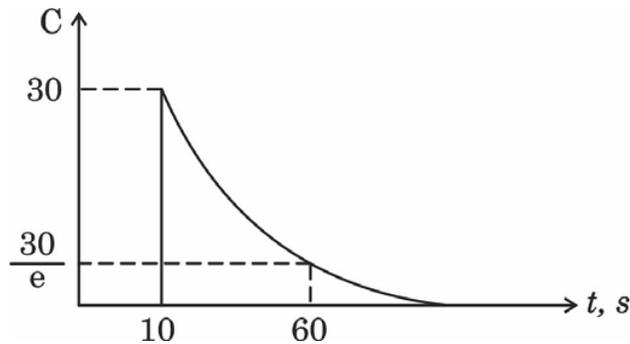


1. Define recycle, bypass and purge. How does recycle affect reactor size? (5 Marks)
2. A liquid-phase reactor carries out the reaction : $A \rightarrow B$. Fresh feed to the reactor is 100 kmol/hr of pure A. The single-pass conversion of A is 30%. Calculate : Amount of A leaving the reactor, B formed and the total outlet flow rate. (5 Marks)
3. What are the limiting conditions to be followed by any equation of states? (5 Marks)
4. Define partial molar property. Explain its physical significance. (5 Marks)
5. Write about the rheological behaviour of any 5 non-Newtonian fluids and give examples for each. (5 Marks)
6. Explain the extended Bernoulli's equation including : (5 Marks)
 - Pump work
 - Head loss
7. Write about any two methods used for the particle size distribution of subsieve particles? (5 Marks)
8. Distinguish between free and hindered settling. (5 Marks)
9. Prove that the rate of heat transfer between two infinite parallel plates reduces to half its value when a very thin radiation shield is placed between them. State the assumptions required, if any. (5 Marks)
10. A brick wall of 25 m² area and 25 cm thickness has a refractory lining of 5 cm thickness. If the temperature at the refractory-lined surface is 700°C and that at the brick side is 100 °C, calculate the heat lost per day from the wall. Thermal conductivities of the brick and refractory material are 0.5 W/m.K and 2 W/m.K, respectively. Also, find the temperature at the interface between the brick wall and the lining. (5 Marks)

11. Explain why the Log Mean Temperature Difference (LMTD) is used instead of the arithmetic mean temperature difference in the analysis of heat exchangers. State the conditions under which the LMTD method is applicable and mention one limitation of the method. (5 Marks)
12. Explain the physical significance of the thermal boundary layer in forced convection over a flat plate. Discuss how the Prandtl number influences the relative thickness of the thermal and hydrodynamic boundary layers and the heat transfer coefficient. (5 Marks)
13. Analyse why the penetration theory predicts higher mass-transfer coefficients than the film theory, with the help of physical reasoning. (5 Marks)
14. Justify the effect of reflux ratio on the number of theoretical stages, energy requirement, and product purity in a distillation column. (5 Marks)
15. Differentiate between gas-phase and liquid-phase controlled mass transfer with suitable equations. (5 Marks)
16. Write down five differences between evaporation and drying. (5 Marks)
17. An aqueous phase autocatalytic reaction, $A + R \rightarrow R + R$ is conducted in an isothermal batch reactor with certain initial concentration of R. Suggest a reactor configuration for this reaction (plug flow, mixed flow or combination of mixed flow and plug flow) which will give the lowest total volume of the reactor under the following condition. Justify your answer with appropriate graphical representation of performance equation.
 - (a) Plot the rate of reaction ($-r_A$) against concentration (C_A) for this reaction. (2 Marks)
 - (b) If the conversion is lower, say 40%. (1 Mark)
 - (c) If the conversion is higher, say 90%. (2 Marks)

18. (a) Two reactors, one with zero dispersion and the second with infinite dispersion are placed in series. If the residence times of the reactors are τ_1 and τ_2 . Sketch the residence time distribution, $E(t)$ of the reactors in series. (3 Marks)
- (b) A pulse tracer is introduced into the fluid entering a reaction vessel having a volume of 1 m^3 and flow rate $1 \text{ m}^3/\text{min}$. The concentration of the tracer measured in the fluid leaving the vessel is shown below. Find the flow model parameters that fit the measured RTD in terms of one or all of the mixing element namely, volume of plug flow reactor V_p , mixed flow volume V_M , and the dead space V_D . (2 Marks)



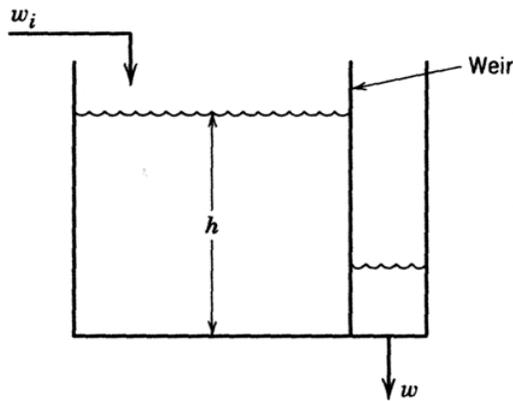
19. (a) Define Thiele modulus ϕ and discuss its significance in an isothermal solid catalysed reaction. (3 Marks)
- (b) A first order isothermal catalytic reaction $A \rightarrow R$, occurs in an infinitely long cylindrical pore. How the effectiveness factor η is related to Thiele modulus. (2 Marks)
20. In an enzymatic reaction, the substrate (S) bind with the enzyme (E) and produce the product (P). Let $[S]$ be the concentration of S and $-r_s$ be the rate of consumption of S.
- (a) Write the form of rate expression and the mechanism proposed by Michaelis-Menten to explain the enzyme fermentation reaction. (3 Marks)
- (b) How to evaluate the two rate constants of the enzyme fermentation from the $-r_s$ versus $[S]$ graph. (2 Marks)

