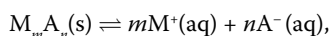


SOLUBILITY PRODUCT CONSTANTS

The solubility product constant K_{sp} is a useful parameter for calculating the aqueous solubility of sparingly soluble compounds under various conditions. It may be determined by direct measurement or calculated from the standard Gibbs energies of formation $\Delta_f G^\circ$ of the species involved at their standard states. Thus if $K_{sp} = [M^+]^m [A^-]^n$ is the equilibrium constant for the reaction



where $M_m A_n$ is the slightly soluble substance and M^+ and A^- are the ions produced in solution by the dissociation of $M_m A_n$, then the Gibbs energy change is

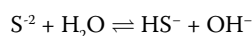
$$\Delta G^\circ = m \Delta_f G^\circ (M^+, aq) + n \Delta_f G^\circ (A^-, aq) - \Delta_f G^\circ (M_m A_n, s)$$

The solubility product constant is calculated from the equation

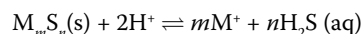
$$\ln K_{sp} = -\Delta G^\circ / RT$$

The first table below gives selected values of K_{sp} at 25°C. Many of these have been calculated from standard state thermodynamic data in References 1 and 2; other values are taken from publications of the IUPAC Solubility Data Project (References 3 to 7).

The above formulation is not convenient for treating sulfides because the S^{2-} ion is usually not present in significant concentrations (see Reference 8). This is due to the hydrolysis reaction



which is strongly shifted to the right except in very basic solutions. Furthermore, the equilibrium constant for this reaction, which depends on the second ionization constant of H_2S , is poorly known. Therefore it is more useful in the case of sulfides to define a different solubility product K_{spa} based on the reaction



Values of K_{spa} , taken from Reference 8, are given for several sulfides in the auxiliary table following the main table. Additional discussion of sulfide equilibria may be found in References 7 and 9.

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Compound	Formula	K_{sp}
Aluminum phosphate	AlPO ₄	$9.84 \cdot 10^{-21}$
Barium bromate	Ba(BrO ₃) ₂	$2.43 \cdot 10^{-4}$
Barium carbonate	BaCO ₃	$2.58 \cdot 10^{-9}$
Barium chromate	BaCrO ₄	$1.17 \cdot 10^{-10}$
Barium fluoride	BaF ₂	$1.84 \cdot 10^{-7}$
Barium hydroxide octahydrate	Ba(OH) ₂ · 8H ₂ O	$2.55 \cdot 10^{-4}$
Barium iodate	Ba(IO ₃) ₂	$4.01 \cdot 10^{-9}$
Barium iodate monohydrate	Ba(IO ₃) ₂ · H ₂ O	$1.67 \cdot 10^{-9}$
Barium molybdate	BaMoO ₄	$3.54 \cdot 10^{-8}$
Barium nitrate	Ba(NO ₃) ₂	$4.64 \cdot 10^{-3}$
Barium selenate	BaSeO ₄	$3.40 \cdot 10^{-8}$
Barium sulfate	BaSO ₄	$1.08 \cdot 10^{-10}$
Barium sulfite	BaSO ₃	$5.0 \cdot 10^{-10}$
Beryllium hydroxide	Be(OH) ₂	$6.92 \cdot 10^{-22}$
Bismuth arsenate	BiAsO ₄	$4.43 \cdot 10^{-10}$
Bismuth iodide	BiI ₃	$7.71 \cdot 10^{-19}$
Cadmium arsenate	Cd ₃ (AsO ₄) ₂	$2.2 \cdot 10^{-33}$
Cadmium carbonate	CdCO ₃	$1.0 \cdot 10^{-12}$
Cadmium fluoride	CdF ₂	$6.44 \cdot 10^{-3}$
Cadmium hydroxide	Cd(OH) ₂	$7.2 \cdot 10^{-15}$
Cadmium iodate	Cd(IO ₃) ₂	$2.5 \cdot 10^{-8}$
Cadmium oxalate trihydrate	CdC ₂ O ₄ · 3H ₂ O	$1.42 \cdot 10^{-8}$
Cadmium phosphate	Cd ₃ (PO ₄) ₂	$2.53 \cdot 10^{-33}$
Calcium carbonate (calcite)	CaCO ₃	$3.36 \cdot 10^{-9}$
Calcium fluoride	CaF ₂	$3.45 \cdot 10^{-11}$
Calcium hydroxide	Ca(OH) ₂	$5.02 \cdot 10^{-6}$

