1. A treated effluent flows in a 0.25 m deep open channel (squared ideal flow PFR) for a distance of 1500 m at a velocity of 0.25 m/h. If the initial concentration of dissolved oxygen is 0.08 mg/L and the concentration at the end of the channel is 2.9 mg/L, estimate the value of the mass transfer coefficient, K_L, for oxygen at 20 °C. Consider C_s for oxygen to be 9.08 g/m^3.

   Note: The general material balance for ideal flow PFR is:
   $$QC|_x - QC|_{x+\Delta x} + rV = \frac{\partial C}{\partial t}\Delta V$$

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2. Determine the Freundlich and Langmuir isotherm coefficients for the following activated carbon adsorption test data. The liquid volume used in the batch adsorption test was 1 L. The initial concentration of the adsorbate in solution was 3.37 mg/L. Equilibrium was obtained after 7 days.

Mass of activated carbon (g)	C_e (mg/L)
0.0	3.37
0.001	3.27
0.01	2.77
0.10	1.86
0.5	1.33

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3. An industrial wastewater effluent contains 1000 mg/L biological pollutant is to be treated in a completely mixed aerated lagoon (a shallow pond). The effluent is coming at a flow rate of 100 m^3/d. The pollutant degrades biologically in the lagoon according to first-order reaction kinetics (k = 0.9 d^{-1}). The volume of the lagoon is 500 m^3 and the lagoon is initially filled with wastewater containing 5 mg/L soluble metal ions. Assume no other water losses or gains (evaporation, seepage, or rainfall) and the lagoon is treated as a CSTR.

   a) Estimate the steady-state concentration of the biological pollutant in the reactor effluent?
   b) How long will it take to remove 99% of the metal ions from the lagoon assuming that the metal ions are non-reactive in the time period considered?

Note: The general material balance for CSTR is: $QC_0 - QC + rV = \frac{dC}{dt}V$

Wastewater effluent:
Q = 100 m^3/d
C_0=1000 ppm

Q = 100 m^3/d
C=? ppm