Density of water

A power function curve-fit was applied to data from the CRC Handbook of Chemistry and Physics:

$$ \rho = \beta_0 + \beta_1 T + \beta_2 T^2 + \beta_3 T^3 + \beta_4 T^4 + \beta_5 T^5 + \beta_6 T^6 $$

where $\rho$ is the density of liquid water in kg/m$^3$, $T$ is the water temperature in degrees Celsius, and with the following parameters:

$\beta_0 = 999.845916$
$\beta_1 = 6.5700958 \times 10^{-2}$
$\beta_2 = -8.7817835 \times 10^{-3}$
$\beta_3 = 8.3996043 \times 10^{-5}$
$\beta_4 = -7.8432029 \times 10^{-7}$
$\beta_5 = 4.6724264 \times 10^{-9}$
$\beta_6 = -1.2487522 \times 10^{-11}$

Viscosity of water

A formula provided in Sengers and Watson (1986) was used. See the original paper, the formula is too complex to present conveniently.

Surface tension of water

The formula provided by Vargaftik et al. (1983) is used:

$$ \sigma = 0.2358 \left[ \frac{647.15 - T_k}{647.15} \right]^{1.256} \left[ 1 - 0.625 \left( \frac{647.15 - T_k}{647.15} \right) \right] $$

where $\sigma$ is the surface tension of water in units of N/m given $T_k$ as the temperature in Kelvin.

Saturation vapor pressure of water

The Sonntag 1990 formulae are used (Sonntag, 1990; Alduchov and Eskridge, 1996). The basic formula is:
\[ E_w = e^{\left[ aT_k^{-1} + b + cT_k + dT_k^2 + e \log T_k \right]} \]

where \( E_w \) is the saturation vapor pressure in kPa units given \( T_k \) as the temperature in Kelvin. The parameters \( a \) through \( e \) for liquid or ice water are given as:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Liquid water</th>
<th>Ice water</th>
</tr>
</thead>
<tbody>
<tr>
<td>( a )</td>
<td>-6096.9385</td>
<td>-6024.5282</td>
</tr>
<tr>
<td>( b )</td>
<td>21.2409642</td>
<td>29.32736</td>
</tr>
<tr>
<td>( c )</td>
<td>-2.711193e-2</td>
<td>1.0613868e-2</td>
</tr>
<tr>
<td>( d )</td>
<td>1.673952e-5</td>
<td>-1.3198825e-5</td>
</tr>
<tr>
<td>( e )</td>
<td>2.433502</td>
<td>-0.49382577</td>
</tr>
</tbody>
</table>

Saturation water vapor concentration

Vapor pressure is converted to vapor concentration (or density) by application of the Ideal Gas Law, giving:

\[ \rho_w = \frac{2.167E_w}{T_k} \]

where \( \rho_w \) is the vapor density in g/m\(^3\) units given \( E_w \) (vapor pressure) in kPa units.

References


