Problem 14-14 Kelvin equation – concave surface

The equilibrium solubility of an organic liquid in water at 30 °C is 1.7 mmol dm^{-3}. The solute does not dissociate on dissolving. The solubility will be higher if the organic liquid will be dispersed in water in the form of tiny droplets. What should be the diameter of the droplets to increase the solubility at least by 1.5 %? The density of the organic liquid is ρ = 0.957 g cm^{-3}, its molar mass 118 g mol^{-1}, and interfacial tension between aqueous and organic phases is 35 mN m^{-1}.

[d =0.46 μm]

Solution:

c_∞ = 1.7 mmol dm^{-3}

γ_{AV} = 35 mN m^{-1} = 0.035 N m^{-1}

M_A = 118 g mol^{-1} = 0.118 kg mol^{-1}

ρ_A = 0.957 g cm^{-3} = 957 kg m^{-3}

T = 303.15 K

The increase of solubility by 1.5 % means: $c_r = c_\infty \cdot 1.015 \quad , \quad c_r / c_\infty = 1.015$

$$\ln\frac{c_r}{c_\infty} = \frac{2\cdot\gamma\cdot V_m^{(org)}}{RT\cdot r} = \frac{2\cdot\gamma\cdot M}{RT\cdot\rho\cdot r}$$

$$r = \frac{2\cdot\gamma\cdot V_m^{(org)}}{RT\cdot r} = \frac{2\cdot\gamma\cdot M}{RT\cdot\rho\cdot\ln(c_r/c_\infty)}$$

$$r = \frac{2\cdot 0.035\cdot 0.118}{8.314\cdot 303.15\cdot 957\cdot \ln 1.015} = 2.3\cdot 10^{-7}\ \text{m} = 0.23\ \mu\text{m}$$

$$\left[\frac{(\text{N m}^{-1})\cdot(\text{kg mol}^{-1})}{(\text{J K}^{-1}\,\text{mol}^{-1})\cdot\text{K}\cdot(\text{kg m}^{-3})} = \text{m}\right]$$

J = N · m

Drop diameter : d =0.46 μm