2.5. SOLUBILITIES

Unit Conversions For this subsection, the following unit conversions are applicable: °F = 9/5°C + 32. To convert cubic centimeters to cubic feet, multiply by 3.532×10^{-5}. To convert millimeters of mercury to pounds-force per square inch, multiply by 0.01934. To convert grams per liter to pounds per cubic foot, multiply by 6.243×10^{-2}.

Introduction The database containing solubilities was originally published in the International Union for Pure and Applied Chemistry (IUPAC)-National Institute of Standards and Technology (NIST) Solubility Data Series. It is available at no cost online at http://srdata.nist.gov/solubility.

The *H* in the following tables is the proportionality constant in Henry's law, $p = Hx$, where x is the mole fraction of the solute in the aqueous liquid phase; p is the partial pressure in atm of the solute in the gas phase; and H is a proportionality constant, generally referred to as Henry's constant. Values of H often have considerable uncertainty and are strong functions of temperature. To convert values of H at 25°C from atm to atm/(mol/m^3), divide by the molar density of water at 25°C, which is 55,342 mol/m^3. Henry's law is valid only for dilute solutions.

Additional values of Henry's constant can be found in "Environmental Simulation Program," OLI Systems, Inc., Morris Plains, N.J.; "Estimated Henry's Law Constant," EPA Online Tools for Site Assessment Calculation (http://www.epa.gov/athens/learn2model/part-two/onsite/esthenry.htm); Rolf Sander, "Compilation of Henry's Law Constants for Inorganic and Organic Species of Potential Importance in Environmental Chemistry," Air Chemistry Department, Max-Planck Institute of Chemistry, Mainz, Germany; Rolf Sander, "Modeling Atmospheric Chemistry: Interactions between Gas-Phase Species and Liquid Cloud/Aerosol Particles," *Surv. Geophys.* **20:** 1–31, 1999 (http://www.henrys-law.org).

Table 2-20 Solubilities of Inorganic Compounds in Water at Various Temperatures*

	Substance	Formula	Solid phase	0°C	10°C	20°C	30°C	40°C	50°C	60°C	70°C	80°C	90°C	100°C	
1	Aluminum chloride	$AlCl_3$	$6H_2O$			69.86[15°]									1
2	sulfate	$Al_2(SO_4)_3$	$18H_2O$	31.2	33.5	36.4	40.4	46.1	52.2	59.2	66.1	73.0	80.8	89.0	2
3	Ammonium aluminum sulfate	$(NH_4)_2Al_2(SO_4)_4$	$24H_2O$	2.1	4.99	7.74	10.94	14.88	20.10	26.70				109.7[96°]	3
4	bicarbonate	NH_4HCO_3		11.9	15.8	21	27								4

	Substance	Formula	Solid phase	0°C	10°C	20°C	30°C	40°C	50°C	60°C	70°C	80°C	90°C	100°C	
5	bromide	NH_4Br		60.6	68	75.5	83.2	91.1	99.2	107.8	116.8	126	135.6	145.6	5
6	chloride	NH_4Cl		29.4	33.3	37.2	41.4	45.8	50.4	55.2	60.2	65.6	71.3	77.3	6
7	chloroplatinate	$(NH_4)_2PtCl_6$			0.7									1.25	7
8	chromate	$(NH_4)_2CrO_4$					40.4								8
9	chromium sulfate	$(NH_4)_2Cr_2(SO_4)_4$	$24II_2O$			$10.78^{25°}$									9
10	dichromate	$(NH_4)_2Cr_2O_7$					47.17								10
11	dihydrogen phosphite	$NH_4H_2PO_3$		171		$190^{14.5°}$	$260^{31°}$								11
12	hydrogen phosphate	$(NH_4)_2HPO_4$				131^{15}									12
13	iodide	NH_4I		154.2	163.2	172.3	181.4	190.5	199.6	208.9	218.7	228.8		250.3	13
14	magnesium phosphate	NH_4MgPO_4	$6H_2O$	0.023		0.052		0.036	0.030	0.040	0.016	0.019			14

	Substance	Formula	Solid phase	0°C	10°C	20°C	30°C	40°C	50°C	60°C	70°C	80°C	90°C	100°C	
15	manganese phosphate	NH_4MnPO_4	$7H_2O$			0		0		0	0.005	0.007			15
16	nitrate	NH_4NO_3		118.3		192	241.8	297.0	344.0	421.0	499.0	580.0	740.0	871.0	16
17	oxalate	$(NH_4)_2C_2O_4$	$1H_2O$	2.2	3.1	4.4	5.9	8.0	10.3						17
18	perchlorate[†]	NH_4ClO_4 [†]		11.56		20.85		30.58		39.05		48.19		57.01	18
19	persulfate	$(NH_4)_2S_2O_8$		58.2											19
20	sulfate	$(NH_4)_2SO_4$		70.6	73.0	75.4	78.0	81.0		88.0		95.3		103.3	20
21	thiocyanate	NH_4CNS		119.8	144	170	207.7								21
22	vanadate (meta)	NH_4VO_3				0.48	0.84	1.32	1.78		3.05				22
23	Antimonious fluoride	SbF_3		384.7		444.7	563.6								23
24	sulfide	Sb_2S_3				0.000175 [18°]									24
25	Arsenic oxide	As_2O_5		59.5	62.1	65.8	69.5	71.2		73.0		75.1		76.7	25