Compound	Formula	K_{sp}
Calcium iodate	Ca(IO ₃) ₂	$6.47 \cdot 10^{-6}$
Calcium iodate hexahydrate	Ca(IO ₃) ₂ · 6H ₂ O	$7.10 \cdot 10^{-7}$
Calcium molybdate	CaMoO ₄	$1.46 \cdot 10^{-8}$
Calcium oxalate monohydrate	CaC ₂ O ₄ · H ₂ O	$2.32 \cdot 10^{-9}$
Calcium phosphate	Ca ₃ (PO ₄) ₂	$2.07 \cdot 10^{-33}$
Calcium sulfate	CaSO ₄	$4.93 \cdot 10^{-5}$
Calcium sulfate dihydrate	CaSO ₄ · 2H ₂ O	$3.14 \cdot 10^{-5}$
Calcium sulfite hemihydrate	CaSO ₃ · 0.5H ₂ O	$3.1 \cdot 10^{-7}$
Cesium perchlorate	CsClO ₄	$3.95 \cdot 10^{-3}$
Cesium periodate	CsIO ₄	$5.16 \cdot 10^{-6}$
Cobalt(II) arsenate	Co ₃ (AsO ₄) ₂	$6.80 \cdot 10^{-29}$
Cobalt(II) hydroxide (blue)	Co(OH) ₂	$5.92 \cdot 10^{-15}$
Cobalt(II) iodate dihydrate	Co(IO ₃) ₂ · 2H ₂ O	$1.21 \cdot 10^{-2}$
Cobalt(II) phosphate	Co ₃ (PO ₄) ₂	$2.05 \cdot 10^{-35}$
Copper(I) bromide	CuBr	$6.27 \cdot 10^{-9}$
Copper(I) chloride	CuCl	$1.72 \cdot 10^{-7}$
Copper(I) cyanide	CuCN	$3.47 \cdot 10^{-20}$
Copper(I) iodide	CuI	$1.27 \cdot 10^{-12}$
Copper(I) thiocyanate	CuSCN	$1.77 \cdot 10^{-13}$
Copper(II) arsenate	Cu ₃ (AsO ₄) ₂	$7.95 \cdot 10^{-36}$
Copper(II) iodate monohydrate	Cu(IO ₃) ₂ · H ₂ O	$6.94 \cdot 10^{-8}$
Copper(II) oxalate	CuC ₂ O ₄	$4.43 \cdot 10^{-10}$
Copper(II) phosphate	Cu ₃ (PO ₄) ₂	$1.40 \cdot 10^{-37}$
Europium(III) hydroxide	Eu(OH) ₃	$9.38 \cdot 10^{-27}$
Gallium(III) hydroxide	Ga(OH) ₃	$7.28 \cdot 10^{-36}$
Iron(II) carbonate	FeCO ₃	$3.13 \cdot 10^{-11}$

