Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.Tech(FT/NEW)/SEM-4/CHE-414/2013

2013

UNIT OPERATION IN CHEMICAL ENGINEERING-I

Time Allotted : 3 Hours *Full Marks :* 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following questions : 10 × 1 = 10

   i) The property of fluid by virtue of which it offers resistance to shear is known as

      a) density b) surface tension

      c) viscosity d) vapour pressure.

   ii) Hagen-Poiseuille equation as applicable for

      a) laminar flow of non-Newtonian fluids

      b) laminar flow of Newtonian fluids

      c) Turbulent flow

      d) the flow of Newtonian and non-Newtonian fluids.

iii) Critical fluidization velocity is given by V_f

a) $\frac{(\rho - \rho s)\, g}{\mu 150\ (1-e)}\ d_p{}^2 e^3$

b) $\frac{(\rho s - \rho)\, g}{\mu 150\ (1-e)}\ d_p{}^2 e^3$

c) $\frac{(\rho_s - \rho)\, dp e^2 g}{\phi 4 \cdot 17 \mu\ (1-e)}\ d_p{}^2 e^3$

d) $\frac{(\rho - \rho s)}{4017 \mu\ (1-e)}\ d_p{}^2 e^3$.

iv) For a rotameter the flow rate is

a) proportional to square of meter readings

b) proportional to square root of meter readings

c) approximately directly proportional to meter readings

d) inversely proportional to meter readings.

v) The dimensions of Kinematic Viscosity is

a) $ML^{-2}T^{-1}$

b) L^2T^{-1}

c) $ML^{-2}T^{-2}$

d) None of these.

vi) The dimension of viscosity is

a) ML/T b) M/LT

c) $1/MLT$ d) T/ML.

vii) Stokes is the unit of

a) length b) area

c) viscosity d) kinematic viscosity.

viii) When the value of $N_{Re} > 4000$ the state of fluid flow is

a) laminar b) transition

c) turbulent d) none of these.

ix) Fouling factor

a) is a dimensionless quantity

b) does not provide a safety factor for design

c) accounts for additional resistances to heat flow

d) none of these.

x) Heat transfer co-efficient (h_1) for liquids increases with

a) increasing temperature

b) decreasing temperature

c) deceasing Reynolds number

d) none of these.

xi) When warm and cold liquids are mixed, the heat transfer is mainly by

a) conduction b) convection

c) radiation d) both (a) and (b).

xii) The value of Stefan-Boltzman constant in SI unit is

a) $5 \cdot 6697 \times 10^{-8}$ W/(m^2 K^4)

b) $0 \cdot 1714 \times 10^{-8}$ W/(m^2 K^4)

c) $5 \cdot 6697 \times 10^{-8}$ kcal/(m^2 K^4)

d) $0 \cdot 1714 \times 10^{-8}$ kcal/(m^2 K^4).

xiii) An example of fluid for which viscosity can change with time is

a) Bingham Plastic b) Pseudoplastic

c) Dilatant d) Rheopectic.

xiv) The Kinematic viscosity of a water having viscosity 0·8 cP is

a) 8 stokes b) 0·8 stokes

c) 0·08 stokes d) 0·008 stokes.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

2. Define minimum fluidization velocity and sphericity factor.

3. Define potential flow, boundary layer and fully developed flow with a net diagram.

4. Define drag force and terminal velocity. What is the relationship between Drag coefficient and Reynold's number ?

5. What is LMTD ? What is the necessity of baffles in a shell and tube heat exchanger ? Give an example of heat exchanger commonly used in dairy industry.

6. Differentiate between classifier and clarifier. What do you mean by 'specific cake resistance' ?

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

7. a) Derive Ergun equation for fluid flowing through a parallel bed.

   b) Explain the term 'sphericity' of a particle.

   c) Quartz particle (density 2650 kg/m^3) are settling in water at room temperature. What will be the maximum particle diameter so that Stoke's formula can hold in this case.

   $\mu = 1004 \times 10^{-6}$ kg/m.s

   Also find the settling velocity of the particle under this condition. 9 + 2 + 4

8. a) Show that the velocity profile of a Newtonian fluid flowing through a circular pipe under laminar flow conditions is a parabola and hence prove that the average velocity is one half of the maximum velocity.

   b) What is the advantage of inclined manometer ? What are the main defects of manometer ?

   c) A cylinder of 0·12 m radius is rotating concentrically inside of a fixed cylinder of 0·13 m radius. Both cylinders are 0·35 m long. Determine the viscosity of liquid which fills the space between the cylinders if torque of 0·88 Nm is required to maintain an angular velocity of 2Π rad/s. 4 + 3 + 2 + 2 + 4

9. a) What do you mean by NPSH and cavitation ?

   b) Water at 20°C is being pumped from a tank to an elevated tank at the rate of 5 lit/sec. Pump has an efficiency of 65%. All of the piping is of uniform diameter of 0·1023 m and total length of the piping system is 170 m. If there are two elbows in the whole piping system, calculate the power needed for the pump. For water, Density is 998·2 kg/m^3 and viscosity is 1·005 cP. Fanning's friction factor is 0·0051 and fitting coefficient for each elbow is 0·75.

   c) Show that $f = 16/N_{Re}$ for laminar flow, where f = fanning's Friction factor. 4 + 7 + 4

10. a) Derive the relationship between overall heat transfer co-efficient and individual heat transfer co-efficient for a plane wall and a pipe.

    b) A thick walled tube of Stainless steel having thermal conductivity of 21·63 W/(m.K) with inside diameter of 25·4 mm and outside diameter of 50·8 mm is covered with a 2·54 cm thick layer of an insulation of thermal conductivity of 0·2423 W/(m.K). Inside wall temperature is 811 K and outside surface of insulation is at 310·8 K. For a 0·308 m length of pipe, calculate heat loss and also the temperature at the interface between metal and insulation.

    c) Define emissivity and gray body. 6 + 7 + 2

11. a) Air is heated in a tube of inside diameter of 50 mm from 37·8°C to 121·1°C. Average volumetric flow rate is 1·57 lit/sec. Length of the tube is 3m. Wall temperature of tube is 204·4°C. At average bulk temperature, air density is 1·016 kg/m^3; air specific heat capacity is 1·009 kJ/(kg.K); air dynamic viscosity is 2·055 × 10^{-5} Pa-sec; and thermal conductivity of air is 0·03 W/(m.K). By using Sieder-Tate equation, calculate convective heat transfer co-efficient.

b) Describe the mechanism of condensation heat transfer.

c) What do you mean by fouling factor of a heat transfer surface ? 8 + 5 + 2

12. a) State Rittinger's law and Kick's law.

b) Calculate the energy required to crush 100 tonnes per hour of limestone if 80% of the feed passes through a screen with 3·75 cm aperture and 80% of the product passes through of screen with 0·03 cm aperture. Work index for limestone is 12·74, where capacity is expressed in ton/min; energy required is in hp and size of the product and feed are in feet.

c) Briefly describe the working principle of a Ball mill.

4 + 7 + 4