

Appendix C

Dissociation (Ionization) Constants (K_a) of Selected Acids

Name and Formula	Lewis Structure [†]	K_{a1}	K_{a2}	K_{a3}
Acetic acid CH_3COOH		1.8×10^{-5}		
Acetylsalicylic acid $\text{CH}_3\text{COOC}_6\text{H}_4\text{COOH}$		3.6×10^{-4}		
Adipic acid $\text{HOOC}(\text{CH}_2)_4\text{COOH}$		3.8×10^{-5}	3.8×10^{-6}	
Arsenic acid H_3AsO_4		6×10^{-3}	1.1×10^{-7}	3×10^{-12}
Ascorbic acid $\text{H}_2\text{C}_6\text{H}_6\text{O}_6$		1.0×10^{-5}	5×10^{-12}	
Benzoic acid $\text{C}_6\text{H}_5\text{COOH}$		6.3×10^{-5}		
Carbonic acid H_2CO_3		4.5×10^{-7}	4.7×10^{-11}	
Chloroacetic acid ClCH_2COOH		1.4×10^{-3}		
Chlorous acid HClO_2		1.1×10^{-2}		

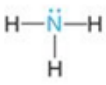
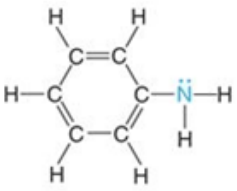
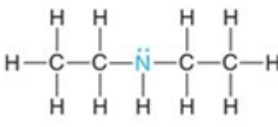
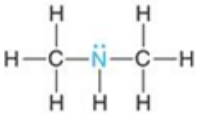
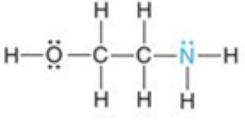
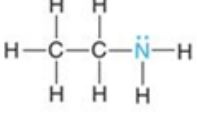
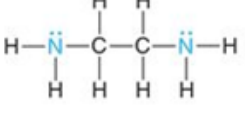
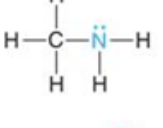
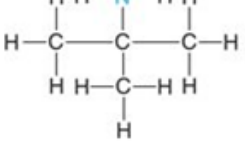
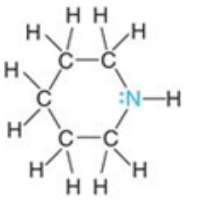
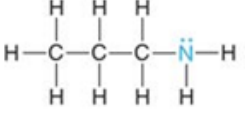
Citric acid HOOCCH ₂ C(OH)(COOH)CH ₂ COOH		7.4×10^{-4}	1.7×10^{-5}	4.0×10^{-7}
Formic acid HCOOH		1.8×10^{-4}		
Glyceric acid HOCH ₂ CH(OH)COOH		2.9×10^{-4}		
Glycolic acid HOCH ₂ COOH		1.5×10^{-4}		
Glyoxylic acid HC(O)COOH		3.5×10^{-4}		
Hydrocyanic acid HCN		6.2×10^{-10}		
Hydrofluoric acid HF		6.8×10^{-4}		
Hydrosulfuric acid H ₂ S		9×10^{-8}	1×10^{-17}	
Hypobromous acid HBrO		2.3×10^{-9}		
Hypochlorous acid HClO		2.9×10^{-8}		
Hypoiodous acid HIO		2.3×10^{-11}		
Iodic acid HIO ₃		1.6×10^{-1}		
Lactic acid CH ₃ CH(OH)COOH		1.4×10^{-4}		
Maleic acid HOOCCH=CHCOOH		1.2×10^{-2}	4.7×10^{-7}	

