

## CHEMICAL ENGINEERING

## Paper - I

Time allowed : Three Hours

Maximum Marks : 200

## Question Paper Specific Instructions

**Please read each of the following instructions carefully before attempting questions :**

There are **EIGHT** questions in all, out of which **FIVE** are to be attempted.

Questions no. 1 and 5 are compulsory. Out of the remaining **SIX** questions, **THREE** are to be attempted selecting at least **ONE** question from each of the two Sections A and B.

Attempts of questions shall be counted in chronological order. Unless struck off, attempt of a question shall be counted even if attempted partly. Any page or portion of the page left blank in the Question-cum-Answer Booklet must be clearly struck off.

All questions carry equal marks. The number of marks carried by a question/part is indicated against it.

Answers must be written in **ENGLISH** only.

Unless otherwise mentioned, symbols and notations have their usual standard meanings.

Assume suitable data, if necessary and indicate the same clearly.

Neat sketches may be drawn, wherever required.

## SECTION A

**Q1. Answer all questions :**

**5×8=40**

- |     |  |   |
|-----|--|---|
| (a) | Explain Danckwerts surface renewal theory of mass transfer.  | 5 |
| (b) | What is meant by NPSH ? Explain its importance in fluid flow.  | 5 |
| (c) | Write briefly about analogy between momentum, heat and mass transfer.                                    | 5 |
| (d) | What type of extractor do you suggest for the separation of liquids with very small density difference ? | 5 |
| (e) | Define Capillary number and explain its use.   | 5 |
| (f) | What is mixing index ? In what way is it useful ?  | 5 |
| (g) | Explain the critical radius concept in case of curved insulation.  | 5 |
| (h) | Determine the hydraulic radius for a square tube of dimensions $s \times s$ .                            | 5 |

- Q2.** (a) What is Murphree plate efficiency ? Discuss briefly how it is affected by the design of column. 10
- (b) Discuss mass transfer resistances in a wetted wall column. 10
- (c) With a neat drying rate curve, explain different zones of drying. 10
- (d) Explain Mier's theory of supersaturation. Also outline the limitations of this theory. 10
- Q3.** (a) Draw a Roll crusher and explain its working briefly. Describe the equation to calculate the diameter of a roll in the Roll crusher. 15
- (b) Discuss the flow pattern caused by a turbine type impeller in an agitated tank and suggest means to prevent swirling and vortex formation. 10
- (c) Water is to be pumped from a pond to the top of the tower 18.29 m above the water level in the pond. It is desired to deliver 0.34 m<sup>3</sup>/min. of water at a pressure of 204 kN/m<sup>2</sup>. The pipeline consists of 122 m length of straight pipe, 76.2 mm I.D. with 8 elbows of 90° and 4 gate valves. Calculate power rating of the pump, having an efficiency of 80%.  
Equivalent length for 90° elbow and gate valve may be taken as 32 D and 7 D, respectively where D is I.D. of the pipeline.  
Friction factor,  $f = \frac{0.046}{Re^{0.2}}$ . 15
- Q4.** (a) Discuss various factors which have an effect on heat transfer capacity of an Evaporator and on its economics. 10
- (b) A polished metal pipe 5 cm outside diameter and 370 K temperature at the outer surface is exposed to ambient conditions at 295 K temperature. The emissivity of the surface is 0.2 and the convection coefficient of heat transfer is 15 W/m<sup>2</sup>.K. Calculate the heat transfer by radiation and natural convection per metre length of the pipe. Take the thermal radiation constant  $\sigma = 5.67 \times 10^{-8} \text{ W/m}^2 \text{ K}^4$ . 20
- (c) Define effectiveness of a heat exchanger. Obtain its expression for a parallel flow heat exchanger in terms of NTU and capacity ratio. 10

## SECTION B

- Q5. Answer all questions :** **5×8=40**
- (a) Distinguish between servo problem and regulator problem. 5
  - (b) Give the transfer function for transportation lag. 5
  - (c) What is meant by equal percent control valve ? 5
  - (d) Compare and contrast the terms – ‘osmosis’ and ‘reverse osmosis’. 5
  - (e) Distinguish between positive feedback and negative feedback. 5
  - (f) Explain membrane selectivity in separation processes using membrane. 5
  - (g) Name various types of heads commonly used in cylindrical vessels, along with their sketches and areas of application. 5
  - (h) Indicate two types of commonly used steels in chemical industry and give their composition. 5
- Q6.**
- (a) Explain the PID control action using hydraulic liquid level control with a neat sketch. 10
  - (b) Prove that two first order systems connected in series is equivalent to a second order over damped system or a critically damped system. 10
  - (c) How do you measure liquid level if the liquid contains suspended solid particles ? Suggest a suitable measuring instrument and explain its working principle. 10
  - (d) Define phase margin and gain margin. Also show how you can compute them from Bode plot. 10
- Q7.**
- (a) What is the principle of dialysis ? List the applications of this operation. What are the available commercial dialysis membranes ? 15
  - (b) What do you understand by liquid surfactant membrane technique ? List out its various advantages and disadvantages over conventional liquid extraction. 15
  - (c) What is ultrafiltration ? Discuss the dependence of membrane permeation rate on applied pressure difference, feed solute concentration and cross flow velocity in ultrafiltration. 10

- Q8. (a) Give alloys used to handle concentrated and dilute sulphuric acid. What are their compositions? 10
- (b) Discuss the design procedure of skirt supports for vertical vessels. 10
- (c) Estimate the thickness of the shell and head of a process vessel. The vessel is a cylinder having ellipsoidal heads (minor to major axis ratio = 1 : 2) at its bottom and top ends. The inside diameter and length of the vessel are 1.5 m and 2.25 m respectively. The vessel is to operate at a pressure of  $1.5 \text{ MN/m}^2$  (absolute). Take design pressure as 10% above operating pressure. Allowable stress for the material of vessel is  $85 \text{ MN/m}^2$ . Weld is fully radiographed. A corrosion allowance of 2 mm may be taken. 20