General Solubility Rules for Inorganic Compounds

Ion	Characteristic Solubility of Compounds Containing Ion
Nitrate, NO_3^-	All nitrates are soluble.
Chloride, Cl^-	All chlorides are soluble except AgCl, $PbCl_2$, and Hg_2Cl_2.
Sulfate, SO_4^{2-}	Sulfates are soluble, except $BaSO_4$ and $PbSO_4$; Ag_2SO_4, $CaSO_4$, and Hg_2SO_4 are only slightly soluble.
Carbonate, CO_3^-; phosphate, PO_4^{3-}; silicate, SiO_4^{4-}	Carbonates, phosphates, and silicates are insoluble, except those of sodium, potassium, and ammonium.
Hydroxide, OH^-	Most hydroxides are insoluble. Exceptions include LiOH, NaOH, KOH, and NH_4OH (soluble); $Ba(OH)_2$ (moderately soluble); and $Ca(OH)_2$ and $Sr(OH)_2$ (slightly soluble).
Sulfide, S^{2-}	All sulfides are insoluble, with the exception of alkali metal sulfides (Na_2S, K_2S, etc.), $(NH_4)_2S$, MgS, CaS, and BaS.
Sodium, Na^+; potassium, K^+; ammonium, NH_4^+	All sodium, potassium, and ammonium compounds are soluble, with the exception of a few compounds that contain these ions along with a heavy metal (for example, K_2PtCl_6).

[a]Based on Dean, J. A., *Lange's Handbook of Chemistry*, 14th ed., McGraw-Hill, 1992.

Source: Table 1.2; Water Chemistry, Benjamin, 2002/ 2010

Solubility Constants of Solids of Interest

Table 8.7 The K_{s0} values of some solids of interest

Metal	Mineral Name	Formula	Log K_{s0}
Ag^+		$AgOH(s)$	−7.70
		$Ag_2CO_3(s)$	−11.07
		$Ag_3PO_4(s)$	−17.55
		$Ag_2S(s)$	−48.97
		$AgCl(s)$	−9.75
Al^{3+}		$Al(OH)_3(s)$	−31.62
	Gibbsite	$Al(OH)_3(s)$	−33.23
		$AlPO_4(s)$	−22.50
Ca^{2+}	Calcite	$CaCO_3(s)$	−8.48
	Aragonite	$CaCO_3(s)$	−8.36
	Portlandite	$Ca(OH)_2(s)$	−5.32
	Lime	$CaO(s)$	4.80
	Gypsum	$CaSO_4(s)$	−4.85
	Hydroxylapatite	$Ca_5(OH)(PO_4)_3(s)$	−44.2
Cu^+	Nantokite	$CuCl(s)$	−6.76
Fe^{2+}		$Fe(OH)_2(s)$	−15.90
	Siderite	$FeCO_3(s)$	−10.55
	Vivianite	$Fe_3(PO_4)_2(s)$	−36.00
		$FeS(s)$	−16.84
Fe^{3+}	Ferrihydrite	$Fe(OH)_3(s)$	−37.11
	Goethite	α-$FeOOH(s)$	−41.50
	Lepidocrocite	γ-$FeOOH(s)$	−46.00
	Hematite	α-$Fe_2O_3(s)$	−40.63
Hg^{2+}		$Hg(OH)_2(s)$	−25.40
		$HgO(s)$	−25.55
		$Hg(CN)_2(s)$	−39.28
		$HgCO_3(s)$	−22.52
	Cinnabar	$HgS(s)$	−52.01

In terms of OH^-

K_{s0} : $Fe(OH)_{3(s)} = Fe^{3+} + 3OH^-$

Source: Water Chemistry, Benjamin, 2002

Metal-Complexation Reactions with OH^-

Table 8.2 Stability constants for complexation of metals by OH^-

	i	Log K_i	Log $^*K_i$	Log β_i	Log $^*\beta_i$
Ag^+	1	2.00	−12.00	2.00	−12.00
	2	2.00	−12.00	4.00	−24.00
Al^{3+}	1	9.01	−4.99	9.01	−4.99
	2	8.89	−5.11	17.90	−10.10
	3	8.10	−5.90	26.00	−16.00
	4	7.00	−7.00	33.00	−23.00
Ca^{2+}	1	1.40	−12.60	1.40	−12.60
Cd^{2+}	1	3.92	−10.08	3.92	−10.08
	2	3.73	−10.27	7.65	−20.35
	3	1.05	−12.95	8.70	−33.30
	4	−0.05	−14.05	8.65	−47.35
Co^{2+}	1	4.80	−9.20	4.80	−9.20
	2	4.90	−9.10	9.70	−18.30
	3	1.10	−12.90	10.80	−31.20
Cr^{3+}	1	10.00	−4.00	10.00	−4.00
	2	8.38	−5.62	18.38	
	3	6.87	−7.13	25.25	
	4	2.98	−11.02	28.23	
Cu^{2+}	1	6.00	−8.00	6.00	
	2	8.32	−5.68	14.32	
	3	0.78	−13.22	15.10	
	4	1.30	−12.70	16.40	
Fe^{2+}	1	4.50	−9.50	4.50	
	2	2.93	−11.07	7.43	
	3	3.57	−10.43	11.00	
Fe^{3+}	1	11.81	−2.19	11.81	
	2	10.52	−3.48	22.33	
	3	6.07	−7.93	28.40	−13.60
	4	6.00	−8.00	34.40	−21.60