Compound	Formula	K_{sp}	Compound	Formula	K_{sp}
Iron(II) fluoride	FeF_2	$2.36 \cdot 10^{-6}$	Radium iodate	$\text{Ra}(\text{IO}_3)_2$	$1.16 \cdot 10^{-9}$
Iron(II) hydroxide	$\text{Fe}(\text{OH})_2$	$4.87 \cdot 10^{-17}$	Radium sulfate	RaSO_4	$3.66 \cdot 10^{-11}$
Iron(III) hydroxide	$\text{Fe}(\text{OH})_3$	$2.79 \cdot 10^{-39}$	Rubidium perchlorate	RbClO_4	$3.00 \cdot 10^{-3}$
Iron(III) phosphate dihydrate	$\text{FePO}_4 \cdot 2\text{H}_2\text{O}$	$9.91 \cdot 10^{-16}$	Scandium fluoride	ScF_3	$5.81 \cdot 10^{-24}$
Lanthanum iodate	$\text{La}(\text{IO}_3)_3$	$7.50 \cdot 10^{-12}$	Scandium hydroxide	$\text{Sc}(\text{OH})_3$	$2.22 \cdot 10^{-31}$
Lead(II) bromide	PbBr_2	$6.60 \cdot 10^{-6}$	Silver(I) acetate	AgCH_3COO	$1.94 \cdot 10^{-3}$
Lead(II) carbonate	PbCO_3	$7.40 \cdot 10^{-14}$	Silver(I) arsenate	Ag_3AsO_4	$1.03 \cdot 10^{-22}$
Lead(II) chloride	PbCl_2	$1.70 \cdot 10^{-5}$	Silver(I) bromate	AgBrO_3	$5.38 \cdot 10^{-5}$
Lead(II) fluoride	PbF_2	$3.3 \cdot 10^{-8}$	Silver(I) bromide	AgBr	$5.35 \cdot 10^{-13}$
Lead(II) hydroxide	$\text{Pb}(\text{OH})_2$	$1.43 \cdot 10^{-20}$	Silver(I) carbonate	Ag_2CO_3	$8.46 \cdot 10^{-12}$
Lead(II) iodate	$\text{Pb}(\text{IO}_3)_2$	$3.69 \cdot 10^{-13}$	Silver(I) chloride	AgCl	$1.77 \cdot 10^{-10}$
Lead(II) iodide	PbI_2	$9.8 \cdot 10^{-9}$	Silver(I) chromate	Ag_2CrO_4	$1.12 \cdot 10^{-12}$
Lead(II) selenate	PbSeO_4	$1.37 \cdot 10^{-7}$	Silver(I) cyanide	AgCN	$5.97 \cdot 10^{-17}$
Lead(II) sulfate	PbSO_4	$2.53 \cdot 10^{-8}$	Silver(I) iodate	AgIO_3	$3.17 \cdot 10^{-8}$
Lithium carbonate	Li_2CO_3	$8.15 \cdot 10^{-4}$	Silver(I) iodide	AgI	$8.52 \cdot 10^{-17}$
Lithium fluoride	LiF	$1.84 \cdot 10^{-3}$	Silver(I) oxalate	$\text{Ag}_2\text{C}_2\text{O}_4$	$5.40 \cdot 10^{-12}$
Lithium phosphate	Li_3PO_4	$2.37 \cdot 10^{-11}$	Silver(I) phosphate	Ag_3PO_4	$8.89 \cdot 10^{-17}$
Magnesium carbonate	MgCO_3	$6.82 \cdot 10^{-6}$	Silver(I) sulfate	Ag_2SO_4	$1.20 \cdot 10^{-5}$
Magnesium carbonate trihydrate	$\text{MgCO}_3 \cdot 3\text{H}_2\text{O}$	$2.38 \cdot 10^{-6}$	Silver(I) sulfite	Ag_2SO_3	$1.50 \cdot 10^{-14}$
Magnesium carbonate pentahydrate	$\text{MgCO}_3 \cdot 5\text{H}_2\text{O}$	$3.79 \cdot 10^{-6}$	Silver(I) thiocyanate	AgSCN	$1.03 \cdot 10^{-12}$
Magnesium fluoride	MgF_2	$5.16 \cdot 10^{-11}$	Strontium arsenate	$\text{Sr}_3(\text{AsO}_4)_2$	$4.29 \cdot 10^{-19}$
Magnesium hydroxide	$\text{Mg}(\text{OH})_2$	$5.61 \cdot 10^{-12}$	Strontium carbonate	SrCO_3	$5.60 \cdot 10^{-10}$
Magnesium oxalate dihydrate	$\text{MgC}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$	$4.83 \cdot 10^{-6}$	Strontium fluoride	SrF_2	$4.33 \cdot 10^{-9}$
Magnesium phosphate	$\text{Mg}_3(\text{PO}_4)_2$	$1.04 \cdot 10^{-24}$	Strontium iodate	$\text{Sr}(\text{IO}_3)_2$	$1.14 \cdot 10^{-7}$
Manganese(II) carbonate	MnCO_3	$2.24 \cdot 10^{-11}$	Strontium iodate monohydrate	$\text{Sr}(\text{IO}_3)_2 \cdot \text{H}_2\text{O}$	$3.77 \cdot 10^{-7}$
Manganese(II) iodate	$\text{Mn}(\text{IO}_3)_2$	$4.37 \cdot 10^{-7}$	Strontium iodate hexahydrate	$\text{Sr}(\text{IO}_3)_2 \cdot 6\text{H}_2\text{O}$	$4.55 \cdot 10^{-7}$
