I St M.Tech End sem Reg. No. | | | | | | | | | | (2017) BRG

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

A Constituent Institution of Manipal University

I SEMESTER M.TECH. (INDUSTRIAL BIOTECHNOLOGY) END SEMESTER EXAMINATIONS, NOVEMBER 2017

SUBJECT: TRANSPORT PHENOMENA IN BIOPROCESSING [BIO 5123]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be assumed suitably

1A. Newtanian fluid is flowing in a horizontal tube of radius R. Develop the velocity profile and the mass flow rate of the flow inside the tube using shell balance approach and state all the assumptions you make while developing the shell balance 8

1B. Explain 'creeping flow' and 'inviscid fluid' from Navier-Stokes equation 2

2A Saturated steam at 135° C is flowing inside a steel pipe having an ID of 21 mm and an OD of 27 mm. the pipe is insulated with 38 mm of insulation on the outside. The convective coefficient for the inside steam surface of the pipe is estimated as h_i = 5678 W/m^2 °C and convective coefficient on the outside of the lagging is estimated as h_o = 11.35 W/m^2 °C. The mean thermal conductivity of the metal is 45 W/m. °C and 0.064 W/m. °C for insulation. 8

- Derive the expression used for the calculation
- Calculate the heat loss for 1 meter of pipe using resistances if the surrounding air is at 27°C
- Calculate the overall heat transfer coefficient

2B Explain the significance of Brinkman Number 2

3A Using Buckingham Pi theorem show that Heat flux in a heat exchanger in dimensionless number and it is a function of other dimensionless numbers. 8

3B Explain the significance of Reynolds Number and Prondtl number in heat exchanger design 2

4A Find the temperature profile of unsteady state heat conduction in semi-infinite slab 6

4B Gas A dissolves in a liquid B in a beaker diffuses isothermally into the liquid phase. As it diffuses, A also undergoes irreversible homogeneous first order reaction A+B → AB. An example of such a system is the absorption of CO_2 by a concentrated aqueous solution of NaOH. Derive the concentration profile gas A in liquid. 4

5A A liquid of constant density and viscosity is in a cylindrical container of radius R and the container is caused to rotate about its own axis at an angular velocity Ω. The cylindrical axis 6

is vertical so that $g_r = g_\theta = 0$ and $g_z = -g$, in which g is the magnitude of the gravitational acceleration. Find the shape of the free surface of the liquid when study state has been established.

5B Consider a catalytic heterogeneous chemical reaction in which a reaction A $\rightarrow$B is carried out and assume reaction occurs instantaneously at the catalytic surface. Imagine that the catalytic particle is surrounded by a stagnant gas film through which A has to diffuse to reach the catalytic surface. Neglect the curvature of the particle. 4

- Obtain the expression for concentration profile of A in stagnant gas film in terms of mole fraction of A

---- ALL THE BEST----