How to Remember the Solubility Rules

AP Chemistry · 28 cards

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Rules

Which salts must you know as soluble for the AP Chemistry exam?

All sodium, potassium, ammonium and nitrate salts are soluble in water. The AP exam does not assess other solubility rules by rote.

Many classes still teach the full list below.

Which cations always form soluble salts?

Group 1 ions (Li^+, Na^+, K^+, Rb^+, Cs^+) and ammonium, NH_4^+.

LiOH and $(NH_4)_2SO_4$ are both soluble.

Which anions always form soluble salts?

Nitrate NO_3^-, and also acetate, chlorate and perchlorate.

$Mg(NO_3)_2$ and $Ca(CH_3COO)_2$ are soluble.

Which chlorides, bromides and iodides are not soluble?

Those of Ag^+, Pb^{2+} and Hg_2^{2+}. All other halides (Cl^-, Br^-, I^-) are soluble.

$CaCl_2$ dissolves, PbI_2 does not.

Which sulfates are not soluble?

Those of Ba^{2+}, Pb^{2+} and Ca^{2+}; many lists add Sr^{2+}, Ag^+ and Hg_2^{2+}. Most other sulfates are soluble.

$CuSO_4$ dissolves, $BaSO_4$ does not.

Are carbonates and phosphates soluble?

Mostly insoluble, except with Group 1 ions and NH_4^+.

$CaCO_3$ is insoluble, $(NH_4)_3PO_4$ is soluble.

Are hydroxides soluble?

Mostly insoluble, except Group 1 and NH_4^+ hydroxides, plus $Ba(OH)_2$ and $Sr(OH)_2$. $Ca(OH)_2$ is only slightly soluble.

$Fe(OH)_3$ is insoluble, $Ba(OH)_2$ is soluble.

Are sulfides soluble?

Mostly insoluble, except with Group 1 ions and NH_4^+. Group 2 sulfides are listed as soluble or slightly soluble depending on the source.

CuS is insoluble, Na_2S is soluble.

What if a salt matches two rules that disagree?

The Group 1, ammonium and nitrate rules win: they have no exceptions.

K_3PO_4 is soluble even though phosphates are mostly insoluble.

Exercises

Write your answer on the line. The answers are at the end.

1. Soluble or insoluble in water?
$NaCH_3COO$

2. Soluble or insoluble in water?
$Pb(NO_3)_2$

3. Soluble or insoluble in water?
NH_4Cl

4. Soluble or insoluble in water?
$AgNO_3$

5. Soluble or insoluble in water?
AgCl

6. Soluble or insoluble in water?
$FeCl_2$

7. Soluble or insoluble in water?
Hg_2Cl_2

8. Soluble or insoluble in water?
$ZnSO_4$

9. Soluble or insoluble in water?
$PbSO_4$

10. Soluble or insoluble in water?
Na_2CO_3

11. Soluble or insoluble in water?
$MgCO_3$

12. Soluble or insoluble in water?
$Ca_3(PO_4)_2$

13. Soluble or insoluble in water?
$Mg(OH)_2$

14. Soluble or insoluble in water?
KOH

15. Soluble or insoluble in water?
ZnS

16. Which solid forms when $AgNO_3$(aq) and NaCl(aq) are mixed?

17. Which solid forms when K_2CO_3(aq) and $Ba(NO_3)_2$(aq) are mixed?

18. Which solid forms when KOH(aq) and $MgCl_2$(aq) are mixed?

19. Does a precipitate form when KNO_3(aq) and NaCl(aq) are mixed?

Answer key

1. Soluble.

It has a sodium cation and an acetate anion, and either one is enough.

2. Soluble.

Nitrates have no exceptions, even with Pb^{2+}.

3. Soluble.

Ammonium salts are soluble whatever the anion.

4. Soluble.

It is a nitrate, so the Ag^{+} cation does not matter here.

5. Insoluble.

Chloride is an exception with Ag^{+}: AgCl is a white precipitate.

6. Soluble.

Chlorides are soluble, and Fe^{2+} is not among the halide exceptions.

7. Insoluble.

Hg_2^{2+} is the third halide exception, after Ag^{+} and Pb^{2+}.

8. Soluble.

Zn^{2+} is not one of the sulfate exceptions (Ba^{2+}, Pb^{2+}, Ca^{2+} and, on longer lists, Sr^{2+}, Ag^{+}, Hg_2^{2+}).

9. Insoluble.

Pb^{2+} makes both its halides and its sulfate insoluble.

10. Soluble.

The sodium rule overrides the mostly insoluble carbonates.

11. Insoluble.

Carbonate with a Group 2 cation is not covered by the soluble exceptions.

12. Insoluble.

Phosphates dissolve only with Group 1 ions or NH_4^{+}, and Ca^{2+} is neither.

13. Insoluble.

Only $Ba(OH)_2$ and $Sr(OH)_2$ are soluble among the Group 2 hydroxides, besides slightly soluble $Ca(OH)_2$.

14. Soluble.

Hydroxides of Group 1 are soluble: this is why KOH is a common strong base solution.

15. Insoluble.

Sulfides dissolve only with Group 1 ions or NH_4^+ (and Group 2, depending on the list).

16. AgCl(s).

The two possible products are AgCl and $NaNO_3$; the sodium nitrate stays dissolved and the silver chloride precipitates.

17. $BaCO_3$(s).

KNO_3 is soluble, but carbonates dissolve only with Group 1 ions or NH_4^+, so barium carbonate precipitates.

18. $Mg(OH)_2$(s).

KCl is soluble, and magnesium hydroxide is not.

19. No.

The possible products, KCl and $NaNO_3$, are both soluble, so every ion stays in solution.