Reg. No.										

Manipal Institute of Technology, Manipal

(A Constituent Institute of Manipal University)

I SEMESTER M.TECH (INDUSTRIAL BIOTECHNOLOGY)

END SEMESTER EXAMINATIONS, DEC 2015/JAN 2016

SUBJECT: **TRANSPORT PHENOMENA IN BIOPROCESSING** [BIO 505]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ANY FIVE FULL** the questions.
- Missing data may be suitable assumed.

1A.	A fungus is used to produce an extra cellular polysaccharide by fermentation of sucrose. After 200h fermentation, the following measurements of shear stress and shear rate were made with a rotating cylinder viscometer. Plot the rheogram for this fluid and determine the appropriate non-Newtonian parameters: <table><tr><td>**Shear stress (N/m^2)**</td><td>4.41</td><td>23.53</td><td>35.71</td><td>45.71</td><td>63.68</td></tr><tr><td>**Shear rate (s^{-1})**</td><td>10.2</td><td>170</td><td>340</td><td>510</td><td>1020</td></tr></table>	**5**
1B.	The distance between the two parallel plates is 0.00914 m and the lower plate is being pulled at a relative velocity of 0.366 m/s greater than the top plate. The fluid used is soybean oil with viscosity of 4×10^{-2} Pa s at 303 K. i. Calculate the shear stress and the shear rate. ii. If glycerol at 293 K having a viscosity of 1.069 kg/ms is used instead of soybean oil, what relative velocity in m/s is needed using the same distance between plates so that the same shear stress is obtained as in part (i)? What is the new shear rate?	**2.5 + 2.5**
2A.	Consider the case of a Newtonian fluid in steady-state laminar flow down an inclined plane surface that makes an angle θ with the horizontal. Using a shell balance, find the equation for the velocity profile within the liquid layer having a thickness L and the maximum velocity of the free surface.	**5 + 5**
3A.	An enzyme (K_M = 10 mM) is immobilized uniformly in a gelatin slab (thickness L and area A). One side is in contact with a substrate solution (100 mM) and the other side is in contact with a glass plate. Derive the equation for the substrate concentration with respect to the distance inside the slab. Assume that the substrate is transferred by molecular diffusion in the x direction only and the gelatin slab is thick enough to catalyze all the substrate while it diffuses into the slab.	**5**
3B.	An enzyme is immobilized in 8 mm diameter agarose bead at a concentration of 0.018 kg protein m^{-3} gel. One bead is immersed in a well-mixed solution containing 3.2×10^{-3} kg/m^3 substrate. The effective diffusivity of substrate in the bead is 2.1×10^{-9} m^2/s. Kinetics of the enzyme can be approximated as first order	**5**

	with specific rate constant 3.11 x 10^5 s^{-1} per kg protein. Mass transfer effects outside the particles are negligible. Determine the steady-state substrate concentration of substrate inside the bead.	
4A.	Recombinant *E.coli* cells contain a plasmid derived from pBR322 incorporating genes for the enzymes b-lactamase and catechol 2,3-dioxygenase from Pseudomonas putida. To produce the desired enzymes the organism requires aerobic conditions. The cells are immobilized in spherical beads of carrageenan gel. The effective diffusivity of oxygen is 1.4 x 10^{-9} m^2/s. Uptake of oxygen is zero-order with intrinsic rate constant 10^{-3} mol/s m^3 particle. The concentration of oxygen at the surface of the catalyst is 8 x 10^{-3} kg /m^3. Cell growth is negligible. i. What is the maximum particle diameter for aerobic conditions throughout the catalyst? ii. If the density of cells in the gel is reduced by a factor of five, what is the maximum particle size for aerobic conditions?	**5+5**
5A.	A composite three – layered wall is formed of a 0.5 cm thick aluminum plate (k = 268.1 W/m K), 0.25 cm thick layer of sheet asbestos (k = 0.1660 W/m K) and 2.0 cm thick layer of rock wool (k = 0.055 W/m K). The asbestos is the center layer. The inner aluminum surface at 500°C and the outer rock wool surface is at 50°C. Determine the flow of heat per unit area.	**5**
5B.	A fresh food product is held in cold storage at 278 K. It is packed in a container in the shape of a flat slab with all faces insulated except for the top flat surface, which is exposed to the air at 278K. For estimation purposes the surface temperature will be assumed to be 278 K. The slab is 152.4 mm thick and the exposed surface are is 0.186 m^2. The density of the foodstuff is 641 kg.m^3. The heat of respiration is 0.07 kJ/kg h and the thermal conductivity is 0.346 W/m K. Calculate the maximum temperature in the food product at steady state and the total heat given off in W.	**5**
6A.	A thick walled tube of stainless steel (A) having a k = 21.63 W/m K with dimension of 0.0254 m ID and 0.0508 m OD is covered with a 0.0254 m layer of asbestos (B) insulation, k 0.2423 W/m K. The inside wall temperature of the pipe is 811 K and the outside surface of the insulation is at 310.8 K. For a 0.305m length of pipe, calculate the heat loss and also the temperature at the interface between the metal and the insulation.	**5**
6B.	A heated sphere of diameter D is placed in a large amount of stagnant fluid. Consider the heat conduction in the fluid surrounding the sphere in the absence of convection. The thermal conductivity k of the fluid may be considered constant. The temperature at the sphere surface is T_R and the temperature far away from the sphere is T_a. Set up the differential equation describing the temperature T in the surrounding fluid as a function of r, the distance from the center of the sphere and determine the temperature profile.	**5**