Department of Biochemical Engineering & Biotechnology
Animal Cell Technology (BE 717/BEL 717)

Major Test

Max. Marks: 50
Time: 2 h (10:30 h – 12:30 h)
Date: December 2, 2006
Venue: I 129

Answer Part A and Part B in separate answer book

Part A

1. What are the similarities and differences in bioreactor (a) design and (b) operations for microbial (primarily bacterial and yeast) and mammalian cells? Essays will not be entertained. answer in a precise point wise manner clearly demarcating between similarities and differences.

[5 + 5 = 10]

2. What parameters need to be considered while utilizing an exogenous (added externally) probe for mammalian cell membranes in order to monitor cell growth in a hollow fibre reactor? Draw a schematic to show the components of a device that can be designed to monitor cell growth in a hollow fibre reactor using the above membrane probe.

[3 + 2 = 5]

Part B

3. Illustrate and describe how action potentials are generated and propagated in neurons.

[10]

4. Derive the expression for the dimensionless oxygen concentration profile θ in the fibre's lumen (inside volume) for large distances down the length of a single tube of hollow fibre bioreactor. (a) Write the dimensionless equations describing the laminar velocity profile and the radial and axial transport of oxygen, using the following dimensionless groups. Diffusion in the axial direction may be ignored.

$$\theta = \frac{C - C_0}{\left(\dfrac{qR}{D}\right)} \quad \zeta = \frac{zD}{2v_{z,avg}R^2} \quad \xi = \frac{r}{R} \quad \phi = \frac{v_z}{v_{z,avg}}$$

C is the local DO concentration (mol/l). C_0 is the DO at the entrance to the fibre. q is the assumed constant flux through the fibre wall. R is the fibre internal radius. D is the oxygen diffusivity. z is axial distance. $v_{z,avg}$ is the average (superficial) velocity of medium through the fibre. r is the radial distance from the centreline. and v_z is the liquid axial velocity. The laminar velocity profile in a tube is a simple parabolic, which in the dimensionless nomenclature becomes $\phi = 2\left(1 - \xi^2\right)$

(b) At large distance down the fibre one may assume fully developed mass and momentum boundary layers. Provide physical explanations for the following choices of boundary conditions:

$$BC1: \quad \xi = 0, \quad \frac{\partial \theta}{\partial \xi} = 0$$

$$BC2: \quad \xi = 1 \quad -\frac{\partial \theta}{\partial \xi} = 1$$

$$BC3: \quad -\zeta = 2\int_0^1 \theta(\xi, \zeta)\left(1 - \xi^2\right)\xi \, d\xi$$

(c) After the boundary layers have been established one would not expect the shape of the radial profile to change, and one would also expect that after some entrance length the DO concentration would change linearly down the length of the fibre. This allows the assumption that the solution has the form $\theta = a\zeta + \psi(\xi)$ where a is a constant and ψ is a function only of ξ. Use this form of θ to solve the problem in terms of the known variables.

[15]

5. What do you understand the hydrodynamic effects on animal cells in microcarrier culture? What are the parameters to asses the hydrodynamic effects in microcarrier culture? Describe the kinetics of cell growth and death in microcarrier culture.

[10]