Code No: R050212306

Set No. 1

II B.Tech I Semester Regular Examinations, November 2006
TRANSPORT PHENOMENA IN BIOPROCESS
(Bio-Technology)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Define mass flux.
   (b) Write the units of mass flux.
   (c) Write the Fick's first law of diffusion.
   (d) What is the difference between mass transfer rate and mass flux [3+3+5+5]

2. Explain the "Critical Oxygen concentration" in fermentation broths. [4+12]

3. In an aerobic fermentation process, the typical average bubble diameter is 3 mm, with an average raise velocity of 18 cm/s. If the diffusivity coefficient is $8 \times 10^{-10} m^2/s$. Find the mass transfer coefficient on the basis of penetration theory. [16]

4. Write briefly on power requirement for mixing. [16]

5. (a) Define shear stress and write the units.
   (b) Define flux and write the dimensions.
   (c) State Newton's law of viscosity and explain what does the negative sign signify.
   (d) What is slip velocity. [4+4+4+4]

6. (a) What are the factors on which the mixing time in stirred vessel depend
   (b) A fermentation broth with viscosity 10-3 PaS and density 1100 kg/m3 is agitated in a 3 m3 baffled tank using a Rushton turbine with diameter 0.8m and stirrer speed one revolution per second. Estimate the mixing time. [8+10]

7. (a) Write briefly on individual heat transfer coefficient and overall heat transfer coefficient
   (b) Draw the temperature profile for heat transfer with fouling deposits on both surfaces. [10+6]

8. Hot, freshly sterilized nutrient medium is cooled in a double pipe heat exchanger before being used in a fermentation. Medium leaving the sterilizer at 110 enters the exchanger at a flow rate of 2.78 kg/s the desired outlet temperature is 28^0C. Heat from the medium is used to raise the temperature of 6.94kg/s water initially at 15 ^0C. The system operates at steady state. Assume the nutrient medium has the properties of water. Calculate the rate of heat transfer required. The density of water is 1000 kg/m^3, specific heat is $4.19 \times 10 - 3J/Kg^0C$. [16]

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1. What are the various theories of diffusion mass transfer. Explain. [16]

2. What are the various factors affecting oxygen mass transfer rate in fermentation broths. [16]

3. Why foaming should be controlled in fermentation broths. What are the various methods available for controlling foam. [16]

4. Write the applications of mixing in bioprocessing. [16]

5. Explain the boundary layer separation with a sketch for flow around a flat plate aligned perpendicular to the direction of flow. [16]

6. Write briefly on mixing and the importance of mixing in bio processing. [16]

7. Water at a rate of 0.015kg/s is heated from 20 to 48^0C in a steel tube of 25mm diameter. Steam is used for heating and it condenses on the outer surface of the tube. Wall temperature is maintained at 108^0C. The flow is fully developed. Calculate the value of heat transfer coefficient. Density of water is 977.2 kg/ m^3. Specific heat is equal to 4188 J/Kg ^{0}C. Thermal conductivity is 0.668 w/ m^0C. Viscosity is $0.4 \times 10 - 3N - S/m^2$.

[16]

8. (a) Calculate the log mean temperature difference in a parallel flow and counter flow double pipe heat exchanger. Inlet and outlet temperature of cold water is 25 ^0C and 45^0C. Inlet and outlet temperature of hot water is 90^0C and 65^0C.

   (b) In a double pipe heat exchanger water flows through the tube and is heated from 25 ^0C to 60^0C by steam condensing on the outer surface of the tube. Steam condensation temperature is 115 ^0C. Calculate the log mean temperature difference.

[8+8]

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Code No: R050212306 **Set No. 3**

II B.Tech I Semester Regular Examinations, November 2006
TRANSPORT PHENOMENA IN BIOPROCESS
(Bio-Technology)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks
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1. Explain Penetration theory and Surface Renewal theory. Highlight the basic difference between these two theories. [16]

2. What are the various steps involved in the transport of gas from gas bubble to the bulk liquid and to the active site in the cell cluster. [16]

3. Why foaming should be controlled in fermentation broths. What are the various methods available for controlling foam. [16]

4. (a) Define power number and explain each term .
   (b) Define impeller Reynolds number and explain each term .
   (c) Define Froude number. What is its significance. [6+5+5]

5. (a) What are the factors to be considered while selecting an impeller for a particular operation.
   (b) Sketch the impellers used for low to medium viscosity liquids.
   (c) What are the important type of impellers used for mixing in agitated tanks.
   (d) Draw the figure and explain the arrangement of baffles set away from the wall for moderate viscosity liquids. [4+4+4+4]

6. Write short notes on
   (a) Cell concentration
   (b) Product and substrate concentration
   (c) Mixing [5+5+6]

7. Show that the heat flow in a hollow sphere whose inner and outer radii are at temperatures T_1 and T_2 is given by $Q = 4\Pi\ k(T_1 - T_2)/\ [(1/r_1) - (1/r_2)]$ where r_1 is the inner radius and r_2 is the outer radius. [16]

8. (a) Write the equation for Nusselt number.
   (b) Express Prandtl number in terms of heat capacity, viscosity and thermal conductivity of fluid.
   (c) Define Reynolds number.
   (d) Write the units of viscosity, heat transfer coefficient, thermal conductivity and heat flux. [4+4+4+4]

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Code No: R050212306 **Set No. 4**

II B.Tech I Semester Regular Examinations, November 2006
TRANSPORT PHENOMENA IN BIOPROCESS
(Bio-Technology)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Define mass flux.
   (b) Write the units of mass flux.
   (c) Write the Fick's first law of diffusion.
   (d) What is the difference between mass transfer rate and mass flux [3+3+5+5]

2. What are the various steps involved in the transport of gas from gas bubble to the bulk liquid and to the active site in the cell cluster. [16]

3. In a typical aerobic fermentation process, the diffusivity coefficient for oxygen into the fermentation broth is $8 \times 10^{-10} m^2$ /s. The stagnant liquid film thickness was calculated to be 6 microns. Find the mass transfer coefficient of oxygen based on the film theory.
[16]

4. Discuss the variation of Power number with Reynolds number for laminar, turbulent and transition region for ungassed fluids. [16]

5. (a) What are the different types of viscometers used for viscosity measurement.
   (b) Explain the construction and the working principle of impeller viscometer and co axial cylinder rotary viscometer. [6+10]

6. Discuss the mechanism, interaction between cells and turbulent eddies.
   (a) Define shear rate and write the units
   (b) Discuss the role of shear in stirred fermenters. [4+12]

7. A pipe line, 150/160 mm in diameter, carries steam. The temperature of the inside surface is 119.8 ^0C. Thermal conductivity of the tube material is 50w/m^0k Calculate the rate of heat loss per meter length of the pipe line. [16]

8. A 150 m^3 bioreactor is operated at 35^0C to produce fungal biomass from glucose. The rate of oxygen uptake by the culture is 1.5 kg/m^3 hr; the agitator dissipates heat at a rate of 1kw/m^3. 60m^3/hr cooling water available from a nearby river at 10^0C is passed through an internal coil in the fermentation tank. If the system operates at steady state, what is the exit temperature of the cooling water. The density of water is 1000 kg/m^3, specific heat is 4.19 $\times 10 - 3J/Kg^0C$. [16]

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