

Chemistry Lecture #48: Soluble & Insoluble Ionic Compounds

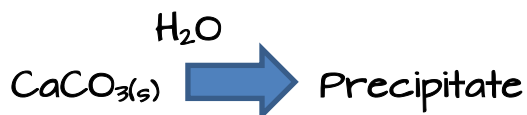
Soluble - More than three grams of the substance can dissolve in 100 mL of water.

Insoluble - Substance cannot dissolve in water.

NaCl is soluble in water. The reason it is soluble is because it breaks apart into positive and negative ions.



CaCO_3 , on the other hand, is insoluble. It will not break apart into Ca^{2+} and CO_3^{2-} when placed in water. It remains as a precipitate or a solid.



There are general guidelines we can follow that allow us to predict if an ionic compound is soluble or insoluble in water. The next page gives the solubility rules for commonly used ions.

Solubility Rules - General Trends for Commonly Used Ions

SOLUBLE IONS

(N)itrate NO_3^-

(A)cetate CH_3COO^- or
 $\text{C}_2\text{H}_3\text{O}^-$

(G)roup 1 (H^+ , Li^+ , Na^+ , K^+ ,
 Rb^+ , Cs^+ , Fr^+)

(S)ulfate SO_4^{2-}

(A)mmonium NH_4^+

(G)roup 17 Halogens (Cl^- , Br^- , I^-)

RULE EXCEPTIONS

Insoluble when combined with
Pb, (M)ercury, or (S)ilver [PMS]
& Ca, (Stro)ntium and Barium
[Castro Bear]

Insoluble when combined with
Pb, (M)ercury, or (S)ilver
[PMS]

The groups of soluble ions can be remembered by the word
"NAGSAG."

INSOLUBLE IONS

(F)luoride	F^-
(C)arbonate	CO_3^{2-}
(H)ydroxide	OH^-
(O)xide	O^{2-}
(S)ulfide	S^{2-}
(P)hosphate	PO_4^{3-}

All insoluble ions become soluble when combined with group 1 elements. E.g, $AlPO_4$ is insoluble, but Na_3PO_4 is soluble.

The insoluble ions can be remembered if you use the phrase, "(F)red's (C)ar (H)its (O)ld (S)ullivan's (P)orche."

These are *general* guidelines for predicting the solubility of ionic compounds. There are exceptions to the guidelines. For example, according to the guidelines, $AgC_2H_3O_2$ would be soluble. In reality, silver acetate is only partially soluble (1.02 g/100 mL of water).

Also, these guidelines are incomplete. They do not include ions such as chlorate (ClO_3^-), chromate (CrO_4^{2-}), and perchlorate (ClO_4^-).

Sometimes it is necessary to use a more detailed chart that contains more ions and shows the exceptions to the general guidelines. The following page shows such a chart.

Solubility Guidelines

A substance is considered soluble if more than three grams of the substance dissolves in 100 mL of water. The more common rules are listed below.

1. All common salts of the group 1A elements and ammonium ions are soluble.
2. All common acetates and nitrates are soluble.
3. All binary compounds of group 7A elements (other than F) with metals are soluble except those of silver, mercury(I), and lead.
4. All sulfates are soluble except those of barium, strontium, lead, calcium, silver, and mercury(I).
5. Except for those in Rule 1, carbonates, hydroxides, oxides, sulfides, and phosphates are insoluble.

Solubility of Compounds in Water

	Acetate	Bromide	Carbonate	Chlorate	Chloride	Chromate	Hydroxide	Iodide	Nitrate	Oxide	Perchlorate	Phosphate	Sulfate	Sulfide
Aluminum	S	S	—	S	S	—	I	S	S	I	S	I	S	D
Ammonium	S	S	S	S	S	S	S	S	S	—	S	S	S	S
Barium	S	S	P	S	S	I	S	S	S	S	S	I	I	D
Calcium	S	S	P	S	S	S	S	S	S	P	S	P	P	P
Copper (II)	S	S	—	S	S	—	I	—	S	I	S	I	S	I
Hydrogen	S	S	—	S	S	—	—	S	S	S	S	S	S	S
Iron(II)	—	S	P	S	S	—	I	S	S	I	S	I	S	I
Iron(III)	—	S	—	S	S	I	I	S	S	I	S	P	P	D
Lead(II)	S	S	—	S	S	I	P	P	S	P	S	I	P	I
Lithium	S	S	S	S	S	?	S	S	S	S	S	P	S	S
Magnesium	S	S	P	S	S	S	I	S	S	I	S	P	S	D
Manganese(II)	S	S	P	S	S	—	I	S	S	I	S	P	S	I
Mercury(I)	P	I	I	S	I	P	—	I	S	I	S	I	P	I
Mercury(II)	S	S	—	S	S	P	I	P	S	P	S	I	D	I
Potassium	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Silver	P	I	I	S	I	P	—	I	S	P	S	I	P	I
Sodium	S	S	S	S	S	S	S	S	S	D	S	S	S	S
Strontium	S	S	P	S	S	P	S	S	S	S	S	I	P	S
Tin(II)	D	S	—	S	S	I	—	S	D	I	S	I	S	I
Tin(IV)	S	S	—	—	S	S	I	D	—	I	S	—	S	I
Zinc	S	S	P	S	S	P	P	S	S	P	S	I	S	I

S – soluble

P – partially soluble

I – insoluble

D – decomposes

Predict if the following compounds are soluble or insoluble using the general guidelines for solubility.

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|------------------------------|-----------------------------|
| 1. AgNO_3 | 7. Hg_2Cl_2 |
| 2. NaCH_3COO | 8. Cs_2CO_3 |
| 3. NH_4Cl | 9. BaCO_3 |
| 4. NH_4OH | 10. AgBr |
| 5. PbSO_4 | 11. CaBr_2 |
| 6. H_2SO_4 | |

Answers

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|--------------|---------------|
| 1. soluble | 7. Insoluble |
| 2. soluble | 8. soluble |
| 3. soluble | 9. insoluble |
| 4. soluble | 10. insoluble |
| 5. insoluble | 11. soluble |
| 6. soluble | |