	Substance	Formula	Solid phase	0°C	10°C	20°C	30°C	40°C	50°C	60°C	70°C	80°C	90°C	100°C	
26	Arsenious sulfide	As_2S_3		5.17×10^{-5} at 18°											26
27	Barium acetate	$Ba(C_2H_3O_2)_2$	$3H_2O$	59	63	71									27
28	acetate	$Ba(C_2H_3O_2)_2$	$1H_2O$				75	79	77	74	74			75	28
29	carbonate	$BaCO_3$			0.0016[8°]	0.0022[18°]	0.0024 at 24.2°								29
30	chlorate	$Ba(ClO_3)_2$	$1H_2O$	20.34	26.95	33.80	41.70	49.61		66.81		84.84		104.9	30
31	chloride	$BaCl_2$	$2H_2O$	31.6	33.3	35.7	38.2	40.7	43.6	46.4	49.4	52.4		58.8	31
32	chromate	$BaCrO_4$		0.0002	0.00028	0.00037	0.00046								32
33	hydroxide	$Ba(OH)_2$	$8H_2O$	1.67	2.48	3.89	5.59	8.22	13.12	20.94		101.4			33
34	iodide	BaI_2	$6H_2O$	170.2	185.7	203.1	219.6								34
35	iodide	BaI_2	$2H_2O$					231.9		247.3		261.0		271.7	35
36	nitrate	$Ba(NO_3)_2$		5.0	7.0	9.2	11.6	14.2	17.1	20.3		27.0		34.2	36
37	nitrite	$Ba(NO_2)_2$	$1H_2O$			67.5						205.8		300	37
38	oxalate	BaC_2O_4			0.0016[8°]	0.0022[18°]	0.0024 at 24.2°								38

	Substance	Formula	Solid phase	0°C	10°C	20°C	30°C	40°C	50°C	60°C	70°C	80°C	90°C	100°C	
39	perchlorate	$Ba(ClO_4)_2$	$3H_2O$	205.8		289.1		358.7	426.3		495.2		562.3		39
40	sulfate	$BaSO_4$		1.15×10^{-4}	2.0×10^{-4}	2.4×10^{-4}	2.85×10^{-4}								40
41	Beryllium sulfate	$BeSO_4$	$6H_2O$				52		60.67						41
42	sulfate	$BeSO_4$	$4H_2O$				43.78	46.74			62		83	100	42
43	sulfate	$BeSO_4$	$2H_2O$									84.76	98	110	43
44	Boric acid	H_3BO_3		2.66	3.57	5.04	6.60	8.72	11.54	14.81	16.73	23.75	30.38	40.25	44
45	Boron oxide	B_2O_3		1.1	1.5	2.2		4.0		6.2		9.5		15.7	45
46	Bromine	Br_2		4.22	3.4	3.20	3.13								46
47	Cadmium chloride	$CdCl_2$	$4H_2O$	97.59	125.1										47
48	chloride	$CdCl_2$	$2½H_2O$	90.01			132.1								48
49	chloride	$CdCl_2$	$1H_2O$		135.1	134.5		135.3		136.5		140.4		147.0	49
50	cyanide	$Cd(CN)_2$				$1.7^{15°}$									50
51	hydroxide	$Cd(OH)_2$					2.6×10^{-4} at 25°								51

	Substance	Formula	Solid phase	0°C	10°C	20°C	30°C	40°C	50°C	60°C	70°C	80°C	90°C	100°C	
52	sulfate	$CdSO_4$		76.48	76.00	76.60		78.54		83.68			63.13	60.77	52
53	Calcium acetate	$Ca(C_2H_3O_2)_2$	$2H_2O$	37.4	36.0	34.7	33.8	33.2		32.7		33.5			53
54	acetate	$Ca(C_2H_3O_2)_2$	$1H_2O$										31.1	29.7	54
1	Calcium bicarbonate	$Ca(HCO_3)_2$		16.15		16.60		17.05		17.50		17.95		18.40	1
2	chloride	$CaCl_2$	$6H_2O$	59.5	65.0	74.5	102								2
3	chloride	$CaCl_2$	$2H_2O$							136.8	141.7	147.0	152.7	159	3
4	fluoride	CaF_2				0.0016[18]°	0.0017[26]°								4
5	hydroxide	$Ca(OH)_2$		0.185	0.176	0.165	0.153	0.141	0.128	0.116	0.106	0.094	0.085	0.077	5
6	nitrate	$Ca(NO_3)_2$	$4H_2O$	102.0	115.3	129.3	152.6	195.9							6
7	nitrate	$Ca(NO_3)_2$	$3H_2O$					237.5	281.5						7
8	nitrate	$Ca(NO_3)_2$										358.7		363.6	8
9	nitrite	$Ca(NO_2)_2$	$4H_2O$	62.07		76.68									9
10	nitrite	$Ca(NO_2)_2$	$2H_2O$							132.6	151.9		244.8		10

	Substance	Formula	Solid phase	0°C	10°C	20°C	30°C	40°C	50°C	60°C	70°C	80°C	90°C	100°C	
11	oxalate	CaC_2O_4			6.7×10^{-4} at 13°	6.8×10^{-4} at 25°	9.5×10^{-4} at 50°	14×10^{-4} at 95°							11
12	sulfate	$CaSO_4$	$2H_2O$	0.1759	0.1928		0.2090	0.2097		0.2047	0.1966			0.1619	12
13	Carbon dioxide, 760 mm ‡	CO_2		0.3346	0.2318	0.1688	0.1257	0.0973	0.0761	0.0576				0	13
14	monoxide, 760 mm ‡	CO		0.0044	0.0035	0.0028	0.0024	0.0021	0.0018	0.0015	0.0013	0.0010	0.0006	0	14
15	Cesium chloride	CsCl		161.4	174.7	186.5	197.3	208.0	218.5	229.7	239.5	250.0	260.1	270.5	15
16	nitrate	$CsNO_3$		9.33	14.9	23.0	33.9	47.2	64.4	83.8	107.0	134.0	163.0	197.0	16
17	sulfate	Cs_2SO_4		167.1	173.1	178.7	184.1	189.9	194.9	199.9	205.0	210.3	214.9	220.3	17
18	Chlorine, 760 mm ‡	Cl_2		1.46	0.980	0.716	0.562	0.451	0.386	0.324	0.274	0.219	0.125	0	18
19	Chromic anhydride	CrO_3		164.9				174.0	182.1				217.5	206.8	19
20	Cuprio chloride	$CuCl_2$	$2H_2O$	70.7	73.76	77.0	80.34	83.8	87.44	91.2		99.2		107.9	20
21	nitrate	$Cu(NO_3)_2$	$6H_2O$	81.8	95.28	125.1									21

