I.F.S. EXAM-2015

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.

Question Nos. 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 sequential 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.

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SECTION—A

1. Answer **all** questions :

   (a) Explain the basic concepts of compressible and incompressible flow.   3

   (b) Explain the significance of Grashof number and show that it is dimensionless.   5

   (c) Determine the pressure drop per unit length in pascal/m in fluidized bed if porosity or volume fraction of voids in a bed is 0·7. The density of solids is 2800 kg / m³ and that of water is 1000 kg / m³.   4

   (d) State Bond's crushing law. What do you mean by "the work index of bauxite is 8·5"?   3

   (e) Using Fenske equation, determine the minimum number of plates required in distillation using the following data :

   $$\alpha_{AB} = 2 \cdot 5, \quad x_D = 0 \cdot 8, \quad x_W = 0 \cdot 01$$

   where the terms have their usual meanings.   6

   (f) What is reflux? Explain about minimum reflux, optimum reflux and partial condenser in the context of a distillation column.   7

   (g) Why is it possible to cool water to a temperature below the dry-bulb temperature of the entering air in cooling towers? Explain.   7

   (h) State and explain various laws of radiation.   5

2. (a) Explain the merits and demerits of centrifugal and reciprocating pump.   10

   (b) A tall vertical column contains solid packing and a fluid is passing through the column in upward direction. Depict pictorially the change in pressure drop across the bed with increase in velocity of the fluid. Explain about fluidization and pneumatic conveying.   10

   (c) Explain with a neat sketch the working principle of Bollman's extractor.   10

   (d) Draw the temperature profiles for countercurrent and cocurrent heat exchanger, and show the temperature approaches on the diagram. What is LMTD? When and why is correction factor necessary in LMTD?   10

3. (a) What are the differences between Pitot tube and Venturi meter in the context of flow measurements? Describe, with a neat sketch, the operation of a venturi meter.   8

   (b) Develop the expression for overall heat transfer coefficient in terms of individual heat transfer coefficients considering the heat transfer to take place between the fluids in a shell and tube heat exchanger by convection and conduction.   10

   (c) Explain the operating principles of leaf filter. Indicate its merits and demerits.   8

   (d) Define free moisture, equilibrium moisture, critical moisture, bound moisture and unbound moisture in drying operation.   14

4. *(a)* Depict the velocity profile for laminar and turbulent flow in a pipe. Show the relationship between average and maximum velocity of fluid in both the cases. 10

(b) Explain various feeding arrangements in a multiple effect evaporator and explain their merits and demerits. 12

(c) Explain clearly the principles of azeotropic and extractive distillation. 8

(d) *(i)* Explain the significance of absorption factor and stripping factor. 5

(ii) How does the temperature approach affect the height of the cooling tower? 5

SECTION—B

5. Answer **all** questions :

(a) Explain the concentration polarization in membrane-based extraction processes. Indicate the influence of polarization factor. 6

(b) What is meant by supercritical fluid extraction? Mention the criteria to be considered in selecting the solvent of the operation. 6

(c) What are different types of stainless steels used in construction of equipments for an industry? 6

(d) Mention different types of heads generally used as enclosure of cylindrical vessel. 5

(e) Explain reproducibility and sensitivity. How are they related? 5

(f) Explain about manipulated variable and load variable citing examples. 5

(g) Define time constant and state its significance. 4

(h) List out the instruments/devices used for measurement of level of liquid. 3

6. *(a)* When a mercury-in-glass thermometer is used to measure the temperature of water bath, the following equation may be used for predicting the temperature profile in the situation :

$$\tau \frac{dT_2}{d\theta} + T_2 = T_1$$

where

τ = time constant = $\dfrac{MC_P}{UA}$

θ = time

T = temperature

Use Laplace transform to obtain the transfer function $\dfrac{T_2(s)}{T_1(s)}$ of the system. 10

(b) Discuss the design methodology for cylindrical vessels under internal pressure.   10

(c) Narrate the important characteristics to be considered for selection of material of construction for a specific purpose.   10

(d) What are the basic differences between Reverse osmosis and Nanofiltration? Name various types of membranes and modules used for reverse osmosis.   10

7. *(a)* Describe the operation of radiation pyrometer with the help of a neat sketch.   10

(b) What are various flow-measuring instruments? Discuss the working principle of a variable area meter.   10

(c) Discuss the industrial application of ion-exchange process.   8

(d) *(i)* How can flanges be classified according to their faces?   6
   (ii) Discuss various steps for the design of cylindrical storage tanks.   6

8. *(a)* Discuss the failure of vessels based on theory of plasticity.   10

(b) Discuss the operating principles of electrodialysis with a neat sketch, giving examples of its applications.   10

(c) *(i)* What are various functional elements of an instrument? Explain with examples.   5
   (ii) What is meant by calibration of an instrument and how is it performed?   5

(d) Develop the transfer function of a second-order system and discuss its response for ramp input.   10

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