



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.

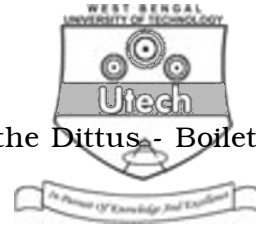
GROUP - A

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

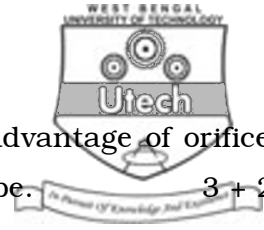


GROUP – B

(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 (ρ_f), viscosity of the fermentation broth (μ_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 ?



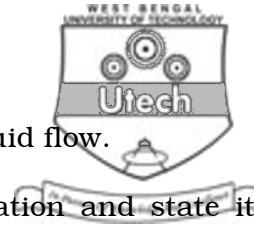
10. What is the Colburn j factor ? State the Colburn analogy between heat transfer and fluid friction for turbulent flow $f = 0.046(DG/\mu)^{-0.2}$? 2 + 3

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 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 $11,000 \text{ W/m}^2\text{C}$. At a particular point along the pipe the oil is at 50°C , its density is 880 kg/m^3 , viscosity = 2.1 cP , thermal conductivity $k = 0.35 \text{ W/m}^\circ\text{C}$, specific heat $c_p = 217 \text{ J/g}^\circ\text{C}$. What is the overall heat transfer coefficient at this point based on the inside area of the pipe. Given $(h/C_p G) (N_{Pr/3})^2 = 0.23 NRe^{-0.2}$. 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
