



Name :

Roll No. :

Invigilator's Signature :

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

2012

UNIT OPERATIONS 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) For a rotameter the flow rate is
 - a) proportional to the 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.
- ii) Which of the following flow measuring devices is an area meter ?
 - a) Venturimeter
 - b) Orifice meter
 - c) Anemometer
 - d) Rotameter.



iii) Nusselt no. is given by

a) $\frac{hC_p}{k}$

b) $\frac{C_p\mu}{k}$

c) $\frac{C_p\mu}{h}$

d) $\frac{hD}{k}$.

iv) 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.

v) Two fluids milk and rapeseed oil, flowing along pipes of same diameter (5 cm) at 20°C and at same velocity of 3 ms^{-1} , $\mu_{\text{milk}} = 2 \cdot 10 \times 10^{-3} \text{ Pa.s}$, $\rho_{\text{milk}} = 1030 \text{ kg/m}^3$, $\mu_{\text{rapeseed}} = 118 \times 10^{-3} \text{ Pa.s}$, $\rho_{\text{rapeseed}} = 900 \text{ kg/m}^3$. Flow will be turbulent through the pipeline in case of

a) flow of milk

b) flow of rapeseed oil

c) in both cases

d) none of these.

vi) 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) one third that of dropwise condensation.



vii) The specific surface area of a solid mixture is given by

a) $\frac{6}{\rho_p} \sum_{i=1}^{i=n} \frac{x_i}{D_{pi}}$

b) $\frac{6}{\phi_s \rho_p} \sum_{i=1}^{i=n} \frac{x_i}{D_{pi}}$

c) $\frac{\phi_s D_p}{6} \sum_{i=1}^{i=h} \frac{D_{pi}}{x_i}$

d) $\frac{\phi_s D_p}{6} \sum_{i=n}^{i=1} \frac{D_i}{\phi_s}$

viii) In counter flow compared to parallel flow, LMTD is

- a) greater
- b) less surface is required
- c) both (a) and (b)
- d) none of these.

ix) The crushing energy required to create new surface is given by

- a) Fick's law
- b) Rittinger's law
- c) Fourier's law
- d) Newton's law.

x) Work Index is associated with

- a) Fick's law
- b) Rittinger's law
- c) Bond's law
- d) Reynolds' law.

xi) Operating speed of a ball mill is always

- a) less than its critical speed
- b) greater than its critical speed
- c) equal to its critical speed
- d) equal to the square of its critical speed.

xii) Maximum rate of heat transfer occurs in

- a) co-current flow
- b) countercurrent flow
- c) turbulent flow
- d) laminar flow.



- xiii) Jaw crusher operates by
- a) compression
 - b) attrition
 - c) impact
 - d) cutting.
- xiv) Stokes law for terminal velocity is associated with
- a) Pitot tube
 - b) compressor
 - c) settling of particles
 - d) screening.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

2. Prove that $f = 16 / N_{Re}$ 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 & giving a discharge of 10 lit/sec. $2 + 3$
3. What are the advantages of 2-4 pass heat exchanger over 1-2 pass heat exchanger ?
4. What do you mean by hydraulic radius ? Determine the value in annular space of two co-centric circular pipes.
5. a) What is the advantage of Rotameter in measurement of fluid flow in a pipeline ?
- b) What is vena contracta of an orifice meter ?
- c) You want to incorporate air in the flowing fluid stream, with a orificemeter device in the pipe line. At what point in the pipeline, you should attach the air pipe line to get maximum dissolution of oxygen in the following fluid stream and why ? $2 + 1 + 2$
6. What is 'filter aid' ? What is 'specific cake resistance' ? What do you mean by rejection coefficient of membrane ? $2 + 2 + 1$



GROUP – C

(Long Answer Type Questions)

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

7. a) How can you determine the shell side heat transfer coefficient in a shell and tube heat exchanger ?
- 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 175°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 70°C. 8 + 7
8. a) Benzene at 100° F is pumped through the system at the rate of 5.35 ft³/min. The reservoir is at atmospheric pressure (14.7 lb_f/inch²). The gauge pressure at the end of the discharge line is 50 lb_f/inch². The discharge is 10 ft, and the pump suction is 4 ft above the surface level of reservoir. The discharge line is having with 1.5 inch. The friction in the suction line is 0.5 lb_f/inch² and that in the discharge line is 5.5 lb_f/inch². The mechanical efficiency of the pump is 0.6. The density of benzene is 54 lb/ft³. And its vapour pressure at 100° F is 3.8 lb_f/inch². Calculate
 - i) the developed head of the pump
 - ii) the total power input
 - iii) if the pump manufacturer specifies a required NPSHR of 10 ft, will the pump be suitable for this service ? 10



- b) Which dimensionless number is used for indication of wall thickness of pipe ? What do you mean by BWG ? 1 + 1
- c) What is cavitation ? 3
9. a) Derive the Hagen-Poiseuille equation. Where this equation is applicable ?
- b) A pump draws a solution of specific gravity 1.84 from a storage tank through 75 mm pipe. The efficiency of the pump is 60%. The velocity in the suction zone is 0.914 m/s. The pump discharges through a 50 mm pipe. The end of the discharge pipe is 15.2 m above the level of the solution in the feed tank. The friction loss in the entire pipe system are 29.9 J/kg. What pressure must the pump developed ? What is the power delivered to the fluid by the pump ? 7 + 8
10. Calculate the specific cake resistance and specific resistances of filter medium from the following data for constant pressure filtration of suspension of incompressible solids of concentration 30 kg/m^3 on a filter medium of area 1 m^2 . Pressure drop was 2 bar. Viscosity of filtrate is $1.1 \times 10^{-3} \text{ kg/ms}$.

V (m ³)	2×10^{-3}	4×10^{-3}	6×10^{-3}	8×10^{-3}	10×10^{-3}
Time t (s)	23	60	114	184	270



11. a) What are the differences between fan, blower and compressor ?

A centrifugal fan is used to take flue gas at rest and at a pressure of 737 mm of Hg and a temperature of 93.3°C and discharge it at a pressure of 765 mm Hg and a velocity of 45.7 m/s. Calculate the power needed to move 16990 m³/h of gas. The efficiency of the fan is 65% and the molecular weight of the gas is 31.3.

- b) What do you mean by positive displacement pump ?
What do you mean by reverse osmosis process ?

10 + 5

12. a) Distinguish between open circuit grinding and closed circuit grinding.
- b) Prove that the critical speed of a ball mill is given by the equation $\eta_c = \frac{1}{2\pi} \sqrt{\frac{1}{R-r}}$ where symbols have their usual meaning.
- c) Differentiate between classifier and clarifier with respect to their operational characteristics.

4 + 6 + 5

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