

From what I could gather [1, 2, 3, 4], one of the simplest possible relationships between chemical potential and concentration applies to solutes in ideal, very diluted solutions and is of logarithmic type

$$\mu = \mu_a + \ln\left(\frac{c}{c_a}\right) \quad (1) \quad \boxed{\text{muc}}$$

where  $\mu_a$  and  $c_a$  are values of chemical potential and concentration at a given state.

I have not found instances of linear relationships between chemical potential and concentration. One wonders whether relationship

$$\dot{x} = k_{\text{on}}c - k_{\text{off}} \quad (2) \quad \boxed{\text{xck}}$$

holds only in the neighborhood of a given state. In this case equations (1) and (2) could be reconciled.

Another remark concerning Fick's law. If (1) is assumed, and Fick's law is expressed in terms of the gradient of the chemical potential

$$h(y,t) = -D \frac{\partial \mu}{\partial y}, \quad \frac{\partial h}{\partial y} = 0 \quad (3) \quad \boxed{\text{hdm}}$$

it is possible to obtain a linear  $c(y)$  by assuming

$$D = \frac{\kappa}{c_a} c. \quad (4) \quad \boxed{\text{Dc}}$$

In fact, using (1) and (3)

$$h(y,t) = -\frac{\kappa}{c_a} c \frac{\partial \mu}{\partial c} \frac{\partial c}{\partial y} = -\frac{\kappa}{c_a} c \frac{c_a}{c} \frac{\partial c}{\partial y} \Leftrightarrow h(y,t) = -\kappa \frac{\partial c}{\partial y}. \quad (5) \quad \boxed{\text{Dm}}$$

## References

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