	Substance	Formula	Solid phase	0°C	10°C	20°C	30°C	40°C	50°C	60°C	70°C	80°C	90°C	100°C	
22	nitrate	$Cu(NO_3)_2$	$3H_2O$					159.8		178.8		207.8			22
23	sulfate	$CuSO_4$	$5H_2O$	14.3	17.4	20.7	25	28.5	33.3	40		55		75.4	23
24	sulfide	CuS				3.3×10^{-5} at 18°									24
25	Cuprous chloride	CuCl				1.52 25°									25
26	Ferric chloride	$FeCl_3$		74.4	81.9	91.8			315.1			525.8		535.7	26
27	Ferrous chloride	$FeCl_2$	$4H_2O$		64.5		73.0	77.3	82.5	88.7		100			27
28	chloride	$FeCl_2$											105.3	105.8	28
29	nitrate	$Fe(NO_3)_2$	$6H_2O$	71.02		83.8				165.6					29
30	sulfate	$FeSO_4$	$7H_2O$	15.65	20.51	26.5	32.9	40.2	48.6						30
31	sulfate	$FeSO_4$	$1H_2O$								50.9	43.6	37.3		31
32	Hydrobromic acid, 760 mm	HBr		221.2	210.3	198			171.5					130	32
33	Hydrochloric acid, 760 mm	HCl		82.3			67.3	63.3	59.6	56.1					33

	Substance	Formula	Solid phase	0°C	10°C	20°C	30°C	40°C	50°C	60°C	70°C	80°C	90°C	100°C	
34	Iodine	I_2				0.029	0.04	0.056	0.078						34
35	Lead acetate	$Pb(C_2H_3O_2)_2$	$3H_2O$				$55.04^{25°}$								35
36	bromide	$PbBr_2$		0.4554		0.85	1.15	1.53	1.94	2.36		3.34		4.75	36
37	carbonate	$PbCO_3$				0.00011									37
38	chloride	$PbCl_2$		0.6728		0.99	1.20	1.45	1.70	1.98		2.62		3.34	38
39	chromate	$PbCrO_4$				7×10^{-6}									39
40	fluoride	PbF_2			0.060	0.064	0.068								40
41	nitrate	$Pb(NO_3)_2$		38.8	48.3	56.5	66	75	85	95		115		38.8	41
42	sulfate	$PbSO_4$		0.0028	0.0035	0.0041	0.0049	0.0056							42
43	Magnesium bromide	$MgBr_2$	$6H_2O$	91.0	94.5	96.5	99.2	101.6	104.1	107.5		113.7		120.2	43
44	chloride	$MgCl_2$	$6H_2O$	52.8	53.5	54.5		57.5		61.0		66.0		73.0	44
45	hydroxide	$Mg(OH)_2$				$0.0009^{18°}$									45
46	nitrate	$Mg(NO_3)_2$	$6H_2O$	66.55				84.74					137.0		46
47	sulfate	$MgSO_4$	$7H_2O$		30.9	35.5	40.8	45.6							47

	Substance	Formula	Solid phase	0°C	10°C	20°C	30°C	40°C	50°C	60°C	70°C	80°C	90°C	100°C	
48	sulfate	$MgSO_4$	$6H_2O$	40.8	42.2	44.5	45.3		50.4	53.5	59.5	64.2	69.0	74.0	48
49	sulfate	$MgSO_4$	$1H_2O$									62.9		68.3	49
50	Manganous sulfate	$MnSO_4$	$7H_2O$	53.23	60.01										50
51	sulfate	$MnSO_4$	$5H_2O$		59.5	62.9	67.76								51
52	sulfate	$MnSO_4$	$4H_2O$			64.5	66.44	68.8	72.6						52
53	sulfate	$MnSO_4$	$1H_2O$						58.17	55.0	52.0	48.0	42.5	34.0	53
54	Mercurous chloride	HgCl		0.00014		0.00002		0.00007							54
55	Molybdic oxide	MoO_3	$2H_2O$			0.138	0.264	0.476	0.687	1.206	2.055	2.106			55
56	Nickel chloride	$NiCl_2$	$6H_2O$	53.9	59.5	64.2	68.9	73.3	78.3	82.2	85.2			87.6	56
57	nitrate	$Ni(NO_3)_2$	$6H_2O$	79.58		96.31		122.2							57
58	nitrate	$Ni(NO_3)_2$	$3H_2O$							163.1	169.1		235.1		58
59	sulfate	$NiSO_4$	$7H_2O$	27.22	32		42.46								59
60	sulfate	$NiSO_4$	$6H_2O$						50.15	54.80	59.44	63.17		76.7	60

	Substance	Formula	Solid phase	0°C	10°C	20°C	30°C	40°C	50°C	60°C	70°C	80°C	90°C	100°C	
61	Nitric oxide, 760 mm	NO		0.00984	0.00757	0.00618	0.00517	0.00440	0.00376	0.00324	0.00267	0.00199	0.00114	0	61
62	Nitrous oxide	N_2O			0.17 05	0.12 11									62
1	Potassium acetate	$KC_2H_3O_2$	$1½H_2O$	216.7	233.9	255.6	283.8	323.3							1
2	acetate	$KC_2H_3O_2$	$½H_2O$						337.3	350	364.8	380.1	396.3		2
3	alum	$K_2SO_4·Al_2(SO_4)_3$	$24H_2O$	3.0	4.0	5.9	8.39	11.70	17.00	24.75	40.0	71.0	109.0		3
4	bicarbonate	$KHCO_3$		22.4	27.7	33.2	39.1	45.4		60.0					4
5	bisulfate	$KHSO_4$		36.3		51.4		67.3						121.6	5
6	bitartrate	$KHC_4H_4O_6$		0.32	0.40	0.53	0.90	1.32	1.83	2.46		4.6		6.95	6
7	carbonate	K_2CO_3	$2H_2O$	105.5	108	110.5	113.7	116.9	121.2	126.8	133.1	139.8	147.5	155.7	7
8	chlorate	$KClO_3$		3.3	5	7.4	10.5	14	19.3	24.5		38.5		57	8
9	chloride	KCl		27.6	31.0	34.0	37.0	40.0	42.6	45.5	48.3	51.1	54.0	56.7	9
10	chromate	K_2CrO_4		58.2	60.0	61.7	63.4	65.2	66.8	68.6	70.4	72.1	73.9	75.6	10

