

H2SO4 Solution Conversions

Constants

MM_{H2SO4} := 98.079 · $\frac{\text{gm}}{\text{mol}}$

Utility Functions

CurveFit(x, X, Y) := interp(Ispline(X, Y), X, Y, x)

My usual interpolation function

%err(x, x0) :=

"Compute % error"

$\frac{x - x0}{SIUnitsOf(x0)}$ if x0 = 0

$\frac{x - x0}{x0}$ otherwise

Calculate percentage error

vector(min, max, inc) :=

ζ ← min

i ← 0

while 1

x_i ← ζ

ζ ← ζ + inc

break if ζ > max + 10⁻⁹

i ← i + 1

x

Generate vector of incrementing elements

Conversion Equatons

w2M(w, sg) := $\frac{w \cdot sg}{MM_{H2SO4}}$

mass fraction to molarity conversion

M2m(ρ, M) := $\frac{M}{\rho - M \cdot MM_{H2SO4}}$

molarity to molality conversion

m2w(m) := $\frac{m \cdot MM_{H2SO4}}{1 + m \cdot MM_{H2SO4}}$

molality to mass fraction conversion

Table 3.1: Relation of sulfuric acid concentrations [1].

	Mass percent (wt%)	Density (kg L ⁻¹)			Molality (mol kg ⁻¹)	Molarity (mol L ⁻¹)			Temperature coefficient of density (10 ⁻³ kg L ⁻¹ °C)
		0 °C	25 °C	50 °C		0 °C	25 °C	50 °C	
Battery acid concentration window	0	0.9998	0.9971	0.9981	0	0	0	0	0.236
	2	1.0147	1.0104	1.0006	0.208	0.2069	0.2060	0.2040	0.282
	4	1.0291	1.0234	1.0129	0.425	0.4197	0.4174	0.4131	0.324
	6	1.0437	1.0367	1.0256	0.651	0.6385	0.6342	0.6274	0.362
	8	1.0585	1.0502	1.0386	0.887	0.8634	0.8566	0.8472	0.398
	10	1.0735	1.0640	1.0517	1.133	1.0945	1.0849	1.0723	0.436
	12	1.0986	1.0780	1.0651	1.390	1.3319	1.3190	1.3032	0.470
	14	1.1039	1.0922	1.0788	1.660	1.5758	1.5590	1.5399	0.502
	16	1.1194	1.1067	1.0927	1.942	1.8261	1.8054	1.7825	0.534
	18	1.1351	1.1215	1.1070	2.238	2.0832	2.0583	2.0317	0.562
	20	1.1510	1.1365	1.1215	2.549	2.3471	2.3175	2.2870	0.590
	22	1.1670	1.1517	1.1362	2.875	2.6177	2.5834	2.5485	0.615
	24	1.1832	1.1672	1.1512	3.220	2.8953	2.8562	2.8170	0.640
	26	1.1996	1.1829	1.1665	3.582	3.1801	3.1358	3.0929	0.662
	28	1.2160	1.1989	1.1820	3.965	3.4715	3.4227	3.3745	0.680
	30	1.2326	1.2150	1.1977	4.370	3.7703	3.7164	3.6635	0.698
	32	1.2493	1.2314	1.2137	4.798	4.0761	4.0177	3.9600	0.712
	34	1.2661	1.2479	1.2300	5.252	4.3891	4.3260	4.2640	0.722
	36	1.2831	1.2647	1.2466	5.735	4.7097	4.6422	4.5757	0.730
	38	1.3004	1.2818	1.2635	6.249	5.0384	4.9663	4.8954	0.738
	40	1.3179	1.2991	1.2806	6.797	5.3749	5.2982	5.2228	0.746
	42	1.3357	1.3167	1.2981	7.383	5.7199	5.6385	5.5589	0.752
	44	1.3538	1.3346	1.3160	8.011	6.0735	5.9873	5.9039	0.756
	46	1.3724	1.3530	1.3343	8.685	6.4368	6.3458	6.2581	0.762
	48	1.3915	1.3719	1.3528	9.412	6.8101	6.7142	6.6207	0.774
	50	1.4110	1.3911	1.3719	10.196	7.1933	7.0918	6.9939	0.782
	55	1.4619	1.4412	1.4214	12.462	8.1980	8.0820	7.9709	0.810
	60	1.5154	1.4940	1.4735	15.294	9.2706	9.1397	9.0143	0.839

