CH 3030 Tutorial 3

1. Wastewater at 600 gpm, containing 10 ppm (by weight) of benzene, is to be stripped with air in a packed column operating at 25°C and 2 atm to produce water containing 0.005 ppm of benzene. The packing is 2-inch polypropylene Flexirings. The vapor pressure of benzene at 25°C is 95.2 torr. The solubility of benzene in water at 25°C is 0.180 g/100 g. An expert in VOC stripping with air suggests use of 1,000 scfm of air (60°F, 1 atm), At these conditions, for benzene: k_La= 0.067 s^{-1} and k_Ga = 0.80 s^{-1}. Determine the:
   a) minimum air-stripping rate in scfm. (Is it less than the rate suggested by the expert? If not, use 1.4 times your minimum value);
   (b) stripping factor based on the air rate suggested by the expert;
   (c) number of transfer units, N_{OG};
   (d) overall mass-transfer coefficient, K_Ga, in units of mol/m^3-s-kPa and s^{-1} and which phase controls mass transfer; and
   (e) volume of packing in m^3.

Pre-requisites

- 1 gallon = 3.79 l; 1 m = 3.2808 ft; 1torr = 1 mm Hg;
- $T^K = 273.15 + \frac{5}{9}\,(T^{\circ F} - 32)$;
- Use the equilibrium relation y = Kx; K = $\frac{\gamma^L P^{vap}}{P^t}$ as benzene-water solution is non-ideal. To calculate liquid activity coefficient (γ^L), concept of liquid-liquid equilibrium for benzene distributed between benzene rich phase and water rich phase has to be invoked.

$$\overline{f_1^L} = \overline{f_2^L}$$
$$\overline{f_i^L} = \gamma_i^L x_i f_i^{\circ L}$$

Here 1 – benzene rich liquid phase; 2 – water rich phase;
Taking $f_i^{\circ L}$ to be equal for both phases, and above equations we get,

$$\gamma_i^L x_i = constant$$

$$\boxed{\boldsymbol{\gamma_1^L x_1 = \gamma_2^L x_2}}$$

Assuming phase 1 to be a pure benzene phase, γ_1^L = 1; x_1 = 1;

Calculate x_2 based on the solubility data for benzene at 25 °C

Using the expression given in the above text-box, calculate liquid activity coefficient ($\boldsymbol{\gamma_2^L}$)