	Substance	Formula	Solid phase	0°C	10°C	20°C	30°C	40°C	50°C	60°C	70°C	80°C	90°C	100°C	
11	dichromate	$K_2Cr_2O_7$		5	7	12	20	26	34	43	52	61	70	80	11
12	ferricyanide	$K_3Fe(CN)_6$		31	36	43	50	60		66				82.6 [104]	12
13	hydroxide	KOH	$2H_2O$	97	103	112	126								13
14	hydroxide	KOH	$1H_2O$						140					178	14
15	nitrate	KNO_3		13.3	20.9	31.6	45.8	63.9	85.5	110.0	138	169	202	246	15
16	nitrite	KNO_2		278.8		298.4		334.9						412.8	16
17	perchlorate	$KClO_4$		0.75	1.05	1.80	2.6	4.4	6.5	9	11.8	14.8	18	21.8	17
18	permanganate	$KMnO_4$		2.83	4.4	6.4	9.0	12.56	16.89	22.2					18
19	persulfate†	$K_2S_2O_8$†	†	1.62	2.60	4.49	7.19	9.89							19
20	sulfate	K_2SO_4		7.35	9.22	11.11	12.97	14.76	16.50	18.17	19.75	21.4	22.8	24.1	20
21	thiocyanate	KCNS		177.0		217.5									21
22	Silver cyanide	AgCN				2.2×10^{-5}									22

	Substance	Formula	Solid phase	0°C	10°C	20°C	30°C	40°C	50°C	60°C	70°C	80°C	90°C	100°C	
23	nitrate	$AgNO_3$		122	170	222	300	376	455	525		669		952	23
24	sulfate	Ag_2SO_4		0.573	0.695	0.796	0.888	0.979	1.08	1.15	1.22	1.30	1.36	1.41	24
25	Sodium acetate	$NaC_2H_3O_2$	$3H_2O$	36.3	40.8	46.5	54.5	65.5	83	139					25
26	acetate	$NaC_2H_3O_2$		119	121	123.5	126	129.5	134	139.5	146	153	161	170	26
27	bicarbonate	$NaHCO_3$		6.9	8.15	9.6	11.1	12.7	14.45	16.4					27
28	carbonate	Na_2CO_3	$10H_2O$	7	12.5	21.5	38.8								28
29	carbonate	Na_2CO_3	$1H_2O$				50.5	48.5		46.4		45.8		45.5	29
30	chlorate	$NaClO_8$		79	89	101	113	126	140	155	172	189		230	30
31	chloride	NaCl		35.65	35.72	35.89	36.09	36.37	36.69	37.04	37.46	37.93	38.47	38.99	31
32	chromate	Na_2CrO_4	$10H_2O$	31.70	50.17	88.7									32
33	chromate	Na_2CrO_4	$4H_2O$				88.7	95.96	104	114.6					33
34	chromate	Na_2CrO_4									123.0	124.8		125.9	34
35	dichromate	$Na_2Cr_2O_7$	$2H_2O$	163.0		177.8			244.8		316.7	376.2			35

	Substance	Formula	Solid phase	0°C	10°C	20°C	30°C	40°C	50°C	60°C	70°C	80°C	90°C	100°C	
36	dichromate	$Na_2Cr_2O_7$												426.3	36
37	dihydrogen phosphate	NaH_2PO_4	$2H_2O$	57.9	69.9	85.2	106.5	138.2							37
38	dihydrogen phosphate	NaH_2PO_4	$1H_2O$						158.6						38
39	dihydrogen phosphate	NaH_2PO_4								179.3	190.3	207.3	225.3	246.6	39
40	hydrogen arsenate	Na_2HAsO_4	$12H_2O$	7.3	15.5	26.5	37	47		65		85			40
41	hydrogen phosphate	Na_2HPO_4	$12H_2O$	1.67	3.6	7.7	20.8								41
42	hydrogen phosphate	Na_2HPO_4	$7H_2O$					51.8							42
43	hydrogen phosphate	Na_2HPO_4	$2H_2O$						80.2	82.9	88.1	92.4	102.9		43
44	hydrogen phosphate	Na_2HPO_4												102.2	44

	Substance	Formula	Solid phase	0°C	10°C	20°C	30°C	40°C	50°C	60°C	70°C	80°C	90°C	100°C	
45	hydroxide	NaOH	$4H_2O$	42											45
46	hydroxide	NaOH	$3½H_2O$		51.5										46
47	hydroxide	NaOH	$1H_2O$			109	119	129	145	174					47
48	hydroxide	NaOH											313	347	48
49	nitrate	$NaNO_3$		73	80	88	96	104	114	124		148		180	49
50	nitrite	$NaNO_2$		72.1	78.0	84.5	91.6	98.4	104.1			132.6		163.2	50
51	oxalate	$Na_2C_2O_4$				3.7								6.33	51
52	phosphate, tri-	Na_3PO_4	$12H_2O$	1.5	4.1	11	20	31	43	55		81		108	52
53	pyrophosphate	$Na_4P_2O_7$	$10H_2O$	3.16	3.95	6.23	9.95	13.50	17.45	21.83		30.04		40.26	53
54	sulfate	Na_2SO_4	$10H_2O$	5.0	9.0	19.4	40.8								54
55	sulfate	Na_2SO_4	$7H_2O$	19.5	30	44									55
56	sulfate	Na_2SO_4						48.8	46.7	45.3		43.7		42.5	56