21. Consider a tank shown in figure designed with a slotted weir so that the outflow rate, w (mass flowrate), is proportional to the liquid level to the 1.5 power; that is,

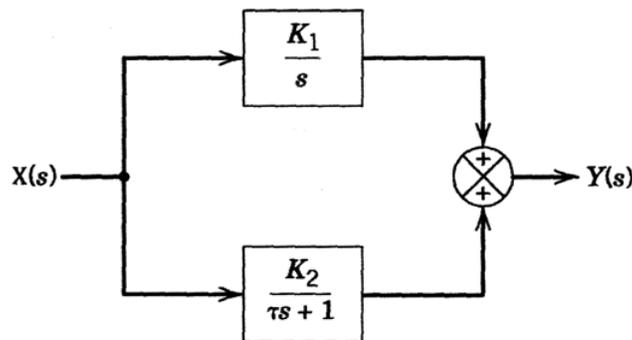
$$w = Rh^{1.5}$$

where R is a constant.

If a single stream enters the tank with mass flow rate w_i , find the transfer function relating the change in height to the change in input mass flow rate. Identify the gain and time constants. Verify units. The cross-sectional area of the tank is A . Density ρ is constant. (5 Marks)



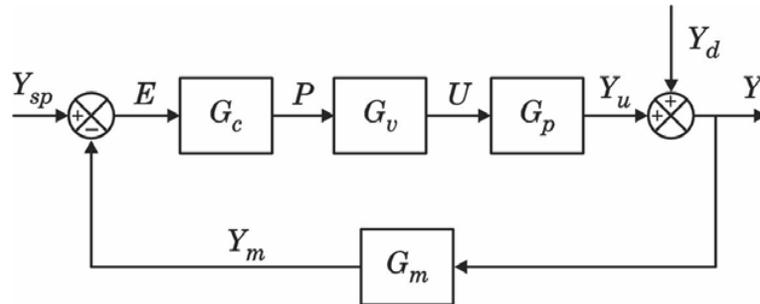
22. Consider the block diagram shown in the figure.



- (a) Find the order of the overall transfer function relating $G(s) = \frac{Y(s)}{X(s)}$. (1 Mark)
- (b) Find the gain, poles, and zeros of $G(s)$ and the location of poles on the complex s plane. (2 Marks)
- (c) What condition(s) will one or more of the zeros be located in the right-half s -plane? (1 Mark)
- (d) For any bounded input, is the output bounded? Justify your answer. (1 Mark)

23. Using Routh array, determine the stability of the feedback system shown in figure. (5 Marks)

$$G_p = \frac{1}{12s+1}; G_v = \frac{1}{6s+1}; G_m = \frac{1}{s+1}; G_c = K_c;$$



24. The set-point of the control system under proportional control ($K_c = 2.0$) undergoes a step change of magnitude 2. For the process transfer function

$$G_p = \frac{5}{(s+1)(2s+1)}$$

- (a) Determine the closed-loop transfer function. (2 Marks)
- (b) Determine the offset. (3 Marks)
25. List and briefly explain five methods used for estimating capital investment. (5 Marks)
26. Give the basic mathematical formula for Discounted Cash Flow (DCF). Also discuss two major advantages and two critical limitations of using DCF as a valuation tool. (5 Marks)
27. Explain the concept of optimum reflux ratio in a distillation column. How does the selection of reflux ratio influence the column height, diameter and overall equipment cost? (5 Marks)
28. The book value of a reactor decreases uniformly every year. Identify the depreciation method, provide its mathematical formulation and state its primary advantages and disadvantages. (5 Marks)

29. Prepare an engineering flow sheet for the manufacture of sulphuric acid by single absorption contact process. (5 Marks)
30. Explain the following related to petroleum coking process : (5 Marks)
- (a) Influence of the process variables temperature and pressure.
 - (b) Three distinct types of coking units.
31. Explain the low-pressure Ziegler polymerization process used in the manufacture of polyethylene. (5 Marks)
32. List five major engineering problems encountered during the production of urea through ammonium carbamate decomposition. (5 Marks)
33. Define lapse rate and discuss the effect of lapse rate on dispersion of gases emitted from a stack. (5 Marks)
34. A water sample contains 100 mg/lit of Ca^{2+} and 24 mg/lit Mg^{2+} . Express hardness of this water sample as milliequivalent/lit and mg/lit of CaCO_3 . Equivalent weight of Calcium ion is 20 and that of Magnesium ion is 12. (5 Marks)
35. Landfilling is one of the most widely used methods for the disposal of solid wastes. Explain various stages of decomposition process in a landfill. (5 Marks)
36. In water treatment plants, trivalent metallic salts are typically added to achieve chemical coagulation. Explain four possible mechanisms by which coagulation is accomplished. (5 Marks)
37. Describe the theory of fire extinguishing. Suppose a fire is detected in a room that stores sensitive measuring and control equipment. Suggest a fire extinguisher which is suitable to deal with fires in this room. Justify your answer. (5 Marks)

38. What are the causes for runaway reactions? Describe the essential requirements to prevent runaway reactions. (5 Marks)
39. How are industrial hazardous zones classified? Explain. (5 Marks)
40. Distinguish between event tree and fault tree analysis. Explain the advantages and disadvantages of fault tree analysis. (5 Marks)
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