$$\mathbf{wt} := (0 \quad 0.02 \quad 0.04 \quad 0.06 \quad 0.08 \quad 0.1 \quad 0.12 \quad 0.14 \quad 0.16 \quad 0.18 \quad 0.2 \quad 0.22 \quad 0.24 \quad 0.26 \quad 0.28 \quad 0.3 \quad 0.32 \quad 0.34 \quad 0.36 \quad 0.38 \quad 0.4 \quad 0.42 \quad 0.44 \quad 0.46 \quad 0.48 \quad 0.5 \quad 0.55 \quad 0.6)^T$$

$$\mathbf{m} := (0 \quad 0.208 \quad 0.425 \quad 0.651 \quad 0.887 \quad 1.133 \quad 1.39 \quad 1.66 \quad 1.942 \quad 2.238 \quad 2.549 \quad 2.875 \quad 3.22 \quad 3.582 \quad 3.965 \quad 4.37 \quad 4.798 \quad 5.252 \quad 5.735 \quad 6.249 \quad 6.797 \quad 7.383 \quad 8.011 \quad 8.685 \quad 9.412 \quad 10.196 \quad 12.462 \quad 15.294)^T \frac{\text{mol}}{\text{kg}}$$

$$\boldsymbol{\rho} := (0.9971 \quad 1.0104 \quad 1.0234 \quad 1.0367 \quad 1.0502 \quad 1.064 \quad 1.078 \quad 1.0922 \quad 1.1067 \quad 1.1215 \quad 1.1365 \quad 1.1517 \quad 1.1672 \quad 1.1829 \quad 1.1989 \quad 1.215 \quad 1.2314 \quad 1.2479 \quad 1.2647 \quad 1.2818 \quad 1.2991 \quad 1.3167 \quad 1.3346 \quad 1.353 \quad 1.3719 \quad 1.3911 \quad 1.4412 \quad 1.494)^T \frac{\text{gm}}{\text{cm}^3}$$

$$\mathbf{M} := (0 \quad 0.206 \quad 0.4174 \quad 0.6342 \quad 0.8566 \quad 1.0849 \quad 1.319 \quad 1.559 \quad 1.8054 \quad 2.0583 \quad 2.3175 \quad 2.5834 \quad 2.8562 \quad 3.1358 \quad 3.4227 \quad 3.7164 \quad 4.0177 \quad 4.326 \quad 4.6422 \quad 4.9663 \quad 5.2982 \quad 5.6385 \quad 5.9873 \quad 6.3458 \quad 6.7142 \quad 7.0918 \quad 8.082 \quad 9.1397)^T \frac{\text{mol}}{\text{L}}$$

Mass fraction

Molality

Density

Molarity

$$\mathbf{M}' := \text{w2M}(\mathbf{wt}, \boldsymbol{\rho}) =$$

	0
0	0.0000000
1	0.2060380
2	0.4173778
3	0.6342030
4	0.8566156
5	1.0848398
6	...

$$\cdot \frac{\text{mol}}{\text{L}}$$

$$\mathbf{m}' := \text{M2m}(\boldsymbol{\rho}, \mathbf{M}') =$$

	0
0	0
1	0.20808
2	0.42483
3	0.6508
4	0.8866
5	1.13287
6	...

$$\cdot \frac{\text{mol}}{\text{kg}}$$

$$\mathbf{wt}' := \text{m2w}(\mathbf{m}) =$$

	0
0	0
1	0.01999
2	0.04002
3	0.06002
4	0.08003
5	0.10001
6	...

$$\max\left(\left|\overrightarrow{\%err(\mathbf{m}', \mathbf{m})}\right|\right) = 0.04546 \cdot \%$$

✓

$$\max\left(\left|\overrightarrow{\%err(\mathbf{M}', \mathbf{M})}\right|\right) = 0.01844 \cdot \%$$

✓

$$\max\left(\left|\overrightarrow{\%err(\mathbf{wt}', \mathbf{wt})}\right|\right) = 0.04184 \cdot \%$$

✓

molality values agree

molarity values agree

mass factor agree