

Name : .....

Roll No. : .....

Invigilator's Signature : .....

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

**2012**

**TRANSFER OPERATIONS - 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.*

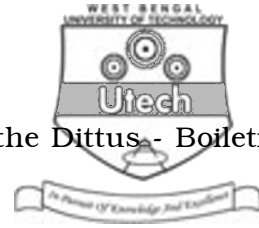
**GROUP - A**

**( Multiple Choice Type Questions )**

1. Choose the correct alternatives for the following :

10 × 1 = 10

- i) Thermal resistance of a solid system is given by
  - a)  $B/k$
  - b)  $1/k$
  - c)  $B/\bar{k}$
  - d)  $k/B$ .
- ii) Parallel flow is effectively used in the heat exchanger of type
  - a) Single pass exchanger
  - b) Multipass exchanger
  - c) Double pipe heat exchanger
  - d) Plate type heat exchanger.
- iii) LMTD should be used for a heat exchanger
  - a) when  $U$  change appreciably
  - b) thick wall heat exchanger pipe
  - c) counter current flow
  - d) Jacketed tubular reactor.



- iv) Viscosity correction is introduced in the Dittus-Boelter equation for
- a) turbulent flow
  - b) laminar flow
  - c) cooling a viscous liquid
  - d) heating a viscous liquid.
- v)  $j_H$  factor vs  $N_{Re}$  with values of  $L/D$  should be plotted for
- a) laminar flow
  - b) turbulent flow
  - c) transition region
  - d) for the flow above  $N_{Re} = 6000$ .
- vi) The value of friction factor ( $f$ ) for laminar flow is
- a)  $16/N_{Re}$
  - b)  $24/N_{Re}$
  - c)  $32/N_{Re}$
  - d)  $N_{Re}/28$ .
- vii) Rubber latex is an example of
- a) Newtonian fluid
  - b) Bingham plastic
  - c) Pseudoplastic
  - d) Dilatant fluid.
- viii) Which of the following pumps is useful for biological fluid transport ?
- a) Piston pump
  - b) Centrifugal pump
  - c) Peristaltic pump
  - d) Gear pump.
- ix) Fine flow control can be done by
- a) globe valve
  - b) butterfly valve
  - c) needle valve
  - d) ball valve.
- x) Ratio of average velocity to maximum velocity for a Newtonian fluid flowing in laminar condition through circular pipe is
- a) 0.5
  - b) 2
  - c) 1.5
  - d) 2/3.

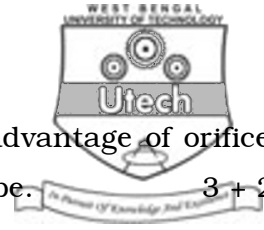


**GROUP – B**

**( Short Answer Type Questions )**

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

2. Power required to drive the impeller installed in a stirred tank fermenter depend on rotational speed of the impeller ( $n$ ), diameter of the impeller ( $D_i$ ), gravitational acceleration ( $g$ ), density of the fermentation broth ( $\rho_f$ ), viscosity of the fermentation broth ( $\mu_f$ ). Obtain the dimensionless form of functional relationship using Buckingham -Pi theorem.
3. Show that the velocity profile of a Newtonian fluid flowing through a circular pipe under laminar flow condition is a parabola.
4. a) Differentiate between particulate fluidization and bubbling fluidization.  
b) Explain the condition of fluidization by showing the graphical relationship of pressure drop and bed heights vs superficial velocity of fluid.  $2 + 3$
5. a) Water flows through an orifice 25 mm diameter in a 100 mm pipe at the rate of  $630 \text{ cm}^3/\text{sec}$ . What is the level of a water manometer connected across the orifice ? The discharge coefficient may be taken as 0.62 and the viscosity of water is 1cP.



- b) Mention one advantage and one disadvantage of orifice meter of measuring flow through a pipe. 3 + 2
6. Give the definition of the following : 5 × 1
- a) Potential flow
  - b) Bringham plastic
  - c) Thixotropic fluid
  - d) Skin friction
  - e) Fee turbulence.
7. A standard 1 inch schedule 40 steel pipe (OD 1.315 inch, ID 1.049 inch) carries saturated steam at 150°C. The pipe is lagged with a 2 inch layer of 85% magnesium ( $k_1 = 0.065 \text{ W/m}^\circ\text{C}$ ) followed by a  $\frac{1}{2}$  inch layer of cork ( $k_2 = 0.055 \text{ W/m}^\circ\text{C}$ ). The outside temperature of the cork is 45°C. The thermal conductivity of steel,  $k = 400 \text{ W/m}^\circ\text{C}$ . Calculate the heat loss from 20 m of pipe in wall.
8. Derive an expression for log mean temperature difference (LMTD) for a heat exchanger with countercurrent flow.
9. Carbon tetrachloride flowing at 19,000 kg/hr is to be cooled from 85°C to 40°C using 13,500 kg/hr of cooling water at 20°C. The film coefficient for carbon tetrachloride outside the tube is  $1700 \text{ W/m}^2 \text{ }^\circ\text{C}$ . The wall resistance is negligible. But  $h_i$  on the water side including the fouling factor is  $11,000 \text{ W/m}^2 \text{ }^\circ\text{C}$ . What area is needed for counter flow exchanger ?



