

L 1035

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2006.

Fourth Semester

Biotechnology

BT 1252 — UNIT OPERATIONS

(Regulation 2004)

Time : Three hours

Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Give four uses of agitation of fluids.
2. Define Reynolds number and Froude number in agitation.
3. How do you find out a filter cake is compressible?
4. Using the general settling velocity equation $v_t = \sqrt{\frac{4(\rho_p - \rho)_g \cdot D_p}{3C_D \cdot \rho}}$ derive v_t for Stoke's region of settling.
5. What is the criterion for using lumped capacity method in transient heat conduction?
6. For a plane wall (thermal conductivity k and thickness x) with convection heat transfer coefficients h_i and h_o on the two sides how do you define overall heat transfer coefficient u ?
7. If Nusselt number is correlated with Reynolds number and Prandtl number for forced convection heat transfer. What is the correlation used for natural convection heat transfer?
8. Water is heated from 30°C to 60°C in a double pipe heat exchanger by condensing steam at 100°C. Calculate ΔT_m .

9. For the following convection heat transfer situations define Reynolds number.
- Fluid flow over plate
 - Fluid flow through pipe
 - Fluid flow through annular pipe
 - Fluid flow over a sphere.
10. Distinguish between forward feed and backward feed evaporation.

PART B — (5 × 16 = 80 marks)

11. (i) Show by suitable derivation why ΔT_m (log mean temperature difference) is used in heat exchangers. (10)
- (ii) Water is flowing at a rate of 0.668 kg/s counter current to oil flowing at a rate of 2.85 kg/s. The inlet temperatures of water and oil are 308 K and 383 K. The overall heat transfer coefficient is 300 w/m²K and area of heat transfer is 15 m². (min = 2796 w/K effectiveness is found to be = 0.71).
- Calculate NTU. (2)
 - Calculate outlet temperature of water. (4)
12. (a) A flat-blade turbine agitator with six blades is installed in a tank. The tank diameter is 1.83 m. Diameter of the impeller to tank diameter ratio is 1/3. The tank is provided with four baffles. The turbine is operated at 90 rpm. The liquid in the tank has a viscosity of 10 CP and density of 929 kg/m³. For the standard design the following data are available.
- | | | | | | |
|------|----|-----|------|-------|-------|
| Re : | 5 | 100 | 1000 | 51000 | 60000 |
| Np : | 14 | 4 | 4.1 | 5 | 5 |
- Calculate the power required in kW. (10)
 - For the same conditions except the viscosity of the solution is 1,00,000 CP calculate the power required in kW. (6)
- Or
- Explain agitator types and flow currents in liquid agitation. (8)
 - Discuss agitator scale up procedure. (8)

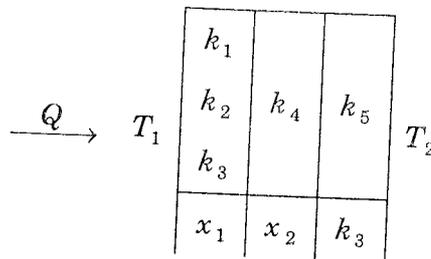
13. (a) Data for the laboratory filtration of CaCO_3 slurry in water is given below at constant $(-\Delta P)$ of 338 kN/m^2 . The filter area is 0.0439 m^2 and slurry concentration is 23.47 kg/m^3 . Calculate specific resistance α and filter medium resistance R_m .

Data: t (sec):	4.4	16.3	34.7	59	89.4
V (vol. of filtrate m^3):	0.498×10^{-3}	1.501×10^{-3}	2.498×10^{-3}	3.506×10^{-3}	4.502×10^{-3}

Viscosity of water $0.9 \times 10^{-4} \text{ Pa.s.}$ (16)

Or

- (b) Oil drops of diameter 0.020 mm are settled from air at 311 K and 101.3 kPa . The density of the oil is 900 kg/m^3 . Viscosity of air is $1.90 \times 10^{-5} \text{ Pa.s}$. Making suitable assumption of settling region calculate settling velocity of oil drops. If this oil laden air is passed through a settling chamber and 3 minutes of residence time is available. What may be the height of the chamber for effective settling? (16)
14. (a) (i) Explain with suitable derivation critical thickness of insulation for a cylinder. (8)
- (ii) For a multilayer series-parallel plane wall derive the steady state heat conduction equation. The multilayer wall is shown below.



k values are thermal conductivities x values are thickness of walls. (8)

Or

- (b) (i) Derive the temperature distribution equation for a rectangular fin with end of the fin insulated. (12)
- (ii) Based on the derivation calculate the heat lost by the fin. (4)

15. (a) In natural convection heat transfer $h = f n \{L, \rho, \mu, CP, \beta, g, \Delta T, k\}$
 where $h = \text{w/m}^2\text{K}$ $CP = \text{J/kg K}$ $k = \text{w/m.K}$

$$L = \text{m} \quad \beta = \frac{1}{T} = \frac{1}{\text{K}}$$

$$\rho = \text{kg/m}^3 \quad g = \text{m/s}^2$$

$$\mu = \text{kg/m.s} \quad \Delta T = . \text{K.}$$

By dimensional analysis show

$$Nu \left(\frac{h \cdot L}{k} \right) = f n \left(Gr \left(\frac{L^3 \rho^2 g \beta \Delta T}{\mu^2} \right), Pr \left(\frac{CP \cdot \mu}{k} \right) \right)$$

Clue : Choose core variables (L, μ, k, g) .

(16)

Or

- (b) Water is flowing through a horizontal pipe at an average temperature of 65.6°C and a velocity of 2.44 m/s . It is being heated by steam condensing at 107.8°C on the outside of pipe wall. Using the data given below calculate

- (i) Waterside heat transfer coefficient
 (ii) Overall heat transfer coefficient neglecting metal wall resistance.

Data : I.D. of pipe = 0.0266 m

O.D. of pipe = 0.0334 m

Water : $\rho = 980 \text{ kg/m}^3$

$\mu = 4.32 \times 10^{-4} \text{ Pa.s}$

$N_{Pr} = 2.72.$

(16)