	Substance	Formula	Solid phase	0°C	10°C	20°C	30°C	40°C	50°C	60°C	70°C	80°C	90°C	100°C	
57	sulfide	Na_2S	$9H_2O$		15.42	18.8	22.5	28.5							57
58	sulfide	Na_2S	$5½H_2O$						39.82	42.69	45.73	51.40	59.23		58
59	sulfide	Na_2S	$6H_2O$						36.4	39.1	43.31	49.14	57.28		59
60	sulfite	Na_2SO_3	$7H_2O$	13.9	20	26.9	36								60
61	sulfite	Na_2SO_3						28	28.2	28.8		28.3			61
62	tetraborate	$Na_2B_4O_7$	$10H_2O$	1.3	1.6	2.7	3.9		10.5	20.3					62
63	tetraborate	$Na_2B_4O_7$	$5H_2O$								24.4	31.5	41	52.5	63
64	vanadate (meta)	$NaVO_8$	$2H_2O$			$15.3_{25°}$		30.2		68.4					64
1	Sodium vanadate (meta)	$NaVO_3$				$21.10^{25°}$		26.23		32.97	36.9	$38.8_{75°}$			1
2	Stannous chloride	$SnCl_2$		83.9		$269.8^{15°}$									2
3	sulfate	$SnSO_4$				19								18	3
4	Strontium acetate	$Sr(C_2H_3O_2)_2$	$4H_2O$	36.9	43.61										4

	Substance	Formula	Solid phase	0°C	10°C	20°C	30°C	40°C	50°C	60°C	70°C	80°C	90°C	100°C	
5	acetate	$Sr(C_2H_3O_2)_2$	$½H_2O$		42.95	41.6	39.5		37.35		36.24	36.10		36.4	5
6	chloride	$SrCl_2$	$6H_2O$	43.5	47.7	52.9	58.7	65.3	72.4	81.8					6
7	chloride	$SrCl_2$	$2H_2O$								85.9	90.5		100.8	7
8	nitrate	$Sr(NO_3)_2$	$1H_2O$	52.7		64.0			83.8	97.2			130.4	139	8
9	nitrate	$Sr(NO_3)_2$	$4H_2O$	40.1		70.5									9
10	nitrate	$Sr(NO_3)_2$					88.6	90.1		93.8	96	98	100		10
11	sulfate	$SrSO_4$		0.0113		0.0114	0.0114								11
12	Sulfur dioxide, 760 mm[†]	SO_2		22.83	16.21	11.29	7.81	5.41	4.5						12
13	Thallium sulfate	Tl_2SO_4		2.70	3.70	4.87	6.16		9.21	10.92	12.74	14.61	16.53	18.45	13
14	Thorium sulfate	$Th(SO_4)_2$	$9H_2O$	0.74	0.98	1.38	1.995	2.998	5.22						14
15	sulfate	$Th(SO_4)_2$	$8H_2O$	1.0	1.25	1.62									15
16	sulfate	$Th(SO_4)_2$	$6H_2O$	1.50		1.90	2.45			6.64					16
17	sulfate	$Th(SO_4)_2$	$4H_2O$					4.04	2.54	1.63	1.09				17

	Substance	Formula	Solid phase	0°C	10°C	20°C	30°C	40°C	50°C	60°C	70°C	80°C	90°C	100°C	
18	Zinc chlorate	$ZnClO_3$	$6H_2O$	145.0	152.5										18
19	chlorate	$ZnClO_3$	$4H_2O$			200.3	209.2	223.2	273.1						19
20	nitrate	$Zn(NO_3)_2$	$6H_2O$	94.78		118.3									20
21	nitrate	$Zn(NO_3)_2$	$3H_2O$					206.9							21
22	sulfate	$ZnSO_4$	$7H_2O$	41.9	47	54.4									22
23	sulfate	$ZnSO_4$	$6H_2O$					70.1	76.8						23
24	sulfate	$ZnSO_4$	$1H_2O$									86.6	83.7	80.8	24

*By N. A. Lange; abridged from "Table of Solubilities of Inorganic Compounds in Water at Various Temperatures" in *Lange's Handbook of Chemistry,* 10th ed., McGraw-Hill, New York, 1961 (except for NaCl, which is from *CRC Handbook of Chemistry and Physics,* 86th ed., CRC Press, 2005). For tables of the solubility of gases in water at various temperatures, Atack (*Handbook of Chemical Data,* Reinhold, New York, 1957) gives values at closer temperature intervals, usually 1 or 5°C, than are tabulated here. For materials marked by ‡, additional data are given in tables subsequent to this one. For the solubility of various hydrocarbons in water at high pressures see *J. Chem. Eng. Data,* **4,** 212 (1959).

This table shows the grams of anhydrous substance that are soluble in 100 g of water at the temperature in degrees Celsius as indicated; when the name is followed by †, the value is expressed in grams of substance in 100 cm^3 of saturated solution. Solid phase gives the hydrated form in equilibrium with the saturated solution.

Table 2-21 Solubility as a Function of Temperature and Henry's Constant at 25°C for Gases in Water

Name	Formula	*A*	*B*	*C*	*D*	*T* range, K	*H* at 25°C, atm
Acetylene	C_2H_2	−156.51	8,160.2	21.403	0	274–343	1,330
Carbon dioxide	CO_2	−159.854	8,741.68	21.6694	−1.10261E-03	273–353	1,635
Carbon monoxide	CO	−171.764	8,296.9	23.3376	0	273–353	58,000
Ethane	C_2H_6	−250.812	12,695.6	34.7413	0	275–323	29,400
Ethylene	C_2H_4	−153.027	7,965.2	20.5248	0	287–346	11,726
Helium	He	−105.9768	4,259.62	14.0094	0	273–348	142,900
Hydrogen	H_2	−125.939	5,528.45	16.8893	0	273–345	70,800
Methane	CH_4	−338.217	13,282.1	51.9144	−0.0425831	273–523	39,200
Nitrogen	N_2	−181.587	8,632.13	24.7981	0	273–350	84,600
Oxygen	O_2	−171.2542	8,391.24	23.24323	0	273–333	43,400

The constants can be used to calculate solubility by the equation $\ln x = A + B/T + C \ln T + DT$, where T is in K and x is the mole fraction of the solute dissolved in water when the solute partial pressure is 1 atm. With the assumption that Henry's law is valid up to 1 atm, $H = 1/x$. Values of the constants are from P. G. T. Fogg and W. Gerrard, *Solubility of Gases in Liquids,* Wiley, 1991, New York, and *Solubility Data Series*, vol. 1, *Helium and Neon*, IUPAC, Pergamon Press, Oxford, 1979. For higher-temperature behavior and an up-to-date reference list, see R. Fernandez-Prini, J. L. Alvarez, and A. H. Harvey, *J. Phys. Chem. Ref. Data* **32**(2):903, 2003. To find *H* at temperatures other than 25°C, first find the solubility and then take the reciprocal.