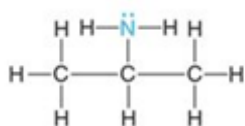
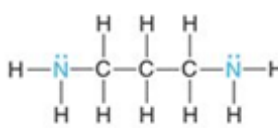
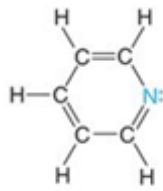
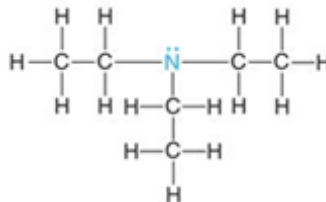
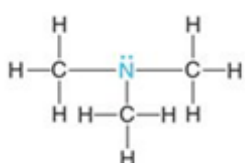
Malonic acid HOOCCH ₂ COOH		1.4×10^{-3}	2.0×10^{-6}
Nitrous acid HNO ₂		7.1×10^{-4}	
Oxalic acid HOOC-COOH		5.6×10^{-2}	5.4×10^{-5}
Phenol C ₆ H ₅ OH		1.0×10^{-10}	
Phenylacetic acid C ₆ H ₅ CH ₂ COOH		4.9×10^{-5}	
Phosphoric acid H ₃ PO ₄ [or PO(OH) ₃]		7.2×10^{-3}	6.3×10^{-8} 4.2×10^{-13}
Phosphorous acid H ₃ PO ₃ [or HPO(OH) ₂]		3×10^{-2}	1.7×10^{-7}
Propanoic acid CH ₃ CH ₂ COOH		1.3×10^{-5}	
Pyruvic acid CH ₃ C(O)COOH		2.8×10^{-3}	
Succinic acid HOOCCH ₂ CH ₂ COOH		6.2×10^{-5}	2.3×10^{-6}
Sulfuric acid H ₂ SO ₄		Very large	1.0×10^{-2}
Sulfurous acid H ₂ SO ₃		1.4×10^{-2}	6.5×10^{-8}

*All values at 298 K, except for acetylsalicylic acid, which is at 37°C (310 K) in 0.15 M NaCl.

†Acidic (ionizable) proton(s) shown in red. Structures have lowest formal charges. Benzene rings show one resonance form.

Dissociation (Ionization) Constants (K_b) of Selected Amine Bases

Name and Formula	Lewis Structure [†]	K_{b1}	K_{b2}
Ammonia NH ₃		1.76×10^{-5}	
Aniline C ₆ H ₅ NH ₂		4.0×10^{-10}	
Diethylamine (CH ₃ CH ₂) ₂ NH		8.6×10^{-4}	
Dimethylamine (CH ₃) ₂ NH		5.9×10^{-4}	
Ethanolamine HOCH ₂ CH ₂ NH ₂		3.2×10^{-5}	
Ethylamine CH ₃ CH ₂ NH ₂		4.3×10^{-4}	
Ethylenediamine H ₂ NCH ₂ CH ₂ NH ₂		8.5×10^{-5}	7.1×10^{-8}
Methylamine CH ₃ NH ₂		4.4×10^{-4}	
<i>tert</i> -Butylamine (CH ₃) ₃ CNH ₂		4.8×10^{-4}	
Piperidine C ₅ H ₁₀ NH		1.3×10^{-3}	
<i>n</i> -Propylamine CH ₃ CH ₂ CH ₂ NH ₂		3.5×10^{-4}	

Isopropylamine (CH ₃) ₂ CHNH ₂		4.7 × 10 ⁻⁴	
1,3-Propylenediamine H ₂ NCH ₂ CH ₂ CH ₂ NH ₂		3.1 × 10 ⁻⁴	3.0 × 10 ⁻⁶
Pyridine C ₅ H ₅ N		1.7 × 10 ⁻⁹	
Triethylamine (CH ₃ CH ₂) ₃ N		5.2 × 10 ⁻⁴	
Trimethylamine (CH ₃) ₃ N		6.3 × 10 ⁻⁵	

[†]Blue type indicates the basic nitrogen and its lone pair.

