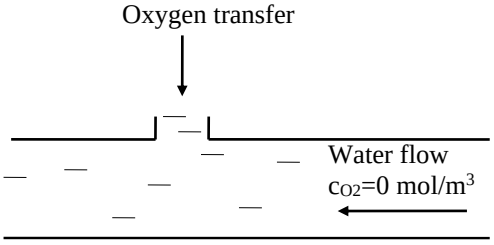
Examples of past exam problems

1. Determine the diffusion flux of CO_2 from the indoor air through a gypsum board wall. The wall is 2.5 cm thick, volume fraction of the solid material 60% and solid particles forming the wall are spherical. CO_2 fraction of air is 0.1 vol-% and 0.01 vol-% in inside and other side of the wall, respectively.

2. Determine evaporation (kg/m^2s) from a wood surface. Temperature of wood surface is 55°C, moisture ratio= 0.2 and the corresponding φ = 0.8. The surrounding air is at 58 °C and x = 0.012. Convection heat transfer coefficient is 18 W/m^2K.

3. Oxygen is transported from atmospheric air to water channel through a round hole (see figure). Water in the hole (diameter=5 mm, length = 6 mm) stays stagnant and fills the hole completely. Determine oxygen flow rate (mg/s) from air to water.



4. What should the ratio between surface areas of a hole in a wall (A_{hole}) and the wall (A_{wall}) be so that in steady state the diffusion flow rates (mol/s) through the hole and the wall are equal?

What is the ratio between real flow velocities (v_{CO2}) of CO2 in that case? The porosity of wall is 30 % and tortuosity 1.4.

5. A porous cardboard web is placed on a hot cylinder which is at 105°C. Determine water evaporation from the cylinder surface to surrounding air. The relative vapor pressure of cardboard at the cylinder surface is □ = 60%, cardboard thickness 0.7 mm, and volume fraction of gas 55%. For the surrounding air T= 20 °C, humidity x = 0.12. The structure can be assumed to be formed of long cylindrical fibers, which are longitudinal to the cardboard web. Air-side heat transfer coefficient is α = 25 W/m^2K.

6. A solid disk (diameter 2.5 cm) is made of benzoic acid. The disc rotates at rotation speed 20 rpm at 25°C. At what rate (kg/m^{2}s) does the disk dissolve into a large amount of water? How about into a large amount of air? The diffusion coefficient is in the water $1.00 \cdot 10^{-5}$ cm^2/s and in the air 0.233 cm^2/s. The molar mass of the benzoic acid is 122 g/mol, its equilibrium composition in the water is 0.003 g/cm^3, and its saturation pressure in the air is 40 Pa.

7. Evaporation of an oil droplet obeys the d^2–law as:

$$d^2 = d_o^2 - K\,t$$

where d_o is the droplet initial diameter, t time and the constant K is proportional to the temperature as

$$K \propto D_{AB}(T) \cdot \ln\left(\frac{p}{p - p_A(T)}\right).$$

Derive this generally used result, i.e., d^2–law and the form of the temperature dependence of K(T). Hint: droplet heat transfer is assumed to obey the correlation Nu = constant.