

SOLUBILITIES OF ELECTROLYTES IN WATER
Chemistry BC 2001x

You need not memorize the less common exceptions, which are given in square brackets: [].

RULE	EXCEPTIONS
1. Salts of the alkali metals (Li^+ , Na^+ , K^+ , Rb^+ , Cs^+) and of the ammonium ion (NH_4^+) are generally <i>soluble</i> .	No common exceptions. [KClO_4 is only <i>slightly</i> soluble.]
2. Nitrate (NO_3^-), chlorate (ClO_3^-), perchlorate (ClO_4^-), and acetate (CH_3COO^- , or $\text{C}_2\text{H}_3\text{O}_2^-$, or OAc^-) salts are generally <i>soluble</i> .	No common exceptions. [KClO_4 is only <i>slightly</i> soluble.] [AgOAc is only <i>slightly</i> soluble.]
3. Chloride (Cl^-), bromide (Br^-), and iodide (I^-) salts are generally <i>soluble</i> .	Cu^+ (note: <i>not</i> Cu^{2+}), Ag^+ , Pb^{2+} , and Hg_2^{2+} (note: <i>not</i> Hg^{2+}) form insoluble Cl^- , Br^- , and I^- salts, except for <i>slightly</i> soluble PbCl_2 . HgI_2 is insoluble .
4. Sulfate (SO_4^{2-}) salts are generally <i>soluble</i> .	SrSO_4 , BaSO_4 , and PbSO_4 are insoluble . CaSO_4 , Ag_2SO_4 , and Hg_2SO_4 are <i>slightly</i> soluble.
5. Carbonate (CO_3^{2-}), phosphate (PO_4^{3-}), sulfite (SO_3^{2-}), and chromate (CrO_4^{2-}) salts are generally insoluble .	The alkali metal and ammonium salts of these anions are soluble (Rule 1). [Li_3PO_4 is only <i>slightly</i> soluble.]
6. Sulfide (S^{2-}) salts are generally insoluble .	The alkali metal sulfides M_2S and $(\text{NH}_4)_2\text{S}$ are soluble (Rule 1). [The alkaline earth metal sulfides MS , Cr_2S_3 , and Al_2S_3 are <i>decomposed</i> by reaction with H_2O .]
7. Hydroxide (OH^-) salts are generally insoluble .	The alkali metal hydroxides MOH are soluble (Rule 1). (Note: no substance NH_4OH exists.) Ca^{2+} , Sr^{2+} , and Ba^{2+} hydroxides are <i>slightly</i> soluble.

STRONG ELECTROLYTES AND WEAK ELECTROLYTES

All strong acids and strong bases are soluble strong electrolytes.

RULE	EXCEPTIONS
Most acids are weak electrolytes.	The only common strong acids are HCl, HBr, HI, HNO ₃ , HClO ₄ , and H ₂ SO ₄ . Note: H ₂ SO ₄ loses only <i>one</i> H ⁺ <i>completely</i> ; the resulting acidic anion, HSO ₄ ⁻ , dissociates only slightly.
Most bases are weak electrolytes.	Soluble hydroxides (e.g. NaOH, KOH) are strong bases. Note: Slightly soluble Ca(OH) ₂ , Sr(OH) ₂ , and Ba(OH) ₂
Most salts are strong electrolytes.	Weak electrolytes: HgCl ₂ , Hg(CN) ₂ . [There are several only moderately strong electrolytes; these include CdCl ₂ , CdBr ₂ , CdI ₂ , and Pb(OAc) ₂ .]

Important Note: Students often confuse the property of being soluble in water or insoluble in water with the property of being a strong electrolyte or a weak electrolyte. *There is simply no connection whatever between these two properties.* The rules and the exceptions regarding each of these properties must be learned independently.

- Substances said to be **soluble** in water, whether they are solids, liquids, or gases, will dissolve completely in water (up to a maximum concentration, which may be quite large; certain liquid substances are in fact miscible with water in all proportions).
Examples of soluble substances: NaCl; KNO₃; HCl; NH₃; CH₃COOH; CH₃OH.
 - Substances that are **soluble** in water may be **strong** electrolytes: *all* of the dissolved substance *dissociates entirely* into *ions*, and none of it exists as undissociated molecules dissolved in the solution. Examples: HCl; HNO₃; NaCl; KBr; Na₂SO₄; NaOH.
 - Substances that are **soluble** in water may be **weak** electrolytes: *most* of the dissolved substance exists as *undissociated molecules* in the solution, and only a small fraction is dissociated into ions. Examples: HF; HNO₂; CH₃COOH; NH₃; C₅H₅N.
 - Substances that are **soluble** in water may be **non-electrolytes**: *all* of the dissolved substance exists as *undissociated* molecules in solution, and no ions at all are formed. Examples: methanol, CH₃OH; acetone, CH₃COCH₃; glucose, C₆H₁₂O₆.
- Substances said to be **insoluble** in water actually do dissolve, but only to a very small extent (the maximum dissolved concentration may be extremely small). Examples: AgCl; Ni(OH)₂. What does dissolve, however little that is, may be a strong electrolyte, or may be a weak electrolyte, or may be a non-electrolyte.
 - Substances that are **insoluble** in water may be **strong** electrolytes: *all* of the dissolved substance, however little that is, *dissociates entirely* into *ions*, and none of it exists as undissociated molecules dissolved in the solution. Example: AgCl.
 - Substances that are **insoluble** in water may be **weak** electrolytes: *most* of the dissolved substance, however little that is, exists as *undissociated molecules* in solution, and only a small fraction is dissociated into ions. Example: C₈H₁₇COOH.
 - Substances that are **insoluble** in water may be **non-electrolytes**: *all* of the dissolved substance, however little that is, exists as *undissociated molecules* in solution, and no ions are formed at all. Examples: H₂; P₄; S₈; cholesterol, C₂₇H₄₆O.