Problem 16-09 Adsorption from solution on solids – Freundlich isotherm

The following table gives the values of the preferential adsorption (Ω_2) and respective equilibrium concentrations of the bulk solution (c_2) obtained during the measurement of adsorption of acetic acid (subscript $_2$) from an aqueous solution on the charcoal:

c_2 / (mol dm^{-3})	Ω_2 / (mol g$^{-1}_{\text{charcoal}}$)
0.0181	$4.660\cdot10^{-4}$
0.8827	$2.479\cdot10^{-3}$

If you know that water is not adsorbed on the charcoal and that adsorption can be described by the Freundlich isotherm, calculate

(a) both constants of Freundlich equation,

(b) mole amount of the acetic acid removed from 400 cm^3 of solution by adsorption on 50 g of charcoal, if the concentration of equilibrium bulk solution was found to be 0.3 mol dm^{-3}.

[(a) n = 0.432; k = $2.64\cdot10^{-3}$ mol $(g_{charcoal})^{-1}$; (b) n = 0.0785 mol]

Solution:

(a) Calculation of the constants of Freundlich isotherm $\Omega_2 = k\cdot c_2^n$

$$\ln\Omega_2 = \ln k + n\cdot\ln c_2$$

$$\ln 4.666\cdot10^{-4} = \ln k + n\cdot\ln 0.0181$$

$$\ln 2.502\cdot10^{-3} = \ln k + n\cdot\ln 0.883$$

$$n = \frac{\ln 2.502\cdot10^{-3} - \ln 4.666\cdot10^{-4}}{\ln 0.883 - \ln 0.0181} = 0.432$$

$$k = \frac{\Omega_2}{c_2^{0.432}} = \frac{2.502\cdot10^{-3}}{(0.883)^{0.432}} = 2.640_{17}\cdot10^{-3}\ \text{mol g}^{-1}_{\text{uhlí}}$$

(b) Amount of acetic acid removed from the solution

V^o = 400 cm^3 = 0.4 dm^3

$m_{charcoal}$ = 50 g

c_2 = 0.3 mol dm^{-3}

$$\Omega_2 = \frac{V^o}{m_s}\cdot(c_2^o - c_2)$$

$$\Omega_2 = \frac{V^o}{m_s}\cdot\left(c_2^o - c_2\right) = (0.008\,c_2^o - 0.0024)\ \text{mol g}^{-1}_{\text{charcoal}}$$

$$\Omega_2 = k\cdot c_2^n = 2.64017\cdot10^{-3}\cdot0.3^{0.432} = 1.56945\cdot10^{-3}\ \text{mol g}^{-1}_{\text{charcoal}}$$

$n_2 = 50\cdot\ 1.56945\cdot10^{-3} = 0.0785$ moles on 50 $g_{charcoal}$