Indian Forest Service Examir... 2013

A-JGPT-M-DIFO-A

CHEMICAL ENGINEERING

Paper I

(CONVENTIONAL)

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 Answer Book 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

Q.1. Answer ***all*** parts :

(a) (i) Distinguish clearly between laminar flow and turbulent flow. *4*

(ii) Explain the terms : 'Mach number' and 'Stagnation temperature' in connection with flow of compressible fluids. *4*

(b) (i) Why is the countercurrent flow heat exchanger more efficient than the parallel flow heat exchanger ? Under what conditions do these exchangers become equally efficient ? *4*

(ii) Why are baffles and tie rods used in shell and tube heat exchanger ? In order to enhance the velocity of fluid flowing through tube side, what modification in the exchanger would you suggest ? Give reasons. *4*

(c) Write down different mass transfer coefficients and related driving forces indicating their units for interphase mass transfer. *8*

(d) State the disadvantages of 'Forced draft' cooling tower. Explain Evaporative cooling. *8*

(e) Explain about particulate fluidization and pneumatic conveying. *8*

Q.2 (a) A Newtonian fluid is flowing through a pipe of circular cross-section. The fluid is incompressible and the flow is laminar, steady and fully developed. Show that the velocity profile is a parabola. *10*

(b) In a filtration process, a general relationship can be written as

$$\frac{d\theta}{dV} = \frac{\mu}{A(\nabla P)}\left[\frac{\alpha c V}{A} + R_m\right]$$

where, V is total volume collected in time θ, α is specific cake resistance, R_m is filter medium resistance, c is concentration of solid in slurry, μ is the viscosity of the filtrate and ∇P is the pressure drop. Experiment was carried out at a constant pressure drop of 5×10^4 N/m^2 with a slurry containing 20 kg/m^3 of $CaCO_3$ in water. The plot of $\frac{\theta}{V}$ vs. V, gave the slope of the curve to be 12·5 S/lit^2 and the intercept to be 26·5 S/lit. If the filter area is 0·09 m^2 and viscosity of the filtrate is 0·001 kg/m.s, calculate the specific cake resistance and filter medium resistance. *10*

(c) Define "angle of nip" for two roll crushers. Develop an expression for angle of nip in terms of radii of the rolls, size of the feed, and gap between the rolls. *20*

Q.3 (a) Explain with examples, the terms :
Natural convection and Forced convection. *5*

(b) In a double pipe heat exchanger, hot water flows at a rate of 50,000 kg/hr and gets cooled from 95 to 65°C. At the same time 50,000 kg/hr of cooling water at 30°C enters the heat exchanger. The overall heat transfer coefficient is 2270 $\frac{W}{m^2K}$. Determine the heat transfer area and effectiveness of the heat exchanger assuming the two streams are in parallel flow. Assume for both the fluids $C_p = 4{\cdot}2\ \frac{kJ}{kg.K}$. *20*

(c) Define Geometric or Angle or view factor in radiation between two large parallel plates. Under what circumstances the value becomes one or zero ? Deduce the expression for total heat flux between two parallel grey surfaces which are large compared to their distance apart. *$2\frac{1}{2} + 2\frac{1}{2} + 10 = 15$*

Q.4. (a) Draw a neat diagram of a Sieve tray column, showing the internals, and explain the functions of the internals. *15*

(b) In the operation of a cooling tower, define the terms (i) temperature approach and (ii) cooling range. How does the temperature approach affect the size of a cooling tower ? *5*

(c) Derive the analytical expression for determination of minimum number of theoretical plates required in plate type column for distillation of a binary mixture assuming the relative volatility to be constant. *20*

SECTION B

Q.5. (a) Describe Bourdon tube with its working principle and areas of application. *10*

(b) Explain about membrane separation process with its working principle, which may be used to separate macromolecules of proteins, polymers and starches. *10*

(c) Transportation lag is often present in industrial control systems. Explain it with its impact on the control of process systems. *10*

(d) Describe three types of compensations, which are commonly used to reinforce the area around an opening in a pressure vessel. *10*

Q.6. (a) Consider a membrane separator element which is used to separate a gas mixture of A and B. The unit is being operated continuously. The feed flow rate is 2×10^3 cm^3(STP)/s and mole fraction of A in feed is 0·413. The feed side pressure is 80 cm Hg and permeate side pressure is 20 cm Hg. Mole fraction of A in reject is 0·30. Membrane characteristics are as follows :

Membrane thickness = 2×10^{-3} cm

Permeability of A = $400 \times 10^{-10} \dfrac{cm^3(STP) \cdot cm}{(s \cdot cm^2 \cdot cm - Hg)}$

Ratio of permeability of A to that of B = 10.

Using complete-mixing model, calculate the mole fraction of A in permeate, fraction of feed permeated, and area of the membrane in the separator unit. *20*

(b) Derive equation used in part (a). *20*

Q.7. (a) As per Code of Practice for design of mild cylindrical oil storage tanks, following equation is used to calculate the thickness of cylindrical shell plates :

$$t = \frac{4 \cdot 9\,[H - 0 \cdot 3]\,DG}{SE}$$

t = minimum thickness of shell plates, mm

D = nominal diameter of tank, m

H = height from bottom of the course to the maximum possible oil filling height, m

G = specific gravity of liquid to be stored

S = allowable stress of material, N/mm^2

E = weld joint efficiency factor

Derive the above equation. *20*

(b) A cylindrical large oil storage tank is used to store 1000 m^3 of liquid petroleum products. Determine its optimum diameter to height ratio so that total cost is minimum.

C_s = Cost of sides per m^2 area

C_h = Cost of head or top cover per m^2 of projected area = $1 \cdot 5\ C_s$

C_b = Cost of the flat bottom per m^2 area = $0 \cdot 75\ C_s$ *20*

Q.8. (a) Describe Bode diagrams used to represent the frequency response characteristics of a system. Construct Bode diagram of a first order system. *25*

(b) What do you understand by feed forward control of chemical process ? Explain with suitable examples. *15*