Table 2-22 Henry's Constant *H* for Various Compounds in Water at 25°C

Group	Compound	Formula	CAS	*H*, atm†	Rating*
Paraffin hydrocarbons	Methane	CH_4	74-82-8	36,600	4
	Ethane	C_2H_6	74-84-0	26,700	3
	Propane	C_3H_8	74-98-6	37,800	3
	Butane	C_4H_{10}	106-97-8	51,100	3
	Pentane	C_5H_{12}	109-66-0	70,000	3
	Octane	C_8H_{18}	111-65-9	2,74,000	3
	Nonane	C_9H_{20}	111-84-2	3,29,000	3
Olefins	Ethylene	C_2H_4	74-85-1	11,700	3
	Propylene	C_3H_6	115-07-1	11,700	4
Aromatics	Benzene	C_6H_6	71-43-2	299	10

Group	Compound	Formula	CAS	*H*, atm	Rating*
	Toluene	C_7H_8	108-88-3	354	10
	o-Xylene	C_8H_{10}	95-47-6	272	10
	Cumene	C_9H_{12}	98-82-8	724	9
	Phenol	C_6H_6O	108-95-2	0.0394	7
Aldehydes	Acetaldehyde	C_2H_4O	75-07-0	5.56	3
	Propionaldehyde	C_3H_6O	123-38-6	4.36	4
Ketones	Methylethyl ketone	C_4H_8O	78-93-3	2.59	5
Esters	Methyl formate	$C_2H_4O_2$	107-31-3	13.6	3
	Ethyl formate	$C_3H_6O_2$	109-94-4	13.6	3
	Methyl acetate	$C_3H_6O_2$	79-20-9	5.04	3
	Butyl acetate	$C_6H_{12}O_2$	123-86-4	13.6	3
Chlorine containing	Chloromethane	CH_3Cl	74-87-3	556	?
	Chloroethane	C_2H_5Cl	75-00-3	681	10
	Chlorobenzene	C_6H_5Cl	108-90-7	204	10
Alcohols	Methanol	CH_4O	67-56-1	0.272	4
	Ethanol	C_2H_6O	64-17-5	0.272	4
	1-Propanol	C_3H_8O	71-23-8	0.507	3
	1-Butanol	$C_4H_{10}O$	71-36-3	0.482	3
Miscellaneous	Acrylonitrile	C_3H_3N	107-13-1	5.54	3
	Dimethyl sulfide	C_2H_6S	75-18-3	121	3
	Dimethyl disulfide	$C_2H_6S_2$	624-92-0	68.1	3
	Methyl mercaptan	CH_4S	74-93-1	177	3
	Ethyl mercaptan	C_2H_6S	75-08-1	161	3
	Pyridine	C_5H_5N	110-86-1	0.817	3

Values in this table were taken from the Design Institute for Physical Properties (DIPPR) of the American Institute of Chemical Engineers (AIChE), 801 Critically Evaluated Gold Standard™ Database, copyright 2016 AIChE, and reproduced with permission of AIChE and of the DIPPR Evaluated Process Design Data Project Steering Committee. Their source should be cited as R. L. Rowley, W. V. Wilding, J. L. Oscarson, T. A. Knotts, N. F. Giles, DIPPR® Data Compilation of Pure Chemical Properties, Design Institute for Physical Properties, AIChE, New York (2016).

Group	Compound	Formula	CAS	*H*, atm	Rating*

*The ratings reflect DIPPR® ESP's effort to provide a critical evaluation and quality assessment of each data point with 15 being the highest score possible. The rating is not directly correlated with the estimated experimental uncertainty.

†Henry's constant is a strong nonlinear function of temperature. A single value measured at one temperature, if used for calculation at a different temperature, can lead to serious errors. Procedures for extrapolation of single-point values over the ambient temperature range (4°C < *T* < 50°C) are presented in Sec. 22, under "Air Pollution Control" > "Biological APC Technologies" > "Estimating Henry's law constants". Estimation procedures for the larger range (4°C < *T* < 200°C) are presented in F. L. Smith and A. H. Harvey, "Avoid Common Pitfalls When Using Henry's Law," *Chem. Eng. Prog*., 103(9), 2007. See also Y.-L. Huang, J. D. Olson, and G. E. Keller II, "Steam Stripping for Removal of Organic Pollutants from Water. 2. Vapor-Liquid Equilibrium Data," *Ind. Eng. Chem. Res*., 31, pp. 1759–1768, 1992. (Also see the Supplementary Material, which contains the databank of 404 compounds of environmental interest and other useful property data.)

Table 2-23 Henry's Constant *H* for Various Compounds in Water at 25°C from Infinite Dilution Activity Coefficients

Compound	CAS no.	Formula	$H = \gamma^{\infty} P_{vp}$, atm
Pentane	109660	C_5H_{12}	63700
Hexane	1100543	C_6H_{14}	84600
Heptane	142825	C_7H_{16}	120000
Benzene	71432	C_6H_6	309
Toluene	108883	C_7H_8	344
o-Xylene	95476	C_8H_{10}	267
Cumene	98,828	C_9H_{12}	613
Styrene	100425	C_8H_8	145
Formaldehyde	50000	CH_2O	14.3
Acetaldehyde	75070	C_2H_4O	4.54
Propanal	123386	C_3H_6O	5.45
Acetone	67641	C_3H_6O	2.13
Methyl ethyl ketone	78933	C_4H_8O	3.11
Methyl *n*-propyl ketone	107879	$C_5H_{10}O$	4.60
Formic acid	64186	CH_2O_2	0.0404
Methyl acetate	79209	$C_3H_6O_2$	6.38
Ethyl acetate	141786	$C_4H_8O_2$	8.01
Butyl acetate	123864	$C_6H_{12}O_2$	12.3
Chloroethane	75003	C_2H_5Cl	626