In terms of OH^-

K_i: $Fe^{3+} + OH^- = Fe(OH)^{2+}$

β_i: $Fe^{3+} + 2OH^- = Fe(OH)_2^+$

In terms of H^+

K_i^*: $Fe^{3+} + H_2O = Fe(OH)^{2+} + H^+$

β_i^*: $Fe^{3+} + 2H_2O = Fe(OH)_2^+ + H^+$

Listing all reactions and constants

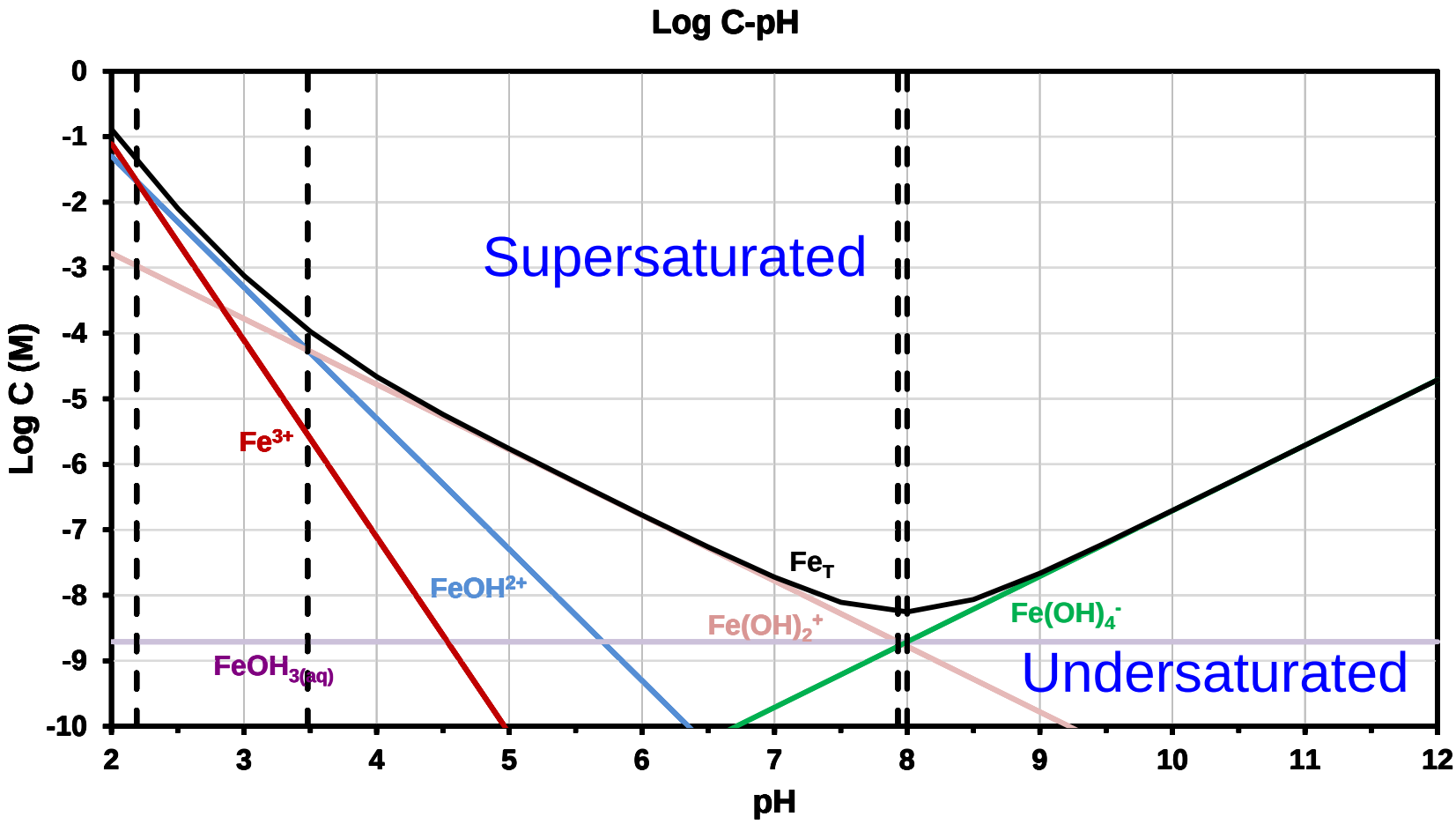
$pK_1^* = 2.19$: $Fe^{3+} + H_2O = Fe(OH)^{2+} + H^+$

$pK_2^* = 3.48$: $Fe(OH)^{2+} + H_2O = Fe(OH)_2^+ + H^+$

$pK_3^* = 7.93$: $Fe(OH)_2^+ + H_2O = Fe(OH)_{3(aq)} + H^+$

$pK_4^* = 8.00$: $Fe(OH)_{3(aq)} + H_2O = Fe(OH)_4^- + H^+$

Solubility Curve for $Fe(OH)_{3(s)}$



$$[Fe_{T,\,diss}] = [Fe^{3+}] + [Fe(OH)^{2+}] + [Fe(OH)_2^{+}] + [Fe(OH)_{3(aq)}] + [Fe(OH)_4^{-}]$$

Class problem

1a) Solid calcium fluoride ($CaF_{2(s)}$) is added to pure water so that at equilibrium some solid remains dissolved. Given that the solubility product is 3×10^{-11} $M^{3,}$ what is the equilibrium concentration of F^- in water?