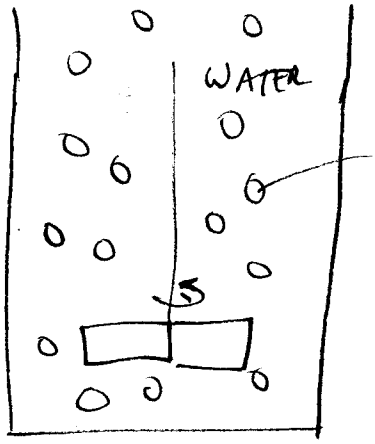
MASS TRANSFER COEFF.- MASS TRANSFER FROM AIR BUBBLES IN FERMENTATION PROCESS

CALCULATE THE MAXIMUM RATE OF ABSORPTION OF O_2 IN A FERMENTOR FROM AIR BUBBLES AT 1.0 atm (abs) HAVING DIAMETERS OF 100 μm @ 37°C INTO WATER HAVING A 0% CONC. OF DISSOLVED O_2. FERMENTOR LIQUID PROPERTIES = WATER.

THE SOLUBILITY OF O_2 FROM AIR IN WATER AT 37°C IS 2.26×10^{-7} gmol O_2 / cm^3 LIQUID.

THE DIFFUSIVITY OF O_2 IN WATER @ 37°C IS 3.25×10^{-5} cm^2/s.

ASSUME THE MASS TRANSFER AT THE BUBBLE SURFACE ON THE OUTSIDE IS THE CONTROLLING FACTOR.



O_2 O_2 OUTSIDE SURFACE TO BULK SOLN.

USE EQN. FOR MASS TRANSFER TO SMALL PARTICLES

$$k = \frac{2D_{AB}}{D_p} + 0.31\, Sc^{-2/3} \left(\frac{\Delta\rho \mu_c g}{\rho_c^2}\right)^{1/3}$$

PROPERTIES (O_2 IN H_2O)

C = WATER
P = AIR

$D_{AB} = 3.25 \times 10^{-5}\ cm^2/s$

$D_p = 100\ \mu m = 0.01\ cm$

μ_c (water) $= 0.76\ cp = 7.6 \times 10^{-3}\ g/cm\ s$ (VISCOSITY NOMOGRAPH)

Remember to convert viscosity units

$\rho_c = 1.0\ g/cm^3$

$$\rho_p = (MW)\frac{A}{V} = \frac{P}{RT}(MW) = \frac{(1\ atm)(29\ g/mol)}{\left(82.06 \frac{cm^3\ atm}{mol \cdot K}\right)(37+273)K}$$

$\rho_p = 1.14 \times 10^{-3}\ g/cm^3$

$$Sc = \frac{\mu_c}{\rho_c D_{AB}} = \frac{7.6\times10^{-3}\ g/cm\cdot s}{(1.0\ g/cm^3)(3.25\times10^{-5}\ cm^2/s)}$$

$$Sc = 233.8$$

$$\Delta\rho = (\rho_c - \rho_p) = (1 - 1.14\times10^{-3})\ g/cm^3 =$$

$$\Delta\rho = 0.9989\ g/cm^3$$

$$k = \frac{2(3.25\times10^{-5}\ cm^2/s)}{(0.01\ cm)} + 0.31(233.8)^{-2/3} \times$$

$$\times \left[\frac{(0.9989\ g/cm^3)(7.6\times10^{-3}\ g/cm\,s)(980.6\ cm/s^2)}{(1.0\ g/cm^3)^2}\right]^{1/3}$$

$$k = 6.5\times10^{-3} + 1.595\times10^{-2} = 2.245\times10^{-2}\ \frac{cm}{s}$$

$$N_A = k(C_{A1} - C_{A2})$$

THE MAXIMUM TRANSFER OCCURS AT THE SOLUBILITY OF O_2 IN WATER AS GIVEN IN PROBLEM STATEMENT

2.26×10^{-7} gmol $O_2/cm^3 = C_{A1}$

THE PROBLEM ALSO STATES THAT THE WATER HAS A 0% CONC., $\therefore C_{A2} = 0$ mol/cm^3

$$N_A = 2.245 \times 10^{-2} \text{ cm/s} \left(2.26 \times 10^{-7} - 0\right) \text{mol/cm}^3$$

$$\boxed{N_A = 5.07 \times 10^{-9} \text{ mol } O_2/\text{cm}^2 \cdot \text{s}}$$

KNOWING THE TOTAL NUMBER OF BUBBLES, THEIR TOTAL AREA CAN BE DETERMINED. THEN THE MAXIMUM RATE OF TRANSFER OF O_2 TO THE FERMENTATION LIQUID CAN BE CALCULATED