ID: Name:

BITS Pilani, Pilani campus, Second semester 2021 -2022

ME F423 Microfluidics and its applications

Comprehensive Examination (Open Book)

Time: 8:00 AM to 11:00 AM, Date: 12/05/2022, Venue: Room No. 2203

Total marks: 35, Weightage: 35%

No solution manuals are permitted. Assume the missing data if any.

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1. Consider two flat, parallel, infinite plates located at y = h and y = -h separated by a Newtonian fluid with viscosity μ. Assume the lower plate is stationary and the top plate is actuated in the positive x direction with a force per unit area given by τ. In terms of the given parameters, determine an expression for the velocity distribution between the plates. [7 marks]
2. The availability of soil macronutrients N, P and K in the ionic form of NO_3^-, NH_4^+, PO_4^{3-} and K^+ are of special interest, as these ions are directly available for plant roots. A microfluidic chip for on-site analysis of soil samples for these ions needs to be designed based on capillary electrophoresis followed by conductivity measurement. Could you propose a preliminary design of this microfluidic chip with a neat schematic diagram? For the design calculations, develop an expression for the electrophoretic particle velocity of ions in a channel that exhibits electro-osmotic flow. [7 marks]
3. What do you understand by Wenzel and Cassie–Baxter regimes of wetting? Could you propose a methodology (list of procedures) to produce a PDMS surface with patterned roughness for increasing hydrophobicity. Also, predict the condition in terms of roughness parameters for the possible transition from Wenzel to Cassie–Baxter wetting regime. [7 marks]
4. Explain the electro wetting phenomenon based on Lippmann equation. An electrolyte droplet is placed on a hydrophobic electrode. The initial contact angle is $\theta_0 = 100^o$. The electrolyte is a NaCl solution with a concentration of 2×10^{-6} M and a relative dielectric constant of 80. The surface tension of the electrolyte is 72 mN/m. Determine the minimum voltage needed to make the surface hydrophilic. (1 M= 1 mol/L and 1 mole of the NaCl is 58.44g. If this amount of NaCl is dissolved in 1 liter of water, then, it can be said that we have a 1 M NaCl solution.) [7 marks]
5. What do you understand by centrifugal microfluidic platform? In a centrifugal microfluidic platform, the pressure across the liquid/gas interface in a channel (75 μm wide, 150 μm deep) is 30 mbar. Assuming a surface tension of the liquid/air interface of 72 mN/m, determine the number of revolutions per minute needed for bursting a liquid drop of a length of 1 mm at an average radial distance of 2 cm. [7 marks]