340,00,000/- and start-up expenses to be capitalized are expected to be INR 620,00,000/-. The company normally uses 12% of the total capital investment for working capital. Determine the estimated amount of working capital for this project using *percentage method*.

(2+2+3+3+3+2+3+2+5=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) Name two disadvantages of using ROI for profitability analysis.
- (b) Name two disadvantages of using Pay-Back period based method of profitability analysis.
- (c) Explain a break-even plot for Break-Even analysis.
- (d) Explain: (i) Tornado Charts and (ii) Strauss Plot for sensitivity analysis.
- (e) An oil tanker from BPCL containing LSHS (*Low Sulphur Heavy Stock*) needs to be tape-traced electrically for bringing the LSHS at pour point (Grade: General; 66°C). Initial cost of one type of electrical tape is Rs. 5,00,000 per km and annual maintenance cost of this tape is Rs. 50,000. Further it will have one time major repair work of Rs. 1,00,000 per km at the end of 10th year. Another type of electrical tape has initial cost as Rs. "C₂" and annual maintenance cost of Rs. 70,000. It involves periodic expenditure of Rs. 25000 in every 10th year. If both choices have to be equally economical (based on capitalized cost) for the effective interest rate of 15%, compounded annually, how much initial amount one should pay for the second type of electrical tape?

- (f) The Bengal Salt Company is going to purchase an evaporator-crystallizer unit to be used for making commercial grade salt crystals. Two evaporator-crystallizer units are designed. Both are equally capable of giving the required specification of products. The following data apply to these two designs:

	Design 1	Design 2
Fixed capital investment (Rs.)	10,00,000	12,00,000
Estimated useful life(Years)	12	8
Salvage value (Rs.)	75,000	65,000
Sum of operating cost and other costs per year (Rs.)	1,00,000	90,000

By computing the variation in the Net Present Worth for both designs with Minimum Acceptable Rate of Return (MARR) from 8% to 16%, determine the interest rate (approx.) at which both evaporator-crystallizer units will have equal Net Present Worth?

(2+2+2+4+7+8=25)

[5]

- (a) A heat exchanger has been designed and needs thermal insulation on its outer surface to minimize heat loss. The insulation can be obtained in thickness of 1,2,3 or 4 inches. The following pertinent data have been provided for the different insulation thicknesses.

Insulation Thicknesses	1 inch	2 inch	3 inch	4 inch
Investment on heat exchanger with insulation, Rs.	1,10,000	1,35,000	1,65,000	2,53,000
Cost for installation insulation (Rs.)	1,08,000	1,04,000	1,17,000	1,21,550
Taxes, insurance, inspection, etc. Rs/yr	20000	25000	30000	32000
Maintenance of pipeline, Rs/yr	50,000	60,000	30,000	18,000
Heat saving, (kJ/hr)	2000	2500	2700	2800

The value of the heat is Rs. 30,000/10,00,000 KJ. The service life of heat exchangers with insulation is 15 years with zero salvage value and minimum acceptance rate of return (MARR) is 10%. The interest rate is also 10%. The exchanger operates 150 days per year. Find out,

- Which particular insulation thickness should be chosen using incremental rate of return (IRR) method?
 - Which particular insulation thickness should be chosen, based on minimum Acceptable Rate of Return (MARR)?
- (b) Shiroy Ranji Private Ltd. Has got four alternatives to purchase reactors, but due to financial reasons they can only purchase one reactor. All cash inflows after taxes (CF) and initial cost are given below in table and they are unequally spread throughout year. All reactors have same life span of 7 years. If the company wants to recover all its investment within 4 years, then

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determine which alternative they should choose to purchase the reactors on the basis of payback period?

Alternatives Cash Flow (CF) ↓	A	B	C	D
Initial cost	Rs.70,000	Rs.12,40,000	Rs.1,80,000	Rs.5,40,000
CF Year 1	Rs.24,000	Rs.47,200	Rs.20,000	Rs.2,04,000
CF Year 2	Rs.24,000	Rs.1,80,000	Rs.17,000	Rs.1,57,000
CF Year 3	Rs.24,000	Rs.73,500	Rs.38,000	Rs.2,50,000
CF Year 4	Rs.24,000	Rs.26,700	Rs.76,000	Rs.75,000
CF Year 5	Rs.24,000	Rs.2,00,000	Rs.27,000	Rs.25,000
CF Year 6	Rs.24,000	Rs.4,50,000	Rs.13,000	Rs.16,000
CF Year 7	Rs.24,000	Rs.73,000	Rs.2,20,000	Rs.0

- (c) A company decided to establish a plant with a service life of 8 years, for this project the company has two alternatives Plan-1 and Plan-2. The initial cost of Plan 1 and 2 are Rs.35000 and Rs.25000 respectively. Rate of return for this project is 16.5%. The cash inflow after tax for both plans are given in table below. Company also decided that the revenue obtained from sales will again reinvested in to the market to get profit. The revenue from Plan-1 will be re-invest at the rate of 4% for first 5 years and after that at the rate of 7.5 %. Similarly the revenue of Plan-2 will be reinvest at the rate of 7.5% for whole service life. What will be the present value (PV) of compounded sum of cash inflows for plan-1(PV1) and Plan-2(PV2)?

Years	Cash inflow after income tax (Rs.)	
Initial cost of machine	35000	25000
CF 1	12460	7890
CF 2	7890	8780
CF 3	10380	14321
CF 4	14480	16728
CF 5	5678	8431
CF 6	8765	7835
CF 7	3241	2313
CF 8	15000	12000

(10+8+7=25)

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

[6]

- (a) Develop scale-up equations for single unit of (i) Batch reactor and (ii) CSTR.
- (b) Develop scale-up equations for isothermal CSTRs in (i) series and in (ii) parallel carrying out first and second order reactions.
- (c) What is the role of Space Time and Damkohler Number for part (b). Explain with respect to part (b).

(4+15+6=25)