

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.*

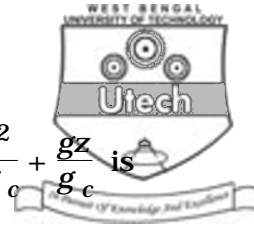
GROUP – A

(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) $5.6697 \times 10^{-8} \text{ W / (m}^2 \text{ K}^4 \text{)}$
- b) $0.1714 \times 10^{-8} \text{ W / (m}^2 \text{ K}^4 \text{)}$
- c) $5.6697 \times 10^{-8} \text{ kcal / (m}^2 \text{ K}^4 \text{)}$
- d) $0.1714 \times 10^{-8} \text{ kcal / (m}^2 \text{ K}^4 \text{)}$.

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) 2.5×10^{-3}
- c) 2.5 d) 0.4×10^3 .
- 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 through 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) $D^{2.5}$ | d) $1/D^{2.5}$ |



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. $3 \times 5 = 15$

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 $5 \text{ m}^3/\text{hr}$ 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 $h = 396 \text{ Btu}/(\text{Sq. ft}) (^\circ\text{F}) (\text{hr})$ was obtained. What is the value of this coefficient in

$\text{kcal}/(\text{sq.ft}) (^\circ\text{C}) (\text{hr})$?

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 :
- Vap. Press. Of liquid = $0.267 \text{ kgf}/\text{cm}^2$
 - Distance between level of liquid in reservoir & suction line 1.2 m.
 - Density of liquid to be pumped $865 \text{ kg}/\text{m}^3$
 - Friction in suction line $0.34 \text{ kgf-m}/\text{m}^2$
 - Pressure in reservoir $10330 \text{ kgf}/\text{m}^2$.



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.

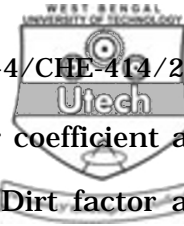
Solid particles having a size of 0.12 mm, a shape factor $\phi_s = 0.88$ and a density of 1000 kg/m^3 are to be fluidized using air at 2.0 atm abs. & 25°C . The voidage at minimum fluidization condition is 0.42.

- 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 $\mu = 1.845 \times 10^{-5} \text{ Pa.s}$; $P = 2.0265 \times 10^5 \text{ Pa}$;

$\rho = 2.374 \text{ kg/m}^3$)

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 $P = 984.1 \text{ kg/m}^3$,

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

$$K = 0.657 \text{ W/m-K.} \quad \text{5 + 10}$$

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 $C_p = 4.178 \text{ kJ/kg K}$ for water.

Calculate the heat transfer coefficient based on

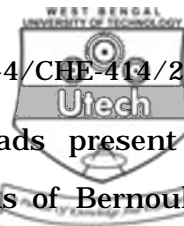
- a) the arithmetic mean difference
- b) the logarithmic mean difference between the temperature of the water and the wall of the tube.

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 $19 \text{ cm}^2/\text{sec}$, find the loss of head due to friction. 6 + 5 + 4
19. Derive Ergun equation for fluid flowing through 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 :
- Diameter of the Ball mill 500 mm
 - Diameter of the ball 50 mm.

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

4 + 6 + 5

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