

Chem201 Self Quiz - 6 (Spectroscopy / Extraction)

1. Molar absorptivities (ϵ , $M^{-1}cm^{-1}$) of compounds X and Y were measured in pure samples at two different λ and are given below:

λ, nm	X	Y
250	14,350	2,505
310	2,708	6,502

A mixture of these two compounds was tested in a 1.0 cm cell. The following absorbances (A) were obtained:

λ, nm	A
250	0.910
310	0.575

Find concentrations of X and Y in the mixture.

At 250 nm: $A' = \epsilon'_X b[X] + \epsilon'_Y b[Y]$

At 310 nm: $A'' = \epsilon''_X b[X] + \epsilon''_Y b[Y]$

$$[X] = \frac{\begin{vmatrix} A' & \epsilon'_Y b \\ A'' & \epsilon''_Y b \end{vmatrix}}{\begin{vmatrix} \epsilon'_X b & \epsilon'_Y b \\ \epsilon''_X b & \epsilon''_Y b \end{vmatrix}} = \frac{(0.910)(6,502) - (2,505)(0.575)}{(14,350)(6,502) - (2,505)(2,708)} = 5.17 \cdot 10^{-5} M$$

$$[Y] = \frac{\begin{vmatrix} \epsilon'_X b & A' \\ \epsilon''_X b & A'' \end{vmatrix}}{\begin{vmatrix} \epsilon'_X b & \epsilon'_Y b \\ \epsilon''_X b & \epsilon''_Y b \end{vmatrix}} = \frac{(14,350)(0.575) - (0.910)(2,708)}{(14,350)(6,502) - (2,505)(2,708)} = 6.69 \cdot 10^{-5} M$$

2. Solute S has a partition coefficient of 4 between water and chloroform.

- a. Calculate the concentration of S in chloroform if S_{aq} is 0.02 M.

$$K = \frac{C_{org}}{C_{aq}} \Rightarrow C_{org} = K \cdot C_{aq} = 4 \cdot 0.02 = 0.08 M$$

- b. If volume of water is 80 mL and the volume of chloroform is 10 mL, find the quotient (moles S)_{org} / (moles S)_{aq}.

$$\frac{\text{moles } S \text{ in org}}{\text{moles } S \text{ in aq}} = \frac{(0.08 \text{ M})(10 \text{ ml})}{(0.02 \text{ M})(80 \text{ ml})} = 0.5$$

- c. Assume that solute S is a weak acid ($\text{p}K_a = 4.5$). What would be its concentration in each phase if an aqueous solution buffered at pH 5.5? Volume of each phase is 25 mL and concentration of S_{aq} is 0.02 M.

$$D = K \frac{[H^+]}{[H^+] + K_a} = 4 \times \frac{10^{-5.5}}{(10^{-5.5}) + (10^{-4.5})} = 0.36$$

Note: use D in place of K for the q.

$$q = \frac{V_1}{V_1 + DV_2} = \frac{25}{25 + 0.36 \cdot 25} = 0.735$$

So, 73.5% of the acid left in water. Therefore,

$$[S]_{\text{aq}} = 0.735 \times 0.02 = 0.0147 \text{ M}$$

$$[S]_{\text{org}} = 0.265 \times 0.02 = 0.0053 \text{ M}$$