Solubility Guidelines & Precipitate Reactions

Mr. Sudbury

Solubility

- Recall that solubility is the amount of a substance needed to form a saturated solution of solute dissolved in solvent.
- Solubility, in general, also means: **"can something dissolve?"**
- A soluble compound CAN dissolve.
- An insoluble compound CAN NOT dissolve.

Solubility Rules

1. All compounds of Group IA elements (the alkali metals) are soluble.
2. All ammonium salts (salts of NH_4^+) are soluble.
3. All nitrate (NO_3^-), chlorate (ClO_3^-), perchlorate (ClO_4^-), and acetate (CH_3COO^- or $C_2H_3O_2^-$) salts are soluble.
4. All chloride (Cl^-), bromide (Br^-), and iodide (I^-) salts are soluble except for those of Ag^+, Pb^{2+}, and Hg_2^{2+}.
5. All sulfate (SO_4^{2-}) compounds are soluble except those of Ba^{2+}, Sr^{2+}, Ca^{2+}, Pb^{2+}, Hg_2^{2+}, and Hg^{2+}, Ca^{2+} and Ag^+ sulfates are only moderately soluble.
6. All hydroxide (OH^-) compounds are insoluble except those of Group I–A (alkali metals) and Ba^{2+}, Ca^{2+}, and Sr^{2+}.
7. All sulfide (S^{2-}) compounds are insoluble except those of Groups I–A and II–A (alkali metals and alkali earths).
8. All sulfites (SO_3^{2-}), carbonates (CO_3^{2-}), chromates (CrO_4^{2-}), and phosphates (PO_4^{3-}) are insoluble except for those of NH_4^+ and Group I–A (alkali metals)(see rules 1 and 2).

Solubility Rules

Soluble?

1. NaCl
2. $AlPO_4$
3. $Mg(OH)_2$
4. $Ca(NO_3)_2$

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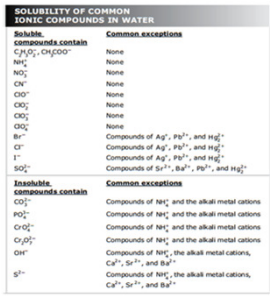
Solubility Hints – EOC Chart

- The EOC formula chart will also tell you soluble and insoluble compounds with the exceptions.



SOLUBILITY OF COMMON IONIC COMPOUNDS IN WATER

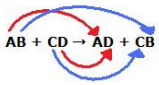
Soluble compounds contain	Common exceptions
$C_2H_3O_2^-$, CH_3COO^-	None
NH_4^+	None
NO_3^-	None
CN^-	None
ClO^-	None
ClO_3^-	None
ClO_4^-	None
Br^-	Compounds of Ag^+, Pb^{2+}, and Hg_2^{2+}
Cl^-	Compounds of Ag^+, Pb^{2+}, and Hg_2^{2+}
I^-	Compounds of Ag^+, Pb^{2+}, and Hg_2^{2+}
SO_4^{2-}	Compounds of Sr^{2+}, Ba^{2+}, Pb^{2+}, and Hg_2^{2+}

Insoluble compounds contain	Common exceptions
CO_3^{2-}	Compounds of NH_4^+ and the alkali metal cations
PO_4^{3-}	Compounds of NH_4^+ and the alkali metal cations
CrO_4^{2-}	Compounds of NH_4^+ and the alkali metal cations
$Cr_2O_7^{2-}$	Compounds of NH_4^+ and the alkali metal cations
OH^-	Compounds of NH_4^+, the alkali metal cations, Ca^{2+}, Sr^{2+}, and Ba^{2+}
S^{2-}	Compounds of NH_4^+, the alkali metal cations, Ca^{2+}, Sr^{2+}, and Ba^{2+}

Why know solubility rules?

- Solubility rules help us know when a precipitate will form in a chemical reaction.
- Precipitation Reactions occur when cations (+) and anions (–) of aqueous solutions combine to form an insoluble ionic solid, called a **precipitate**.
- Whether or not such a reaction occurs can be determined by using the **solubility rules** for common ionic solids.
- Since not all aqueous reactions form precipitates, one must consult the solubility rules before determining the state of the products and writing a **net ionic equation.** Being able to predict these reactions allows scientists to calculate what ions are present in a solution, and allows industries to form chemicals by extracting certain elements from these reactions.

