10. Notations

Latin Symbols

- \( A \) Pre-exponential factor in the Arrhenius equation \( \text{L/(mol s)} \)
- \( A \) Debye-Hückel parameter \( \text{kg}^{1/2}\text{mol}^{-1/2} \)
- \( A_{\text{film}} \) Surface area of the liquid film on the tubes \( \text{m}^2 \)
- \( A_{\text{jets}} \) Surface area of the water jets between the tubes \( \text{m}^2 \)
- \( A_{\text{Ph}} \) Phase interface area \( \text{m}^2 \)
- \( a_i \) Activity of the component \( i \)
- \( b \) Sum of the ion and gas specific parameters \( \text{m}^3/\text{kmol} \)
- \( b_+ \) Ion specific parameter for cations \( \text{m}^3/\text{kmol} \)
- \( b_- \) Ion specific parameter for anions \( \text{m}^3/\text{kmol} \)
- \( b_G \) Gas specific parameter \( \text{m}^3/\text{kmol} \)
- \( C_i \) Concentration of the component \( i \) \( \text{mol/m}^3 \)
- \( C_2 \) Constant in equation (5.46) \(-\)
- \( CF \) Concentration Factor \(-\)
- \( CI \) Chlorinity \( \text{g/kg} \)
- \( D_{iL} \) Diffusion coefficient of the component \( i \) in the solution \( \text{L/m}^2\text{s} \)
- \( d_i \) Inside tube diameter \( \text{m} \)
- \( d_o \) Outside tube diameter \( \text{m} \)
- \( d_{\text{jets}} \) Diameter of the jets \( \text{m} \)
- \( E \) Enhancement factor \(-\)
- \( E_A \) Activation energy \( \text{kJ/mol} \)
- \( g \) Gravitational acceleration \( \text{m/s}^2 \)
- \( H_{ij} \) Henry's law coefficient of the gas \( i \) in the solution \( j \) \( \text{mol/(m}^3\text{bar)} \)
- \( h \) Heat transfer coefficient \( \text{W/(m}^2\text{K)} \)
- \( h \) Sum of the ion and gas specific parameters \( \text{kg/mol, L/mol} \)
- \( h_+ \) Ion specific parameter for cations \( \text{kg/mol, L/mol} \)
- \( h_- \) Ion specific parameter for anions \( \text{kg/mol, L/mol} \)
- \( h_G \) Gas specific parameter \( \text{kg/mol, L/mol} \)
- \( I \) Ionic strength \( \text{mol/kg} \)
- \([i]\) Concentration of the component \( i \) \( \text{mol/kg solution} \)
- \([i]_{\text{SW}} \) Concentration of the component \( i \) that is free and involved in ion-pairs in seawater \( \text{mol/kg solution} \)
K Constant in equation (5.46) -
K Thermodynamic equilibrium constant of the reaction on molal scale -
$K_{SW}^*$ Stoichiometric equilibrium constant of the reaction referring to the seawater scale on the basis mol/kg solution -
$K_1^{SW}$ First dissociation constant of carbonic acid in seawater on the basis mol/kg solution -
$K_2^{SW}$ Second dissociation constant of carbonic acid in seawater on the basis mol/kg solution -
$K_{SP}^{SW}$ Solubility product constant of calcium carbonate in seawater on the basis mol$^2$/kg$^2$ solution -
$K_{SW}^*$ Dissociation constant of water in seawater on the basis mol$^2$/kg$^2$ solution -
k Boltzmann constant J/K
k Rate constant of the reaction 1/s, L/(mol s)
k Thermal conductivity W/(m K)
$k^o$ Rate constant of the reaction in ideal solution 1/s, L/(mol s)
$k_1$ Rate constant of forward reaction 1/s
$k_{-1}$ Rate constant of backward reaction 1/s
$k_2$ Rate constant of second order reaction L/(mol s)
$k_L^o$ Mass transfer coefficient in liquid phase without chemical reaction m/s
$k_L$ Mass transfer coefficient in liquid phase with chemical reaction m/s
$K_L$ Overall mass transfer coefficient in the liquid phase m/s
L Length of tube m
LSI Langelier Saturation Index -
$m_i$ Molality of the component i mol/kg solvent
$m$ Mass flow rate kg/s
NTA Normalized total alkalinity mol/kg
NTC Normalized total carbon dioxide content mol/kg
$\dot{N}_i$ Molar desorption rate of the component i mol/s
$\dot{n}_i$ Molar desorption flux of the component i mol/(m$^2$ s)
$n_{jets}$ Number of water jets between adjacent tubes -
n$_{row}$ Number of tubes in a horizontal tube row -
n$_{tubes}$ Number of tubes in the tube bundle -
pH pH value -
p$_i$ Partial pressure of the component i N/m$^2$, bar
R Universal gas constant $J/(\text{mol K})$
RSI Ryznar Stability Index -
r Reaction rate $\text{mol}/(\text{m}^3 \text{s})$
ro Outside tube radius $\text{m}$

