Name : .....

Roll No. : .....

Invigilator's Signature : .....

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

2013

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 : $10 \times 1 = 10$

i) Viscosity has the dimensions

a) $ML^{-1}T^{-1}$ b) $M^{-1}LT$

c) $ML^{-1}T^{-3}$ d) MLT^{-3}

Where M, L, T are used for mass, length and time respectively.

ii) 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.

iii) A plate 0.6 mm distant from a fixed plate, moves at 0.24m/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) 2.5×10^{-3}

c) 2.5 d) 0.4×10^{3}.

iv) Hagen – Poiseuille equation is 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.

v) Which of the following flow measuring devices is an area meter ?

a) Venturimeter b) Orifice meter

c) Anemometer d) Rotameter.

vi) The dimensions of Kinematic Viscosity is

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

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

vii) Which of the following is a fine Crusher ?

a) Black Jaw Crusher

b) Gyratory Crusher

c) Toothed Roll Crusher

d) Dodge Jaw Crusher.

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

a) Strouhal Number

b) Sherwood Number

c) Euler Number

d) Grashoff Number.

ix) Maximum rate of heat transfer is achieved by

a) co-current flow b) counter current flow

c) turbulent flow d) laminar flow.

x) 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.

xi) In frictional flow, the quantity $P/\rho + V^2/2g_c + gz/g_c$ is

a) constant along a streamline

b) not constant

c) increased in the direction of flow

d) none of these.

xii) The loss due to sudden contraction is proportional to

a) velocity b) velocity head

c) turbulence d) none of these.

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 $f = 16/N_{Re}$ for laminar flow.

   Find the type of flow of an oil of specific gravity 0.9 and 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 1.2 L/s of water at 28°C. What will be the maximum capacity for kerosene in L/s for the same rotameter & the same float ?

   Specific gravity of stainless steel = 7.92

   Specific gravity of kerosene = 0.82. 2 + 3

5. a) What is emissivity ?

   b) Cookies travelling on a conveyor inside a continuous baking oven occupy most of the area on the surface of the conveyor. The top wall of the oven directly above the conveyor has an emissivity of 0.92 and the cookies have an emissivity of 0.8. If the top wall of the oven has a temperature of 1750°C, calculate the average rate of heat transfer by radiation between the cookies per unit area on the side which faces the top wall of the oven when the cookies surface temperature is 700°C. 1 + 4

6. Using Buckingham π-theorem, show that Nusselt number is a function of Reynolds number and Prandtl number in case of convective heat flow through a circular pipe involving no phase change. The fluid flow is in turbulent condition.

GROUP – C
(Long Answer Type Questions)

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

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

Solid particles having a size of 0·12 mm, a shape factor ϕ_s = 0·88 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

8. 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

9. 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, $\mu = 485 \times 10^{-6}$ Pa-s,

   K = 0·657 W/m-K. 5 + 10

10. 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

11. Derive Ergun equation for fluid flowing trough a parallel bed. Quartz particle (density 2650 kg/m ^{3}) are settling in water at room temperature. 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

12. 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 Ballmill 500 mm

b) Diameter of the ball 50 mm.

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

4 + 6 + 5