IFoS 2010

000552

B-JGT-K-DFA

CHEMICAL ENGINEERING

Paper I

Time Allowed : Three Hours | *Maximum Marks : 200*

INSTRUCTIONS

Candidates should attempt questions 1 and 5 which are compulsory, and any THREE of the remaining questions, selecting at least ONE question from each Section.
All questions carry equal marks.
Marks allotted to parts of a question are indicated against each.

Answers must be written in ENGLISH only.

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

Neat sketches may be drawn, wherever required.

SECTION A

1. Answer any ***four*** of the following : *10×4=40*

(a) Draw a comparison between the equations relating to molecular transport of momentum, heat and mass. State the meaning of, and units for, each term in the equations. *10*

(b) What is the physical law underlying the equation of motion ? Write down Navier-Stokes' equation for steady, laminar flow of an incompressible Newtonian fluid. Write the meaning of each term in the equation. Rewrite the equation when the viscosity of fluid is (i) sufficiently high, and (ii) negligibly small. Also, write down the magnitudes of normal stress and tangential stress when an inviscid fluid is in static condition. *10*

(c) State briefly how the number of theoretical stages in continuous counter-current multi-stage extractor may be determined. *10*

(d) (i) Explain the principles involved in calculating the diameter of a cooling tower. *5*

(ii) What are kiln action and flight action in rotary dryer practice ? *5*

(e) (i) What is 'critical insulation radius' ? Deduce an expression for critical insulation radius on a cylindrical surface in terms of thermal conductivity of insulating material and outside film heat transfer coefficient. *7*

(ii) Show that the overall heat transfer coefficient is lower than the least film heat transfer coefficient. *3*

2. (a) Write down Hagen-Poiseuille equation for flow of a Newtonian, incompressible fluid through a tube. Show that it is dimensionally consistent. Describe the procedure for characterising non-Newtonian fluid with the help of Hagen-Poiseuille equation. *10*

(b) Derive the expression of work done in the isentropic compression of a gas in single stage compressor. *10*

(c) A fluid is being passed in upward direction through a vertical column packed with spherical glass balls (each of 5 mm dia.). Show in a sketch, the change in pressure with the change in velocity of fluid through the column. Explain the terms : 'Loading Point', 'Flooding point', and 'Minimum fluidization velocity'. *10*

(d) (i) State Bond's law of crushing and explain Work index. *4*

(ii) Show that a small toggle force is multiplied by the action of toggle to give a much higher force for crushing by a jaw crusher. *6*

3. (a) (i) How can Prandtl number and Lewis number be expressed in terms of diffusivities ? *4*

(ii) What are the limitations of Wilke-Chang equation ? *3*

(iii) Explain Knudsen diffusion. *3*

(b) (i) Derive the equation of the operating line by material balance for a steady-state counter-current continuous mass transfer operation using concentrations in mole fraction. 5

(ii) Why do the operating lines of a stripper and an absorber lie on the opposite sides of the equilibrium line ? Explain. 5

(c) A solid is dried from unbound moisture content to a certain level of bound moisture content for which drying rate curve is available (any rate of drying curve at constant drying condition). How can the drying time be determined for the solid material ? 10

(d) (i) What are 'solutropic' mixtures ? 3

(ii) "High interfacial tension is desirable in extraction" – Explain. 3

(iii) Discuss about selectivity of a solvent used in extraction. What is its value at Plait point ? 4

4. (a) What are the advantages and disadvantages of square pitch and triangular pitch arrangements of tubes in a 'Shell and Tube Heat Exchanger' ? Why are the baffles used in such exchangers ? What is the disadvantage of spacing the baffles close together ? Indicate the maximum and minimum values of baffle spacing as recommended by TEMA. 10

(b) (i) Obtain expressions for 'Number of transfer unit' and 'Length of a transfer unit' used for calculation of total length of a counter-current heat exchanger. *7*

(ii) What is LMTD correction factor ? What is the limiting value of the factor ? *3*

(c) (i) Discuss different regimes in pool boiling. *5*

(ii) Explain 'Film condensation' and 'Dropwise condensation'. Indicate the difference(s) between the two, if any. *5*

(d) Describe with a sketch, the operation of a vertical natural circulation calandria type evaporator. *10*

SECTION B

5. Answer any ***four*** of the following : *10×4=40*

(a) Explain 'Ultrafiltration' and 'Microfiltration'. Cite example in each case. *10*

(b) Discuss the important characteristics of a control valve. *10*

(c) (i) What are the special characteristics of quenched and tempered low alloy steels ? *7*

(ii) Why is molybdenum added with high nickel-chromium alloys of iron ? *3*

(d) State and explain the laws governing operation of thermocouples. *10*

(e) (i) What is a Piezometer ? Mention its merits and demerits. *6*

(ii) State the working principle of a Strain gauge. *4*

6. (a) What is 'Extraction ratio' for a haemodialyser ? How does it differ in case of parallel and counterflow configurations ? What is its heat transfer analogue ? Develop an expression for the extraction ratio of a co-current haemodialyser. *15*

(b) "For engineering purpose ion-exchange is considered as a special case of adsorption" – Justify. *5*

(c) Write down various driving forces used for calculation of mass flux of a component across the membranes. *10*

(d) Write notes on (i) polymer nanocomposite membranes, and (ii) carbon membranes. *10*

7. (a) Explain the measures one has to undertake in minimising galvanic corrosion. *10*

(b) Discuss the design procedure for flat heads. *10*

(c) State the advantages of flange joints over other joints used in equipment and accessories in a plant. Discuss with sketches, if necessary, various types of flange and gasket along with their uses. *20*

8. (a) In order to understand the transient response of a parameter/variable encountered in a process, different forcing functions are used. Represent these functions graphically and analytically. *10*

(b) Derive the expression of steady-state response of a first order process provided with a sinusoidal input. *10*

(c) Explain the following used in computer aided control circuit : *10*

(i) Sampler and Hold

(ii) AD and DA converters

(d) Describe with sketch, the operation of Electromagnetic meter. *10*