S Salinity $\text{g/kg}$
S Vertical tube spacing $\text{m}$
s Rate of surface renewal $1/\text{s}$

T Temperature $\text{K}$
T0 Top brine temperature $\text{°C}$
t The age of the element in the penetration theory $\text{s}$
TA Total alkalinity $\text{mol/kg}$
TC Total carbon dioxide content $\text{mol/kg}$
tD Diffusion time $\text{s}$
tP Residence time $\text{s}$
tR Average reaction time $\text{s}$

u Velocity $\text{m/s}$

V Liquid volume $\text{m}^3$
V Volume flow rate $\text{m}^3/\text{s}$

z Distance from the tube bottom line $\text{m}$

**Greek Letters**

$\beta_A$ Contribution of the neutral molecule A in eq. (4.49) $\text{m}^3/\text{kmol}$
$\beta_{\text{ion}}$ Contribution of the ion in eq. (4.48) $\text{m}^3/\text{kmol}$
$\gamma$ Activity coefficient of the component i -
$\delta$ Film thickness $\text{m}$
$\delta_f$ Thickness of liquid film flowing over horizontal tubes $\text{m}$

$\Gamma$ Mass flow rate per unit tube length ($\Gamma = \frac{\dot{m}}{2L}$) $\text{kg/(m s)}$

$\lambda$ Distance between the water jets (wavelength) $\text{m}$
$\lambda_d$ Taylor wavelength $\text{m}$
$\mu$ Dynamic viscosity $\text{kg/(m s)}$
$\nu$ Kinematic viscosity $\text{m}^2/\text{s}$
$\rho$ Density $\text{kg/m}^3$
$\sigma$ Surface tension $\text{N/m}$
$\theta$ Temperature $\text{°C}$
10. Notations

Indices

A Component A
B Bulk
BD Blow-down
b brine
CO$_2$ Carbon dioxide
CO$_3^{2-}$ Carbonate ion
D Distillate
eq Chemical equilibrium
F Feed water
FC Final condenser
G Gas
g Gas phase
H$^+$ Hydrogen ion
HCO$_3^-$ Bicarbonate ion
H$_2$CO$_3$ Carbonic acid
i Component
L Liquid side
OH$^-$ Hydroxide ion
Ph Phase interface
s Solid
s Saturation
SW Seawater
v Vapour
W Water
* Physical equilibrium

Dimensionless Numbers

Ga Galilei number
\[ Ga = \left( \frac{\pi d_o}{2} \right)^3 \frac{g}{v^2} \]

Ha Hatta number
\[ Ha = \frac{\sqrt{k_1 D_A}}{k_L^o} \]

Ka Kapitza number
\[ Ka = \frac{\sigma^3 \rho}{g \mu^4} \]
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<thead>
<tr>
<th>Notation</th>
<th>Description</th>
<th>Equation</th>
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<tbody>
<tr>
<td><strong>Nu</strong></td>
<td>Nusselt number</td>
<td>( \text{Nu} = \frac{h}{k} \left( \frac{v^2}{g} \right)^{\frac{1}{3}} )</td>
</tr>
<tr>
<td><strong>Pr</strong></td>
<td>Prandtl number</td>
<td>( \text{Pr} = \frac{c_p \mu}{k} )</td>
</tr>
<tr>
<td><strong>Re</strong></td>
<td>Film Reynolds number</td>
<td>( \text{Re} = \frac{4 \Gamma}{\mu} )</td>
</tr>
<tr>
<td><strong>Sc</strong></td>
<td>Schmidt number</td>
<td>( \text{Sc} = \frac{v}{D} )</td>
</tr>
<tr>
<td><strong>Sh</strong></td>
<td>Sherwood number</td>
<td>( \text{Sh} = \frac{k_i^0}{D} \left( \frac{v^2}{g} \right)^{\frac{1}{3}} )</td>
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