Dissociation (Ionization) Constants (K_a) of Some Hydrated Metal Ions

Free Ion	Hydrated Ion	K_a
Fe ³⁺	Fe(H ₂ O) ₆ ³⁺ (aq)	6 × 10 ⁻³
Sn ²⁺	Sn(H ₂ O) ₆ ²⁺ (aq)	4 × 10 ⁻⁴
Cr ³⁺	Cr(H ₂ O) ₆ ³⁺ (aq)	1 × 10 ⁻⁴
Al ³⁺	Al(H ₂ O) ₆ ³⁺ (aq)	1 × 10 ⁻⁵
Cu ²⁺	Cu(H ₂ O) ₆ ²⁺ (aq)	3 × 10 ⁻⁸
Pb ²⁺	Pb(H ₂ O) ₆ ²⁺ (aq)	3 × 10 ⁻⁸
Zn ²⁺	Zn(H ₂ O) ₆ ²⁺ (aq)	1 × 10 ⁻⁹
Co ²⁺	Co(H ₂ O) ₆ ²⁺ (aq)	2 × 10 ⁻¹⁰
Ni ²⁺	Ni(H ₂ O) ₆ ²⁺ (aq)	1 × 10 ⁻¹⁰

Formation Constants (K_f) of Some Complex Ions

Complex Ion	K_f
Ag(CN) ₂ ⁻	3.0 × 10 ²⁰
Ag(NH ₃) ₂ ⁺	1.7 × 10 ⁷
Ag(S ₂ O ₃) ₂ ³⁻	4.7 × 10 ¹³
AlF ₆ ³⁻	4 × 10 ¹⁹
Al(OH) ₄ ⁻	3 × 10 ³³
Be(OH) ₄ ²⁻	4 × 10 ¹⁸
CdI ₄ ²⁻	1 × 10 ⁶
Co(OH) ₄ ²⁻	5 × 10 ⁹
Cr(OH) ₄ ⁻	8.0 × 10 ²⁹
Cu(NH ₃) ₄ ²⁺	5.6 × 10 ¹¹
Fe(CN) ₆ ⁴⁻	3 × 10 ³⁵
Fe(CN) ₆ ³⁻	4.0 × 10 ⁴³
Hg(CN) ₄ ²⁻	9.3 × 10 ³⁸
Ni(NH ₃) ₆ ²⁺	2.0 × 10 ⁸
Pb(OH) ₃ ⁻	8 × 10 ¹³
Sn(OH) ₃ ⁻	3 × 10 ²⁵
Zn(CN) ₄ ²⁻	4.2 × 10 ¹⁹
Zn(NH ₃) ₄ ²⁺	7.8 × 10 ⁸
Zn(OH) ₄ ²⁻	3 × 10 ¹⁵