10. What is the Colburn  $j$  factor ? State the Colburn analogy between heat transfer and fluid friction for turbulent flow  $f = 0.046(DG/\mu)^{-0.2}$  ? 2 + 3

**GROUP – C**

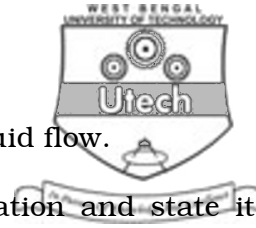
**( Long Answer Type Questions )**

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

11. a) A pump draws a solution of specific gravity 1.84 from store tank of large cross-sectional area through a pipe of ID 0.08 m . The average velocity in the suction line is 3m/sec. ID of the discharge line is 0.065 m. The end of the discharge line is 35 m above the level of the solution in the feed tank. Frictional losses in the system is 4.7 m of the solution. What pressure must the pump develop in  $\text{kg m}^2$  ? Assuming the overall efficiency 60%, calculate the energy requirement in kWh.
- b) Draw and explain the characteristics curves of centrifugal pump.
- c) Describe the working principle of piston pump.
- d) Differentiate between gate valve and globe valve.

8 + 3 + 2 + 2

12. a) Prove that the following numbers are dimensionless :
- (i) Nusselt number
  - (ii) Froud number
  - (iii) Power number
  - (iv) Grashof number.



- b) State the equation of continuity for fluid flow.
- c) Write down Hagen - Poiseuille equation and state its application.
- d) Write down the Bernoulli's equation mentioning the significance of each of the terms.
- e) Define streamline and sphericity.
- f) Calculate the hydraulic mean diameter of the annular space between 40 mm and 50 mm tube.

4 + 2 + 2 + 3 + 2 + 2

13. a) The following data were obtained in a constant pressure filtration of yeast suspension.

$t$ (min)	4	20	48	76	120
$V$ (lit filtrate)	115	365	680	850	1130

Characteristics of filter cake :  $A = 0.28 \text{ m}^2$ ,  $C = 1920 \text{ kg/ m}^3$ ,  
 $\mu = 2.9 \times 10^{-3}$ ,  $\alpha = 4 \text{ m/kg}$ .

Determine :

- (i) Pressure drop across the filter
  - (ii) filter medium resistance ( $r_m$ )
  - (iii) size of the filter to process 4000 lit of cell suspension in 20 minute. 12
- b) Define work index and derive the relation between Bond coefficient ( $K_b$ ) and work index ( $W_i$ ). 3



14. a) Derive an expression for overall heat transfer coefficient based on the inside diameter of the pipe in terms of individual heat transfer coefficient ( $h_i$ ,  $h_o$ ) and thermal conductivity of the wall ( $k$ ).
- b) Oil is flowing through a 75 mm ID iron pipe at 1m/sec. It is being heated by steam outside the pipe, and the steam film coefficient is 11,000 W/ m<sup>2</sup>°C. At a particular point along the pipe the oil is at 50°C, its density is 880 kg/ m<sup>3</sup>, viscosity = 2.1 cP, thermal conductivity  $k = 0.35$  W/m°C, specific heat  $c_p = 217$  J/g°C. What is the overall heat transfer coefficient at this point based on the inside area of the pipe. Given  $(h/C_p G) (N_{Pr} \frac{2}{3}) = 0.23 NRe^{-0.2}$ . 5 + 10
15. a) Draw 1-2 parallel counter flow shell and tube heat exchanger with a schematic diagram and explain its mode of action.
- b) What is the radiation law for radiation between surfaces ? Explain the different terms used in the heat transfer equation by radiation ? 10 + 5
16. a) Deduce the expression for unsteady state heat transfer in a semi-infinite solid bar.
- b) Indicate the steps for a analytical solution by an separation of variables. 10 + 5

