Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.TECH (FT-OLD)/SEM-4/CHE-414/2012

2012

UNIT OPERATION OF 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 : 10 × 1 = 10

i) Bernoulli's equation describes

a) mechanical energy balance in potential flow

b) kinetic energy balance in laminar flow

c) mechanical energy balance in turbulent flow

d) mechanical energy balance in boundary layer.

ii) In frictional flow, the quantity $\frac{P}{\rho} + \frac{V^2}{2g_c} + \frac{gz}{g_c}$ is

a) constant along a streamline

b) not constant

c) increased in the direction of flow

d) none of these.

iii) The loss due to sudden contraction is proportional to

a) velocity b) velocity head

c) turbulence d) none of these.

iv) 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.

v) Heat transfer coefficient (h_1) for liquids increases with

a) increasing temperature

b) decreasing temperature

c) decreasing Reynolds number

d) none of these.

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

a) conduction b) convection

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

vii) The value of Stefan-Boltzmann 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 / ($m^2 K^4$).

viii) The Bernoulli's equation can be written in the form

$$\frac{P}{\gamma} + Z + \frac{v^2}{2g} = \text{constant}$$

The 'constant' for points lying on the same streamline and those which lie on other streamlines will have the same value only if the flow is

a) steady b) uniform

c) incompressible d) irrigational.

ix) 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.

x) A plate 0·6 mm distant from a fixed plate, moves at 0·24 m/s and requires a force per unit area of 1 N/m^2 to maintain the speed. The fluid viscosity of the substance between the plates in $N.s/m^2$ is

a) 0·4 b) $2{\cdot}5 \times 10^{-3}$

c) 2·5 d) $0{\cdot}4 \times 10^{3}$.

xi) The dimensions of Kinematic Viscosity is

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

c) $ML^{-2}T^{-2}$ d) none of these.

xii) Which of the following is a fine Crusher ?

a) Black Jaw Crusher

b) Gyratory Crusher

c) Toothed Roll Crusher

d) Dodge Jaw Crusher.

xiii) Which of the following is directly concerned with heat transfer ?

a) Strouhal number

b) Sherwood number

c) Euler number

d) Grashoff number.

xiv) Potential flow is the flow of

a) incompressible fluid with no shear

b) incompressible fluid with shear

c) Newtonian fluids

d) non-Newtonian fluids.

xv) The simple Pitot tube measures

a) density

b) the static pressure

c) the dynamic pressure

d) the total pressure.

xvi) For a rotameter, the flow rate is

a) proportional to square root of meter reading

b) proportional to square of meter reading

c) approximately directly proportional to meter reading

d) inversely proportional to meter reading.

xvii) A sphere, a cube and a thin circular plate, all made of the same material and having the same mass are initially heated to the same temperature 300°C. Which of these objects will cool at the slowest when left in the air at room temperature ?

a) Sphere

b) Cube

c) Circular plate

d) All will cool at the same rate.

xviii) $f = \frac{16}{N_{Re}}$ is valid for

a) turbulent flow

b) laminar flow drough an open channel

c) steady flow

d) none of these.

xix) Power required to drive a ball mill with a particular ball load is proportional to

a) D b) $\frac{1}{D}$

c) $D^{2 \cdot 5}$ d) $1/D^{2 \cdot 5}$.

xx) Maximum rate of heat transfer is achieved by

a) co-current flow

b) counter current flow

c) turbulent flow

d) laminar flow.

xxi) In counter flow compared to parallel flow

a) LMTD is greater

b) less surface is required for a given heat transfer rate

c) both (a) and (b)

d) more surface is required for a given heat transfer rate

xxii) The heat transfer coefficient in film type condensation is

a) greater than that for dropwise condensation

b) less than that for dropwise condensation

c) same as that for dropwise condensation

d) half of that for dropwise condensation.

xxiii) Prandtl Number is given by

a) $\frac{C_p \mu}{K}$ b) $\frac{hD}{K}$

c) $\frac{hC_p}{K}$ d) $\frac{C_p \mu}{h}$.

