Appendix A
Activities calculation

Solution activities are computed with the help of the Debye-Huckel theory [1]:

$$ln(a) = M_{m_{solv}} \nu M_{AB} \left(1 - \frac{\alpha(T)}{3}|z^+ z^-|\sqrt{I}\sigma(B\sqrt{I}) + \frac{\delta I}{2}\right) \quad (1)$$

In this equation, $M_{m_{solv}}$ is the molar mass of solvent (in $\frac{kg}{mol}$). It is $0.018\frac{kg}{mol}$ in the case of water. ν is the number of ions present after dissociation of the compounds and z^+ and z^- their valence. For example, $NaCl$ dissolution generates two ions (Na^+ and Cl^-) and $\nu = 2$, $z^+ = 1$ and $z^- = -1$. For Na_2CO_3, $\nu = 3$, $z^+ = 1$ and $z^- = -2$ as it liberates 2 Na^+ and 1 CO_3^{2-}. M_{AB} is the molality of the solution, the number of moles of solute by kg of solvent (in $\frac{mol}{kg}$). I is the ionic strength given by the relationship:

$$I = \frac{1}{2} M_{AB} \sum_{ions} \nu_i z_i^2 \quad (2)$$

with ν_i the number ion species i (for example, $\nu_{Na^+} = 2$ in Na_2CO_3).

$\alpha(T)$ is the first Debye-Huckel coefficient. It depends on temperature. A linear approximation has be made to estimate its evolution (see Figure 1).

$$\alpha(T) = 0.0025 \cdot T + 1.1149 \quad (3)$$

B and δ are two other Debye-Huckel coefficients. Their value is given in the Table 1. Finally, $\sigma(y)$ is the following function:

$$\sigma(y) = \frac{3}{y}\left(1 + y - 2ln(1+y) - \frac{1}{1+y}\right) \quad (4)$$

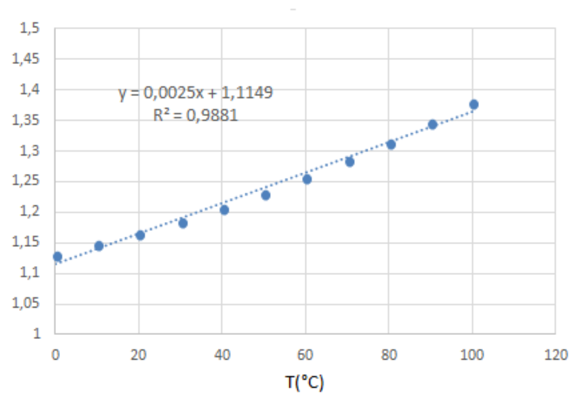

Figure 1: Linear regression of the first Debye-Huckel coefficient.

	B	δ	References
Na_2CO_3	0.8953	0.0150	[1]
$NaCl$	1.0000	0.1370	[2]

Table 1: Debye-Huckel coefficients

Finally, the water vapor pressure $p^{vap}(T)$ is given by the Antoine relation [3]:

$$p^{vap}(T) = 133.32exp\left(8.07131 - \frac{1730.63}{233.426 + T}\right) \tag{5}$$

with p^{vap} in bar and T in $°C$.

Bibliography

[1] S. I. Sandler, *Chemical, biochemical and engineering thermodynamics.* John Wiley & Sons, 6th ed., 2006.

[2] D. W. Green and R. H. Perry, *Perry's chemical engineer's handbook.* McGraw Hill, 8th ed., 2008.

[3] W. Ye, J. Lin, J. Shen, P. Luis, and B. Van der Bruggen, "Membrane crystallization of sodium carbonate for carbon dioxide recovery: Effect of impurities on the crystal morphology," *Crystal Growth and Design*, vol. 13, pp. 2363–2372, 2013.