Compound	CAS no.	Formula	$H = \gamma \quad P$, atm
1-Chloropropane	74986	C_3H_7Cl	792
Chlorobenzene	108907	C_6H_5Cl	219
Methanol	67561	CH_4O	0.263
Ethanol	64175	C_2H_6O	0.293
Pyridine	110861	C_5H_5N	0.544
Diethyl ether	60297	$C_4H_{10}O$	48.7
Thiophene	110021	C_4H_4S	160

Henry's constant *H* at 25°C is the vapor pressure at 25°C times the infinite dilution activity coefficient, also at 25°C. Infinite dilution activity coefficients are from Mitchell and Jurs, *J. Chem. Inf. Comput. Sci*. **38:** 200 (1998). Henry's constant is a strong nonlinear function of temperature. A single value measured at one temperature, if used for calculation at a different temperature, can lead to serious errors. Procedures for extrapolation of single-point values over the ambient temperature range (4°C < *T* < 50°C) are presented in Sec. 22, pp. 22–49, under "Estimating Henry's law constants." Estimation procedures for the larger range (4°C < *T* < 200°C) are presented in F. L. Smith and A. H. Harvey, "Avoid Common Pitfalls When Using Henry's Law," *Chem. Eng. Prog.,* **103**(9), 2007. See also Y.-L. Huang, J. D. Olson, and G. E. Keller II, "Steam Stripping for Removal of Organic Pollutants from Water. 2. Vapor-Liquid Equilibrium Data," *Ind. Eng. Chem. Res.*, **31**, pp. 1759–1768, 1992. (Also see the Supplementary Material, which contains the databank of 404 compounds of environmental interest and other useful property data.)

Table 2-24 Air*

t, °C	0	5	10	15	20	25	30	35
$10^{-4} \times H^{\dagger}$	4.32	4.88	5.49	6.07	6.64	7.20	7.71	8.23
t, °C	40	45	50	60	70	80	90	100
$10^{-4} \times H^{\dagger}$	8.70	9.11	9.46	10.1	10.5	10.7	10.8	10.7

**International Critical Tables,* vol. 3, p. 257.

$^{\dagger}H$ is calculated from the absorption coefficients of O_2 and N_2, taking into consideration the correction for constant argon content.

Table 2-25 Ammonia-Water at 10 and 20°C*

Mass fraction NH_3 in liquid	*P*, kPa (10°C)	Mass fraction NH_3 in vapor (10°C)	*P*, kPa (20°C)	Mass fraction NH_3 in vapor (20°C)
0.0	1.23	0.0	2.34	0.0
0.00467	1.37	0.1		
0.00495			2.60	0.1
0.1	7.07	0.84164	11.95	0.82096
0.2	20.07	0.95438	32.34	0.94541
0.3	47.37	0.98565	73.85	0.98199
0.4	99.84	0.99544	150.56	0.99393
0.5	184.44	0.99848	269.50	0.99783
0.6	292.15	0.99943	416.63	0.99913
0.7	399.03	0.99975	560.61	0.99960
0.8	486.44	0.99988	678.61	0.99980
0.9	554.33	0.99995	771.87	0.99991
1.0	615.05	1.0	857.48	1.0

*Selected values from R. Tillner-Roth and D. G. Friend, *J. Phys. Chem. Ref. Data* **27**:63 (1998). This reference lists solubilities for temperatures from −70 to 340°C. Densities, enthalpies, and entropies are listed for both the two-phase and single-phase regions for pressures up to 40 MPa.

Table 2-26 Carbon Dioxide (CO_2)*

Total pressure, atm	0°C†	10°C	15°C	20°C	25°C	35°C	50°C	75°C	100°C
1	1.445	0.985	0.802	0.692	0.608	0.473	0.342	0.248	0.187
2	2.89	1.946	1.587	1.374	1.207	0.943	0.683	0.495	0.373
10	12.71	8.81	7.32	6.44	5.74	4.54	3.30	2.41	1.841
20	21.23	15.38	13.13	11.84	10.75	8.64	6.34	4.65	3.62
30	25.79	19.80	17.49	16.22	15.05	12.80	9.10	6.78	5.35
36		21.45	19.42	18.30	17.29	14.80	10.63	7.90	6.35

*Values selected from G. Houghton, A. M. McLean, and P. D. Ritchie, *Chem. Eng. Sci*. **6**:132–137, 1957.

†Liquid mol fraction $CO_2 \times 10^3$

Table 2-27 Chlorine (Cl_2)

Partial pressure of Cl_2, mmHg	Solubility, g of Cl_2 per liter					
	0°C	10°C	20°C	30°C	40°C	50°C
5	0.488	0.451	0.438	0.424	0.412	0.398
10	0.679	0.603	0.575	0.553	0.532	0.512
30	1.221	1.024	0.937	0.873	0.821	0.781
50	1.717	1.354	1.210	1.106	1.025	0.962
100	2.79	2.08	1.773	1.573	1.424	1.313
150	3.81	2.73	2.27	1.966	1.754	1.599
200	4.78	3.35	2.74	2.34	2.05	1.856
250	5.71	3.95	3.19	2.69	2.34	2.09
300		4.54	3.63	3.03	2.61	2.31
350		5.13	4.06	3.35	2.86	2.53
400		5.71	4.48	3.69	3.11	2.74
450		6.26	4.88	3.98	3.36	2.94
500		6.85	5.29	4.30	3.61	3.14
550		7.39	5.71	4.60	3.84	3.33
600		7.97	6.12	4.91	4.08	3.52
650		8.52	6.52	5.21	4.32	3.71
700		9.09	6.90	5.50	4.54	3.89
750		9.65	7.29	5.80	4.77	4.07
800		10.21	7.69	6.08	4.99	4.27
900			8.46	6.68	5.44	4.62
1000			9.27	7.27	5.89	4.97
1200	$Cl_2.8H_2O_2$ separates		10.84	8.42	6.81	5.67
1500			13.23	10.14	8.05	6.70
2000			17.07	13.02	10.22	8.38
2500			21.0	15.84	12.32	10.03