xxiv) Which area is used in case of heat flow by conduction through a cylinder ?

a) Logarithmic mean area

b) Arithmetic mean area

c) Geometric mean area

d) None of these.

xxv) Poise converted into stokes by

a) multiplying with density (gm/c.c.)

b) dividing by density (gm/c.c.)

c) multiplying with specific gravity

d) dividing by specific gravity.

xxvi) With increase in temperature, viscosity of a liquid

a) increases

b) decreases

c) remains constant

d) first decreases and then increases.

xxvii) In turbulent flow

a) the fluid particles move in an orderly manner

b) momentum transfer is an molecular scale only

c) shear stresses are generally larger than in a similar laminar flow

d) shear stress is caused more effectively by cohesion than momentum transfer.

xxviii) The ratio of kinematic viscosity to thermal diffusivity is called the

a) Peclet number

b) Prandtl number

c) Stanton number

d) Nusselt number.

xxix) Cavitation occurs in a centrifugal pump when

a) the suction pressure < vapour pressure of the liquid at that temperature

b) the suction pressure > vapour pressure of the liquid at that temperature

c) the suction pressure = vapour pressure

d) the suction pressure = developed head.

GROUP – B

(Short Answer Type Questions)

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

2. What do you mean by cavitation ? What are the effects of cavitation ? How cavitation can be removed ? 1 + 2 + 2

3. Proved that $f = \frac{16}{N_{Re}}$ for laminar flow.

   Find the type of flow of an oil of specific gravity 0·9 & dynamic viscosity 20 poise flowing through a pipe of diameter 20 cm and giving a discharge of 10 lit/sec. 2 + 3

4. Rotameter is also known as variable area meter. Explain.

   A Rotameter with stainless steel float has a maximum capacity of 1·2L/s of water at 28°C. What will be the maximum capacity for kerosene in L/s for the same rotameter and the same float ?

   Specific gravity of stainless steel = 7·92

   Specific gravity of kerosene = 0·82. 2 + 3

5. Water is to be pumped from a large reservoir resting on floor at a rate 5 m^3/hr to the open top of an absorption tower through 50 m ID pipe. The point of discharge is 6 m above the floor and frictional losses in the entire system is 25 kg *f*-m/kg. At what height in the reservoir the water be kept if the pump can develop 0·1 hp ?

6. a) Prove that the following numbers are actually dimensionless :

   i) Nusselt No.

   ii) Prandtl No.

   b) The dimensional formula of a heat transfer coefficient [h] is

   $$[\,h\,] = QL^{-2}\,\theta^{-1}\,T^{-1}$$

   In experimental work on the rate of heat transfer, a value of h = 396 Btu/(Sq. ft) (°F) (hr) was obtained. What is the value of this coefficient in

   kcal/(sq.ft) (°C) (hr) ? 2 + 3

7. Explain Buckingham-π-theorem with a suitable example.

8. What is LMTD ? Derive its formula.

9. Define kinematic viscosity. Calculate the critical velocity of water flowing through 25 mm id pipe. Take the viscosity of water 0·008 P. 2 + 3

10. Calculate NPSH of pump having the following data :

   a) Vap. Press. Of liquid = 0·267 kgf/cm ^{2}

   b) Distance between level of liquid in reservoir & suction line 1·2 m.

   c) Density of liquid to be pumped 865 kg/m ^{3}

   d) Friction in suction line 0·34 kgf-m/m ^{2}

   e) Pressure in reservoir 10330 kgf/m ^{2}.

11. the water is flowing through a pipe of 10 cm dia with an avg. velocity of 10 cm/sec. What is the rate of discharge of the water ? Also determine the velocity at the other end of the pipe, if the dia of the pipe is gradually changed to 20 cm.