Solubility-Product Constants (K_{sp}) of Slightly Soluble Ionic Compounds

Name, Formula	K_{sp}	Name, Formula	K_{sp}
Carbonates		Cobalt(II) hydroxide, Co(OH)_2	1.3×10^{-15}
Barium carbonate, BaCO_3	2.0×10^{-9}	Copper(II) hydroxide, Cu(OH)_2	2.2×10^{-20}
Cadmium carbonate, CdCO_3	1.8×10^{-14}	Iron(II) hydroxide, Fe(OH)_2	4.1×10^{-15}
Calcium carbonate, CaCO_3	3.3×10^{-9}	Iron(III) hydroxide, Fe(OH)_3	1.6×10^{-39}
Cobalt(II) carbonate, CoCO_3	1.0×10^{-10}	Magnesium hydroxide, Mg(OH)_2	6.3×10^{-10}
Copper(II) carbonate, CuCO_3	3×10^{-12}	Manganese(II) hydroxide, Mn(OH)_2	1.6×10^{-13}
Lead(II) carbonate, PbCO_3	7.4×10^{-14}	Nickel(II) hydroxide, Ni(OH)_2	6×10^{-16}
Magnesium carbonate, MgCO_3	3.5×10^{-8}	Zinc hydroxide, Zn(OH)_2	3×10^{-16}
Mercury(I) carbonate, Hg_2CO_3	8.9×10^{-17}	Iodates	
Nickel(II) carbonate, NiCO_3	1.3×10^{-7}	Barium iodate, $\text{Ba(IO}_3)_2$	1.5×10^{-9}
Strontium carbonate, SrCO_3	5.4×10^{-10}	Calcium iodate, $\text{Ca(IO}_3)_2$	7.1×10^{-7}
Zinc carbonate, ZnCO_3	1.0×10^{-10}	Lead(II) iodate, $\text{Pb(IO}_3)_2$	2.5×10^{-13}
Chromates		Silver iodate, AgIO_3	3.1×10^{-8}
Barium chromate, BaCrO_4	2.1×10^{-10}	Strontium iodate, $\text{Sr(IO}_3)_2$	3.3×10^{-7}
Calcium chromate, CaCrO_4	1×10^{-8}	Zinc iodate, $\text{Zn(IO}_3)_2$	3.9×10^{-6}
Lead(II) chromate, PbCrO_4	2.3×10^{-13}	Oxalates	
Silver chromate, Ag_2CrO_4	2.6×10^{-12}	Barium oxalate dihydrate, $\text{BaC}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$	1.1×10^{-7}
Cyanides		Calcium oxalate monohydrate, $\text{CaC}_2\text{O}_4 \cdot \text{H}_2\text{O}$	2.3×10^{-9}
Mercury(I) cyanide, $\text{Hg}_2(\text{CN})_2$	5×10^{-40}	Strontium oxalate monohydrate, $\text{SrC}_2\text{O}_4 \cdot \text{H}_2\text{O}$	5.6×10^{-8}
Silver cyanide, AgCN	2.2×10^{-16}	Phosphates	
Halides		Calcium phosphate, $\text{Ca}_3(\text{PO}_4)_2$	1.2×10^{-29}
<i>Fluorides</i>		Magnesium phosphate, $\text{Mg}_3(\text{PO}_4)_2$	5.2×10^{-24}
Barium fluoride, BaF_2	1.5×10^{-6}	Silver phosphate, Ag_3PO_4	2.6×10^{-18}
Calcium fluoride, CaF_2	3.2×10^{-11}	Sulfates	
Lead(II) fluoride, PbF_2	3.6×10^{-8}	Barium sulfate, BaSO_4	1.1×10^{-10}
Magnesium fluoride, MgF_2	7.4×10^{-9}	Calcium sulfate, CaSO_4	2.4×10^{-5}
Strontium fluoride, SrF_2	2.6×10^{-9}	Lead(II) sulfate, PbSO_4	1.6×10^{-8}
<i>Chlorides</i>		Radium sulfate, RaSO_4	2×10^{-11}
Copper(I) chloride, CuCl	1.9×10^{-7}	Silver sulfate, Ag_2SO_4	1.5×10^{-5}
Lead(II) chloride, PbCl_2	1.7×10^{-5}	Strontium sulfate, SrSO_4	3.2×10^{-7}
Silver chloride, AgCl	1.8×10^{-10}	Sulfides	
<i>Bromides</i>		Cadmium sulfide, CdS	1.0×10^{-24}
Copper(I) bromide, CuBr	5×10^{-9}	Copper(II) sulfide, CuS	8×10^{-34}
Silver bromide, AgBr	5.0×10^{-13}	Iron(II) sulfide, FeS	8×10^{-16}
<i>Iodides</i>		Lead(II) sulfide, PbS	3×10^{-25}
Copper(I) iodide, CuI	1×10^{-12}	Manganese(II) sulfide, MnS	3×10^{-11}
Lead(II) iodide, PbI_2	7.9×10^{-9}	Mercury(II) sulfide, HgS	2×10^{-50}
Mercury(I) iodide, Hg_2I_2	4.7×10^{-29}	Nickel(II) sulfide, NiS	3×10^{-16}
Silver iodide, AgI	8.3×10^{-17}	Silver sulfide, Ag_2S	8×10^{-48}
Hydroxides		Tin(II) sulfide, SnS	1.3×10^{-23}
Aluminum hydroxide, Al(OH)_3	3×10^{-34}	Zinc sulfide, ZnS	2.0×10^{-22}
Cadmium hydroxide, Cd(OH)_2	7.2×10^{-15}		
Calcium hydroxide, Ca(OH)_2	6.5×10^{-6}		