Manganese(II) oxalate dihydrate	$\text{MnC}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$	$1.70 \cdot 10^{-7}$	Strontium sulfate	SrSO_4	$3.44 \cdot 10^{-7}$
Mercury(I) bromide	Hg_2Br_2	$6.40 \cdot 10^{-23}$	Thallium(I) bromate	TlBrO_3	$1.10 \cdot 10^{-4}$
Mercury(I) carbonate	Hg_2CO_3	$3.6 \cdot 10^{-17}$	Thallium(I) bromide	TlBr	$3.71 \cdot 10^{-6}$
Mercury(I) chloride	Hg_2Cl_2	$1.43 \cdot 10^{-18}$	Thallium(I) chloride	TlCl	$1.86 \cdot 10^{-4}$
Mercury(I) fluoride	Hg_2F_2	$3.10 \cdot 10^{-6}$	Thallium(I) chromate	Tl_2CrO_4	$8.67 \cdot 10^{-13}$
Mercury(I) iodide	Hg_2I_2	$5.2 \cdot 10^{-29}$	Thallium(I) iodate	TlIO_3	$3.12 \cdot 10^{-6}$
Mercury(I) oxalate	$\text{Hg}_2\text{C}_2\text{O}_4$	$1.75 \cdot 10^{-13}$	Thallium(I) iodide	TlI	$5.54 \cdot 10^{-8}$
Mercury(I) sulfate	Hg_2SO_4	$6.5 \cdot 10^{-7}$	Thallium(I) thiocyanate	TlSCN	$1.57 \cdot 10^{-4}$
Mercury(I) thiocyanate	$\text{Hg}_2(\text{SCN})_2$	$3.2 \cdot 10^{-20}$	Thallium(III) hydroxide	$\text{Tl}(\text{OH})_3$	$1.68 \cdot 10^{-44}$
Mercury(II) bromide	HgBr_2	$6.2 \cdot 10^{-20}$	Tin(II) hydroxide	$\text{Sn}(\text{OH})_2$	$5.45 \cdot 10^{-27}$
Mercury(II) iodide	HgI_2	$2.9 \cdot 10^{-29}$	Yttrium carbonate	$\text{Y}_2(\text{CO}_3)_3$	$1.03 \cdot 10^{-31}$
Neodymium carbonate	$\text{Nd}_2(\text{CO}_3)_3$	$1.08 \cdot 10^{-33}$	Yttrium fluoride	YF_3	$8.62 \cdot 10^{-21}$
Nickel(II) carbonate	NiCO_3	$1.42 \cdot 10^{-7}$	Yttrium hydroxide	$\text{Y}(\text{OH})_3$	$1.00 \cdot 10^{-22}$
Nickel(II) hydroxide	$\text{Ni}(\text{OH})_2$	$5.48 \cdot 10^{-16}$	Yttrium iodate	$\text{Y}(\text{IO}_3)_3$	$1.12 \cdot 10^{-10}$
Nickel(II) iodate	$\text{Ni}(\text{IO}_3)_2$	$4.71 \cdot 10^{-5}$	Zinc arsenate	$\text{Zn}_3(\text{AsO}_4)_2$	$2.8 \cdot 10^{-28}$
Nickel(II) phosphate	$\text{Ni}_3(\text{PO}_4)_2$	$4.74 \cdot 10^{-32}$	Zinc carbonate	ZnCO_3	$1.46 \cdot 10^{-10}$
Palladium(II) thiocyanate	$\text{Pd}(\text{SCN})_2$	$4.39 \cdot 10^{-23}$	Zinc carbonate monohydrate	$\text{ZnCO}_3 \cdot \text{H}_2\text{O}$	$5.42 \cdot 10^{-11}$
Potassium hexachloroplatinate	K_2PtCl_6	$7.48 \cdot 10^{-6}$	Zinc fluoride	ZnF_2	$3.04 \cdot 10^{-2}$
Potassium perchlorate	KClO_4	$1.05 \cdot 10^{-2}$	Zinc hydroxide	$\text{Zn}(\text{OH})_2$	$3 \cdot 10^{-17}$
Potassium periodate	KIO_4	$3.71 \cdot 10^{-4}$	Zinc iodate dihydrate	$\text{Zn}(\text{IO}_3)_2 \cdot 2\text{H}_2\text{O}$	$4.1 \cdot 10^{-6}$
Praseodymium hydroxide	$\text{Pr}(\text{OH})_3$	$3.39 \cdot 10^{-24}$	Zinc oxalate dihydrate	$\text{ZnC}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$	$1.38 \cdot 10^{-9}$
			Zinc selenide	ZnSe	$3.6 \cdot 10^{-26}$
			Zinc selenite monohydrate	$\text{ZnSeO}_3 \cdot \text{H}_2\text{O}$	$1.59 \cdot 10^{-7}$

Sulfides

Compound	Formula	K_{spa}
Cadmium sulfide	CdS	$8 \cdot 10^{-7}$
Copper(II) sulfide	CuS	$6 \cdot 10^{-16}$
Iron(II) sulfide	FeS	$6 \cdot 10^2$
Lead(II) sulfide	PbS	$3 \cdot 10^{-7}$
Manganese(II) sulfide (green)	MnS	$3 \cdot 10^7$
Mercury(II) sulfide (red)	HgS	$4 \cdot 10^{-33}$
Mercury(II) sulfide (black)	HgS	$2 \cdot 10^{-32}$
Silver(I) sulfide	Ag ₂ S	$6 \cdot 10^{-30}$
Tin(II) sulfide	SnS	$1 \cdot 10^{-5}$
Zinc sulfide (sphalerite)	ZnS	$2 \cdot 10^{-4}$
Zinc sulfide (wurtzite)	ZnS	$3 \cdot 10^{-2}$