CODE : FRO-2017

CHEMICAL ENGINEERING

Roll No. ....

Time : 3 Hours   Maximum Marks : 200

Note :— (i) Question paper consists of *two* parts viz.
            Part I and Part II. Each part contains four
            questions. The paper as a whole carries eight
            questions. Question Nos. 1 and 5 are
            compulsory. The candidates are required to
            attempt *three* more questions out of the
            remaining six questions taking at least *one*
            question from each part i.e. this is in addition
            to the compulsory question of each part.
            Attempt *five* questions in all. *All* questions
            carry equal marks. The parts of a question are
            to be attempted at one place in continuation.
            Answers should be brief and to the point.

      (ii) Parts of same question must be attempted
            together and not to be attempted in between
            the answers to other questions.

      (iii) Use of non-programmable calculator is allowed.

P.T.O.

Part I

1. (a) Briefly discuss about the settling and sedimentation processes. Write down the force balance equation for a settling process, assume that the particle is rigid sphere.   10

   (b) Three parallel plates are separated by two fluids A and B having viscosities of $\mu_A = 1$ cP and $\mu_B = 0.8$ cP, respectively. The lower and upper plates are moving with the velocity $V_L = 2$ m/s (forward) and $V_U = 1$ m/s (backward), respectively. The lower and middle plates are separated by distance of $Y_1 = 5$ cm by Fluid A, whereas the middle and upper plates are separated by distance of Y_2 by Fluid B. What should the value of Y_2 to keep the middle plate stationary ?   10

   (c) Compare the main features of the centrifugal, reciprocating, rotary positive displacement and air displacement pumps.   10

   (d) Discuss the Rittinger' and Bond's laws.   10

2. (a) For the multi-phase mixture consisting of n number of species, define (with formula the mass average velocity, molar average velocity and volume average velocity. 6

(b) Under what circumstances, the molar and mass average velocities will be equal to the volume average velocity ? 4

(c) In the distillation process, under what circumstances/conditions, the trays and packings should be used ? 10

(d) Draw the sketches of contacting patterns for the following gas-liquid systems :

(i) counter-current packed bed or plate column,

(ii) co-current packed bed,

(iii) in-line static mixer,

(iv) spray columns, and

(v) agitated tanks. 10

(e) Write a short note on the super critical extraction.   10

3. (a) Explain briefly about LMTD, NTU and effectiveness.   10

(b) How is the mixing and contamination prevented in recuperative heat exchangers ? Show the schematics of the temperature distribution in the parallel and counter-current flow heat exchangers.   10

(c) Name the *four* unit operations which involve boiling.   10

(d) Write a short note on the reverse osmosis and ultrafiltration.   10

4. (a) Draw a block diagram of a process control loop.   10

(b) In the context of pressure gauges, briefly discuss about diaphragms, capsules and bellows.   10

(c)   Define the range, the span and the reading accuracy

of an instrument.

A pressure gauge ranges from 0 to 100 psi and

the worst-case spread in the readings is ±4.5 psi.

What is a percentage of full-scale reading or

deflection (%FSD) accuracy ?   10

(d)   Write a short note on material of construction,

their characteristics and selection in process

equipment design.   10

Part II

5.   (a)   What are the *four* main factors which influence

the rate of reactions ?   8

(b)   Briefly discuss about the *six* categories under which

all chemical reactions can be placed ?   12

(c)   In a drug production process, the flow rate of exit stream from reactor is 10 L/min. The concentration of drag in water is 40% and the specific gravity of the solution is 1.025. Determine the concentration (in kg/L) and flow rate (in kg.mol/min) of the drag. The molecular weight of the drag can be taken as 190, if required.   10

(d)   Define the term 'process variable' ? What are the *four* commonly measured variables that affect the performance of the chemical process industries ? 10

6.   (a)   Define the bubble point (BP) and dew point (DP) temperatures.   10

(b)   Write down the seven typical state functions used in chemical engineering.   14

(c)   What is the relation between the chemical equilibrium and steady state ?   4

(d)   Explain the *four* laws of thermodynamics.   12

7. (a) The capital cost (P) of a heat exchanger is Rs. 10,000 with a lifetime of 10 years. If the money can be invested at 6% (annual interest rate), calculate :

(i) the annual depreciation costs,

(ii) the annual capital recovery, if P is deposited in a bank at 6% and

(iii) compare between the two values. 10

(b) What are the *three* distinctive functions performed in chemical plants ? 10

(c) Briefly discuss about the *three* basic roles of process economics in process design. 10

(d) The *three* important parameters, i.e., conversion, selectivity and yield, are used to describe the performance of a chemical reactor. Discuss about them with the help of suitable example. 10

8. (a) Consider the mixed parallel and series reaction system. What would be the choices of reactor arrangements to obtain the best overall selectivity when the parallel reaction has a higher order than the primary reaction ? Name and draw the sketch of reactor arrangements. 10

(b) Explain about the excess air requirements and adiabatic flame temperature. 10

(c) Explain about the measurement techniques of pollution levels and their control strategies. 10

(d) Write the short notes on ozone layer depletion and acid rain. 10