TABLE 2.1 Mean activity coefficients of strong electrolytes

m	0.001	0.002	0.005	0.01	0.05	0.1	0.2	0.5	1.0	2.0	3.0	4.0
$NiSO_4$	—	—	—	—	—	.18	.13	.075	.051	.041	—	—
NH_4Cl	.961	.944	.911	.88	.79	.74	.69	.62	.57	—	—	—
NH_4I	.962	.946	.917	.89	.80	.76	.71	.65	.60	—	—	—
$(NH_4)_2SO_4$	.874	.821	.726	.67	.48	.40	.32	.22	.16	—	—	—
NaCl	.966	.953	.929	.904	.823	.780	.730	.68	.66	.67	.71	.78
NaI	.97	.96	.94	.91	.86	.83	.81	.78	.80	.95	—	—
$NaNO_3$	.966	.953	.93	.90	.82	.77	.70	.62	.55	.48	.44	.41
Na_2SO_4	.887	.847	.778	.714	.53	.45	.36	.27	.20	—	—	—
$PbCl_2$	.86	.80	.70	.61	—	—	—	—	—	—	—	—
$ZnCl_2$	.88	.84	.77	.71	.56	.50	.45	.38	.33	—	—	—
$ZnSO_4$	.70	.61	.48	.39	—	.15	.11	.065	.045	.036	.04	—
$CuCl_2$	.89	.85	.78	.72	.58	.52	.47	.42	.43	.51	.59	—
$CuSO_4$	.74	—	.53	.41	.21	.16	.11	.068	.047	—	—	—
$FeCl_2$	.89	.86	.80	.75	.62	.58	.55	.59	.67	—	—	—
KCl	.965	.952	.927	.901	.815	.769	.719	.651	.606	.576	.571	.579
KI	.965	.951	.927	.905	.84	.80	.76	.71	.68	.69	.72	.75
$MgCl_2$	—	—	—	—	—	.56	.53	.52	.62	1.05	2.1	—
$MgSO_4$	—	—	—	.40	.22	.18	.13	.088	.064	.055	.064	—
$MnSO_4$	—	—	—	—	—	.25	.17	.11	.073	.058	.062	.079
HCl	.966	.952	.928	.904	.830	.796	.767	.758	.809	1.01	1.32	1.76
HNO_3	.965	.951	.927	.902	.823	.785	.748	.715	.720	.783	.876	.982
H_2SO_4	.830	.757	.639	.544	.340	.265	.209	.154	.130	.124	.141	.171
NaOH	—	—	—	—	.82	—	.73	.69	.68	.70	.77	.89
KOH	—	—	.92	.90	.82	.80	—	.73	.76	.89	1.08	1.35
$AgNO_3$	—	—	.92	.90	.79	.72	.64	.51	.40	.28	—	—
$BaCl_2$	.88	—	.77	.72	.56	.49	.44	.39	.39	.44	—	—
$CaCl_2$	.89	.85	.785	.725	.57	.515	.48	.52	.71	—	—	—
$Ca(NO_3)_2$	.88	.84	.77	.71	.54	.48	.42	.38	.35	.35	.37	.42

Source: Latimer 1952.

$$\log \gamma_{\pm} = \frac{-A|z_+ z_-|\sqrt{I}}{1 + Ba\sqrt{I}}$$

TABLE 2.2 Values of constants *A* and *B* in the Debye–Huckel equation

Temperature, °C	A	B ($\times 10^{-8}$)
0	0.4883	0.3241
5	0.4921	0.3249
10	0.4960	0.3258
15	0.5000	0.3262
20	0.5042	0.3273
25	0.5085	0.3281
30	0.5130	0.3290
35	0.5175	0.3297
40	0.5221	0.3305
45	0.5271	0.3314
50	0.5319	0.3321
55	0.5371	0.3329
60	0.5425	0.3338

Source: Garrels and Christ 1965.

TABLE 2.3 Values of the size, *a*, in the Debye–Huckel equation (effective hydrated diameter)

$a \times 10^8$ cm	Inorganic and Organic Ions
2.5	Rb^+, Cs^+, NH_4^+, Tl^+, Ag^+
3.0	K^+, Cl^-, Br^-,I^-,NO_3^-,CN^-, NO_2^-, NO_3^-
3.5	OH^-, F^-, HS^-, BrO_3^-, IO_4^-, MnO_4^-, ClO_3^-, ClO_4^-, $HCOO^-$, H_2 citrate$^-$, $CH_3NH_3^-$, $(CH_3)_2NH_2^+$
4.0–4.5	Na^+, HCO_3^-, $H_2PO_4^-$, HSO_3^-, Hg_2^{++}, $SO_4^=$, SeO_4^-, $CrO_4^=$, $HPO_4^=$, PO_4^{3-}, ClO_2^-, IO_3^-, HCO_3^-, $Co(NH_3)_4(NO_2)_2^+$, $S_2O_3^=$, $(CH_3)_3NH^+$, $C_2H_5NH_3^+$
4.5	Pb^{++}, $CO_3^=$, SO_3^+,$MoO_4^=$, $Co(NH_3)_5Cl^{++}$, $Fe(CN)_5NO^=$, CH_3COO^-, $(COO)_2^=$
5.0	Sr^{++}, Ba^{++}, Ra^{++}, Cd^{++}, Hg^{++}, $S^=$, $WO_4^=$, $S_2O_4^=$, $Fe(CN)_6^{4-}$, $CHCl_2COO^-$, $H_2C(COO)_2^=$, Citrate^{3-}
6.0	Li^+, Ca^{++}, Cu^{++}, Zn^{++}, Sn^{++}, Mn^{++}, Fe^{++}, Ni^{++}, Co^{++}, Co(ethylenediamine)$_3^{3+}$, $Co(S_2O_3)(CN)_6^{4-}$, $(C_3H_7)_2NH_2^+$, $C_6H_4(COO)_2^=$, $(CH_2CH_2COO)_2^-$
8.0	Mg^{++}, Be^{++}, $(C_6H_5)_2CHCOO^-$, $(C_3H_7)_4N^+$
9.0	H^+, Fe^{3+}, Al^{3+}, Cr^{3+}, trivalent rare earths (Sc^{3+}, Y^{3+}, La^{3+}, Ce^{3+}, Pr^{3+}, Nd^{3+}, Sm^{3+}), $Co(SO_3)_2(CN)_4^{5-}$
11.0	Th^{4+}, Zr^{4+}, Ce^{4+}, Sn^{4+}