Partial pressure of Cl , mmHg	Solubility, g of Cl per liter					
	0°C	10°C	20°C	30°C	40°C	50°C
3000				18.73	14.47	11.70
3500				21.7	16.62	13.38
4000				24.7	18.84	15.04
4500				27.7	20.7	16.75
5000				30.8	23.3	18.46

Partial pressure of Cl_2, mmHg	Solubility, g of Cl_2 per liter					
	60°C	70°C	80°C	90°C	100°C	110°C
5	0.383	0.369	0.351	0.339	0.326	0.316
10	0.492	0.470	0.447	0.431	0.415	0.402
30	0.743	0.704	0.671	0.642	0.627	0.598
50	0.912	0.863	0.815	0.781	0.747	0.722
100	1.228	1.149	1.085	1.034	0.987	0.950
150	1.482	1.382	1.294	1.227	1.174	1.137
200	1.706	1.580	1.479	1.396	1.333	1.276
250	1.914	1.764	1.642	1.553	1.480	1.413
300	2.10	1.932	1.793	1.700	1.610	1.542
350	2.28	2.10	1.940	1.831	1.736	1.661
400	2.47	2.25	2.08	1.965	1.854	1.773
450	2.64	2.41	2.22	2.09	1.972	1.880
500	2.80	2.55	2.35	2.21	2.08	1.986
550	2.97	2.69	2.47	2.32	2.19	2.09
600	3.13	2.83	2.59	2.43	2.29	2.19
650	3.29	2.97	2.72	2.55	2.41	2.28
700	3.44	3.10	2.84	2.66	2.50	2.37
750	3.59	3.23	2.96	2.76	2.60	2.47
800	3.75	3.37	3.08	2.87	2.69	2.56

Partial pressure of Cl , mmHg	Solubility, g of Cl per liter					
	0°C	10°C	20°C	30°C	40°C	50°C
900	4.04	3.63	3.30	3.08	2.89	2.74
1000	4.36	3.88	3.53	3.28	3.07	2.91
1200	4.92	4.37	3.95	3.67	3.43	3.25
1500	5.76	5.09	4.58	4.23	3.95	3.74
2000	7.14	6.26	5.63	5.17	4.78	4.49
2500	8.48	7.40	6.61	6.05	5.59	5.25
3000	9.83	8.52	7.54	6.92	6.38	5.97
3500	11.22	9.65	8.53	7.79	7.16	6.72
4000	12.54	10.76	9.52	8.65	7.94	7.42
4500	13.88	11.91	10.46	9.49	8.72	8.13
5000	15.26	13.01	11.42	10.35	9.48	8.84

Table 2-28 Chlorine Dioxide (ClO_2)

Vol % of ClO_2 in gas phase	0°C	5°C	10°C	15°C	20°C	30°C	40°C
1	2.00	1.50	1.25	1.00	0.90	0.60	0.46
3	6.00	4.7	3.85	3.20	2.70	1.95	1.30
5	10.0	7.8	6.30	5.25	4.30	3.20	2.25
7	14.0	10.9	8.95	7.35	6.15	4.40	3.20
10	20.0	15.5	12.8	10.5	8.80	6.30	4.50
11		17.0	14.0	11.7	9.70	7.00	5.00
12		18.6	15.3	12.8	10.55	7.50	5.45
13		20.3	16.6	13.8	11.5	8.20	5.85
14			18.0	14.9	12.3	8.80	6.35
15			19.2	16.0	13.2	9.50	6.80
16			20.3	17.0	14.2	10.1	7.20

Ishi, *Chem. Eng. (Japan)*, **22:**153 (1958).

Weight of ClO_2, grams per liter of solution

Table 2-29 Hydrogen Chloride (HCl)

Weights of HCl per 100 weights of H_2O	Partial pressure of HCl, mmHg			
	0°C	10°C	20°C	30°C
78.6	510	840		
66.7	130	233	399	627
56.3	29.0	56.4	105.5	188
47.0	5.7	11.8	23.5	44.5
38.9	1.0	2.27	4.90	9.90
31.6	0.175	0.43	1.00	2.17
25.0	0.0316	0.084	0.205	0.48
19.05	0.0056	0.016	0.0428	0.106
13.64	0.00099	0.00305	0.0088	0.0234
8.70	0.000118	0.000583	0.00178	0.00515
4.17	0.000018	0.000069	0.00024	0.00077
2.04		0.0000117	0.000044	0.000151

Weights of HCl per 100 weights of H_2O	Partial pressure of HCl, mm Hg		
	50°C	80°C	110°C
78.6			
66.7			
56.3	535		
47.0	141	623	
38.9	35.7	188	760
31.6	8.9	54.5	253
25.0	2.21	15.6	83
19.05	0.55	4.66	28
13.64	0.136	1.34	9.3
8.70	0.0344	0.39	3.10
4.17	0.0064	0.095	0.93

Weights of HCl per 100 weights of H O	Partial pressure of HCl, mmHg			
	0°C	10°C	20°C	30°C
2.04	0.00140	0.0245	0.280	
Enthalpy and phase-equilibrium data for the binary system HCl-H_2O are given by Van Nuys, *Trans. Am. Inst. Chem. Engrs.*, **39,** 663 (1943).				

Table 2-30 Hydrogen Sulfide (H_2S)

t, °C	0	5	10	15	20	25	30	35
$10^{-2} \times H$	2.68	3.15	3.67	4.23	4.83	5.45	6.09	6.76
t, °C	40	45	50	60	70	80	90	100
$10^{-2} \times H$	7.45	8.14	8.84	10.3	11.9	13.5	14.4	14.8
International Critical Tables, vol. 3, p. 259.								