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UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination - December, 2017

Program/Course : M. Tech Chemical (Spl. in Process Design)
Subject: Transport Phenomena
Code: CHPD7001
No. of pages: 2

Semester: I
Max. Marks: 100
Duration: 3 hrs

NOTE:

(A) **OPEN BOOK and OPEN NOTES EXAMINATION**

(B) Assume all missing data and Sketch wherever necessary

(C) **State your assumptions clearly**

ANSWER **ANY TWO** QUESTIONS 2 x 50 = 100

1. In recent years significant research work has been done in studying the effect of magnetic fields on biofluids, especially blood. Magnetic property of blood is due to the presence of hemoglobin molecules. Experiments show appreciable dielectric properties for blood which produces a Lorentz force even in the case of constant magnetic fields. The idea is to consider both magnetic and electric properties of blood in a unified mathematical model. Develop a mathematical flow model assuming blood to be Newtonian and non-Newtonian fluid.

   Hint: For non-Newtonian assume blood to follow Power-law model

   Ref.: *Tzirakis, et al.*, Numerical modeling of non Newtonian biomagnetic fluid flow, Computers and Fluids, 126 (2016) 170-180.

2. In a proposed adsorption process the gel particles are assumed to be uniform, porous spheres entering a column and falling in a rod-like flow through a rising stream of liquid. Assume the liquid essentially moves with a uniform velocity profile (at right angles to the column axis). As the gel spheres fall they preferentially adsorb aromatics so that the concentration of the aromatics in the liquid decreases as it rises to the top of the column. Two mechanisms of adsorption have been postulated.

   (i) Linear isotherm $n = kc$ (n = aromatic concentration on the surface of the sphere which is in equilibrium with c, the aromatic concentration in the bulk liquid in contact with the sphere)

   (ii) Langmuir type isotherm, $c = n/(k_2 + k_1 n)$

   For each case assume n is directly proportional to the bulk concentration in the solid immediately below the surface and:

   (a) Set up the equation of mass transfer into a single sphere. [15 marks]

   (b) Determine the boundary conditions and initial condition at the sphere radius R for steady state fall. [15 marks]

(c) Relate $\left(\frac{\partial c}{\partial t}\right)$ to the rate of aromatic adsorbed by the sphere as it falls. Let S = rate of flow of solids and V = rate of flow of liquid. The initial concentration in the liquid is c_0.

[20 marks]

3. A fluid passes isothermally upward in laminar flow through a long vertical straight tube of circular cross section at a constant rate. After all entrance effects have disappeared and fully developed laminar flow exists, the fluid is suddenly heated or cooled by a change in the exterior wall temperature. It is desired to find the resulting temperature and velocity fields. Assume ρ_0, μ_0 and T_0 are entrance density, viscosity and Temperature, respectively.

$$\rho = \rho_0 \left[1 - \beta \left(T - T_0\right)\right]$$
$$\frac{1}{\mu} = \frac{1}{\mu_0} \left[1 + \gamma \left(T - T_0\right)\right]$$

Set up the simplest possible mathematical model which represents the process.