Source: Garrels and Christ 1965; Butler 1998; and Kielland 1937.

TABLE 2.5 Henry's law constants for various gases in water at 25°C

Gas	Henry's Constant (atm)
Oxygen	4.38×10^4
Carbon dioxide	1.64×10^3
Carbon monoxide	5.80×10^4
Nitrogen	8.65×10^4

Source: Perry 1982.

TABLE 2.6 Solubility constants, K_I, for use in Eq. 2.23

Species, *i*	K_I	Species, *i*	K_I
H^+	0	NO_3^-	0.013
NH_4^+	0.033	Cl^-	0.029
K^+	0.099	HSO_4^-	0.069
Na^+	0.107	OH^-	0.081
Zn^{++}	0.108	HCO_3^-	0.083
Mg^{++}	0.119	SO_4^{-2}	0.121
NH_3	0.007		

TABLE 2.7 Equilibrium constants for ligand complexation for various metals

		Log of Equilibrium Constant				
Ligand	Ion	K_{s0}	K_{s1}	K_{s2}	K_{s3}	K_{s4}
Cl^-	Cu^+	–6.73	–5.0	–1.12	–1.47	
	Ag^+	–9.75	–6.70	–4.70	–4.70	–4.46
	Tl^+	–3.04	–3.15	–3.74	–4.70	
	Hg^{++}	–13.79	–7.05	–0.57	+0.28	+1.28
Br^-	Ag^+	–12.10	–7.96	–5.00	–4.15	–3.22
	Hg^{++}	–19.10	–10.05	–1.77	+0.64	+1.90
	Tl^+	–4.81	–4.48	–4.62	–5.10	–5.80
I^-	Ag^+	–16.35	–8.22	–5.40	–2.60	–1.96
	Hg^{++}	–27.70	–14.83	–3.88	–0.10	+2.13
	Pb^{++}	–8.15	–6.23	–4.47	–4.65	–3.85
CN^-	Cu^+	–19.49	–13.0	–4.23	+0.36	+2.06
	Ag^+	–15.92	–7.0	+4.62	+5.32	+4.19
	Hg^{++}	–35.10	–17.10	–0.40	+3.43	+6.41

TABLE 2.11 Standard redox electrode potentials

Electrode	$E^{o}_{M/M+n}$
Au/Au^{+}	1.7
Au/Au^{+3}	1.50
Pt/Pt^{+}	1.20
Pd/Pd^{+2}	0.987
Ag/Ag^{+}	0.799
Hg/Hg^{+2}	0.789
Cu/Cu^{+}	0.521
Cu/Cu^{+2}	0.337
H_2/H^{+}	0.00
Fe/Fe^{+3}	–0.036
Pb/Pb^{+2}	–0.126
Sn/Sn^{+2}	–0.136
Ni/Ni^{+2}	–0.250
Co/Co^{+2}	–0.277
In/In^{+3}	–0.342
Cd/Cd^{+2}	–0.403
Fe/Fe^{+2}	–0.440
Cr/Cr^{+3}	–0.740
Zn/Zn^{+2}	–0.763
Mn/Mn^{+2}	–1.18
Zr/Zr^{+4}	–1.53
Ti/Ti^{+2}	–1.63
Al/Al^{+3}	–1.66
Be/Be^{+2}	–1.85
Mg/Mg^{+2}	–2.37
Na/Na^{+}	–2.714

TABLE 2.12 Gibbs free energy formation of metal ions

Metal Ion	ΔG_f^0 (kcal)	Metal Ion	ΔG_f^0 (kcal)
Al^{3+}	–115.0	Cd^{2+}	–18.58
Ca^{2+}	–132.18	Cr^{2+}	–42.1
Co^{2+}	–12.8	Co^{3+}	28.9
Cu^{+}	12.0	Cu^{2+}	15.53
Au^{+}	39.0	Au^{3+}	103.6
Fe^{2+}	–20.3	Fe^{3+}	–2.52
Pb^{2+}	–5.81	Mn^{2+}	–54.4
Mn^{3+}	–19.6	Mg^{2+}	–108.99
Hg^{2+}	39.38	Ni^{2+}	–11.53
Pd^{2+}	45.5	Pt^{2+}	54.8
K^{+}	–67.466	Rb^{+}	–67.45
Ag^{+}	18.43	Na^{+}	–62.589
Sr^{2+}	–133.2	Th^{4+}	–175.2
Sn^{2+}	–6.275	Ti^{2+}	–75.1
U^{3+}	–124.4	Zn^{2+}	–35.184