GROUP – C
(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

12. Define the term 'fluidization'. Discuss the condition of fluidization with graphical interpretation.

Solid particles having a size of 0·12 mm, a shape factor $\phi_s = 0{\cdot}88$ and a density of 1000 kg/m^3 are to be fluidized using air at 2·0 atm abs. & 25°C. The voidage at minimum fluidization condition is 0·42.

a) If the cross-section of the empty bed is 0·30 m^2 & the bed contains 300 kg of solid, calculate the height of the fluidized bed.

b) Calculate the pressure drop at minimum fluidizing conditions.

c) Calculate the minimum velocity for fluidizing.

(Given : Physical properties of air at 2·0 atm and 25°C are $\mu = 1{\cdot}845 \times 10^{-5}$ Pa.s ; $P = 2{\cdot}0265 \times 10^5$ Pa ;

$\rho = 2{\cdot}374$ kg/m^3) 2 + 4 + 9

13. Derive relation between overall heat transfer coefficient and individual heat transfer coefficient. What is Dirt factor and how does it effect heat transfer coefficient ? A steam pipe line, 150/160 mm in diameter, is covered with a layer of insulating material of thickness 50 mm. The thermal conductivity of the pipe is 50 W/m-K & that of insulating material is 0·08 W/m-K. The temperature inside the pipeline is 120 °C and that of the outside surface of the insulation is 40°C. Calculate the rate of heat transfer. 5 + 4 + 6

14. Discuss the mechanism of condensation heat transfer. Determine the heat transfer coefficient for water flowing in a tube of 16 mm diameter at a velocity of 3 m/s. The temperature of the tube is 24°C, the water enters at 80°C and leaves at 36°C. Using the Dittus-Boelter equation.

    Where a = 0·3 and the properties of water at the arithmetic mean bulk temperature are P = 984·1 kg/m ^{3},

    C_p = 4178 J/kg K, $\mu = 485 \times 10^{-6}$ Pas,

    K = 0·657 W/m-K. 5 + 10

15. Mention the name of different industrial heat exchange equipment. With the help neat sketch, describe the different parts of a shell and tube heat exchanger. 3 + 12

16. What do you understand by the mean area of heat transfer ? Explain the heat transfer by conduction through resistances in parallel. Hot water flowing through a tube with a diameter of 16 mm and a length of 2 m, transfers heat through the wall of the tube to the surrounding medium. The rate of flow of water through the tube is 0·01 kg/s, the water inlet temperature is 80°C, outlet temperature is 36°C and the mean temperature of the wall of the tube is 24°C. Given C_p = 4·178 kJ/kg K for water.

    Calculate the heat transfer coefficient based on

    a) the arithmetic mean difference

    b) the logarithmic mean difference between the temperature of the water and the wall of the tube.

    3 + 3 + 9

17. Mention the name of different comminuting equipment. What do you understand by crushing efficiency ?

    A certain crusher accepts a feed of rock having volume-surface mean diameter of 0·75 inches and discharges a product of diameter of 0·20 inches. The power required to crush 15 T/hr in 12 hp. What should be the power consumption if the capacity is reduced to 10T/hr and volume surface mean diameter to 0·15 inches by using Rittinger's law. 3 + 4 + 8

18. State and explain the three different heads present in Bernoulli's equation. What are the limitations of Bernoulli's equation and how the equation can be modified ? A pipeline 600 m long and of 15 cm Dia is discharging an oil with velocity of 50 cm/sec. If the kinematic viscosity of oil is 19 cm^2/sec, find the loss of head due to friction. 6 + 5 + 4

19. Derive Ergun equation for fluid flowing trough a parallel bed. Quartz particle (density 2650 kg/m^3) are settling in water at room temperatures. What will be the maximum particle diameter so that Stokes formula can hold in the following case.

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

Also find the settling velocity of the particle under this condition. 10 + 5

20. State and explain Rittinger's law. Discuss the working principle of Ballmill. Calculate the operating speed of Ballmill from the following data :

a) Diameter of the Ball mill 500 mm

b) Diameter of the ball 50 mm.

Operating speed of the ballmill is 35% of critical velocity.

4 + 6 + 5