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 m³/min. of water at a pressure of 204 kN/m². 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, $f = \dfrac{0\cdot046}{Re^{0\cdot2}}$. *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/m².K. Calculate the heat transfer by radiation and natural convection per metre length of the pipe. Take the thermal radiation constant $\sigma = 5\cdot67 \times 10^{-8}$ W/m² K⁴. *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 and 2·25 m respectively. The vessel is to operate at a pressure of 1·5 MN/m^2 (absolute). Take design pressure as 10% above operating pressure. Allowable stress for the material of vessel is 85 MN/m^2. Weld is fully radiographed. A corrosion allowance of 2 mm may be taken. *20*