**Homework 6**

1. Consider a patient that is on dialysis. The average flow rate of blood through the dialyzer is 400 mL/min. The membrane used in the dialyzer has an effective area of 1.8 m2. The overall mass transfer coefficient for the urea in the dialyzer is 1.2 x 10-3 cm/s. Assume the flow rate of the dialysate is 500 mL/min. Determine **(A)** the number of transfer units for the dialyzer, **(B)** the extraction ratio for both cocurrent **AND** countercurrent exchanges, and **(C)** the dialysance for both cocurrent and countercurrent exchanges. Assume the patients blood concentration of urea started at 35 mM and the apparent volume for urea is 40 L. Urea is produced in the body at a constant rate of 150 mmol/min. Assuming the system can be modeled using a one-compartment model, determine the time it would take (for both cocurrent and countercurrent exchanges) for the urea concentration in the blood to drop to 8 mM using the properties of the dialysis machine presented in this problem. ***(Ans: )***
2. Consider a cellulosic membrane (r = 1.5 g/cm3) used in a dialyzer that removes urea from blood. Assume the membrane is 25 mm thick, the membrane tortuosity is 2, and the void (i.e., pore) *volume* is 0.4. Assume the membrane pores have a nominal molecular weight cutoff (NMWCO) of 20 kDa. Assume a urea molecule is spherical with a radius of 0.3 nm. Assume the bulk diffusivity of urea in plasma at 37oC is 6.6 x 10-6 cm2/s. Assume the blood has an initial urea concentration of 1 mg/mL, and the dialysate is initially free of urea. Determine **(A)** the permeability of the membrane to urea, and **(B)** the total (dry) membrane mass needed to remove 70% of the urea for both cocurrent and countercurrent exchanges, assuming the blood flow rate is 300 mL/min and the dialysate flow rate is 800 mL/min. (Assume that the overall mass transfer coefficient is equal to the membrane permeability.) **(Ans: )**
3. Consider a blood oxygenator that transfers oxygen into the blood at a rate of 200 mL/min. Blood enters the oxygenator at a rate of 5 L/min with an initial oxygen partial pressure of 40 mmHg. Gas is fed into the oxygenator at a rate of 10 L/min with an average, constant oxygen partial pressure of 650 mmHg. The system operates at 1 atm and 37oC. Assume the mass transfer coefficient for oxygen on the blood side is *kb* = 0.0101 cm/s. Determine **(A)** the partial pressure of oxygen in the blood leaving the oxygenator, and **(B)** the necessary membrane surface area to facilitate this process. (Reminder: from the Hill equation for looking at hemoglobin saturation, assume P50 = 26 mmHg, n = 2.34, and Csat = 8800 mM.)

**(Ans: )**

1. Consider heparinase immobilized on a cross-linked agarose support in a well-mixed flow reactor. The total volume of the enzyme particles (i.e., ) is 80 mL. The enzyme loading per enzymatic particle is 120 U/mL. Assume the effective diffusivity of heparin within the enzymatic particles is 10-6 cm2/s. The partition coefficient was determined to be 0.35. The enzymatic particles have a radius of 112 mm. The flow rate through the reactor was 110 mL/min, and the inlet heparin concentration is 0.2 mg/mL. The external mass transfer coefficient was determined to be 2.6 x 10-3 cm/s. Assume the reaction rate constants for the Michaelis-Menten equation that represents this system are: Km = 0.078 mg/mL, and kcat = 0.89 mg/(U hr). Determine **(A)** the Thiele modulus, **(B)** the overall effectiveness factor, **(C)** the conversion (percentage) of heparin. **(Ans: )**