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 × 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^3/min. of water at a pressure of 204 kN/m^2. 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, $f = \frac{0{\cdot}046}{Re^{0{\cdot}2}}$. *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 $W/m^2.K$. Calculate the heat transfer by radiation and natural convection per metre length of the pipe. Take the thermal radiation constant $\sigma = 5{\cdot}67 \times 10^{-8}$ $W/m^2 K^4$. *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 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*