Double-Replacement Rxn



$CdSO_{4(aq)} + K_2S_{(aq)} \rightarrow CdS_{(s)} + K_2SO_{4(aq)}$

- Rule 7: All sulfide (S^{2-}) compounds are insoluble except those of Groups I-A and II-A (alkali metals and alkali earths).
- Rule 5: All sulfate (SO_4^{2-}) compounds are soluble except those of Ba^{2+}, Sr^{2+}, Ca^{2+}, Pb^{2+}, Hg_2^{2+}, and Hg^{2+}, Ca^{2+} and Ag^{+} sulfates are only moderately soluble.

Double-Replacement Rxn

- $2NaOH_{(aq)} + MgCl_{2(aq)} \rightarrow 2NaCl_{(aq)} + Mg(OH)_{2(s)}$
- **Rule 1.** All compounds of Group IA elements (the alkali metals) are soluble.
- **Rule 6.** All hydroxide (OH^{-}) compounds are insoluble except those of Group I-A (alkali metals) and Ba^{2+}, Ca^{2+}, and Sr^{2+}.

Double-Replacement Rxn

- $2KI_{(aq)} + Pb(NO_3)_{2(aq)} \rightarrow 2KNO_{3(aq)} + PbI_{(s)}$
- Rule 3: All nitrate (NO_3^{-}), chlorate (ClO_3^{-}), perchlorate (ClO_4^{-}), and acetate (CH_3COO^{-} or $C_2H_3O_2^{-}$) salts are soluble.
- Rule 4: All chloride (Cl^{-}), bromide (Br^{-}), and iodide (I^{-}) salts are soluble except for those of Ag^{+}, Pb^{2+}, and Hg_2^{2+}.

Net Ionic Equation

- For the reaction of: $BaCl_2$ with a solution of Na_2SO_4 to form the insoluble solid $BaSO_4$ and $NaCl_{(aq)}$we would write:
- $2Na^{1+}_{(aq)} + SO_4^{2-}{}_{(aq)} + Ba^{2+}_{(aq)} + 2Cl^{1-}_{(aq)} \rightarrow 2Na^{1+}_{(aq)} + 2Cl^{1-}_{(aq)} + BaSO_{4(s)}$
- $2Na^{1+}_{(aq)} + SO_4^{2-}{}_{(aq)} + Ba^{2+}_{(aq)} + 2Cl^{1-}_{(aq)} \rightarrow 2Na^{1+}_{(aq)} + 2Cl^{1-}_{(aq)} + BaSO_{4(s)}$
- Spectator Ions are ions present in the same form on both sides of the reaction, not change happens to them.
- The Net Ionic Equation is: $SO_4^{2-}{}_{(aq)} + Ba^{2+}_{(aq)} \rightarrow BaSO_{4(s)}$

The End - Pause

- Precipitate Reactions for an insoluble (s) compound and an soluble (aq) compound.
- Look at solubility rules and exceptions to predict (s) or (aq).

Neutralization Reactions

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Neutralization Reactions

- A neutralization reaction occurs when an acid and a base react to form a salt and water.
- A **salt** is any compound which can be derived from the neutralization of an acid and a base.
- The word "neutralization" is used because the acid and base properties of H^+ and OH^- are destroyed or neutralized.
- In the reaction, H^+ and OH^- combine to form HOH (or H_2O) (AKA: water molecules.)
- A neutralization is a type of *double replacement reaction*. A salt is the product of an acid–base reaction and is a much broader term then common table salt.

Neutralization Reactions

- Acid + Base → Salt + Water
- $HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + HOH_{(l)}$
- $H_2SO_{4(aq)} + 2NH_4OH_{(aq)} \rightarrow (NH_4)_2SO_{4(aq)} + 2HOH_{(l)}$

The End

- Neutralization between an acid and a base produces a salt and water.