Qualitative Solubility Rules

These rules are based on experimental observation. They are to be used as a guideline to determine water-solubility of a compound, or in predicting the result of a precipitation reaction. When asked a question such as "Is compound X *expected* to be soluble?" use these rules. These are neither complete nor absolute in determining whether a compound is soluble.

Note: Any contradiction in rules is resolved by a rule that is higher on the list.

Generally Soluble Compounds	**Exceptions**
Salts of alkali metals, NH_4^+	No exceptions
Salts of ClO_4^-, ClO_3^-	No exceptions
Salts of $C_2H_3O_2^-$	Slightly soluble: $AgC_2H_3O_2$
Salts of halides	Insoluble when paired with Ag^+, Hg_2^{2+}, Pb^{2+} Insoluble: $HgBr_2$, HgI_2
Salts of SO_4^{2-}	Insol with Ba^{2+}, Ca^{2+}, Pb^{2+}, Ag^{2+}
Nitrates, nitrites	$AgNO_2$

Generally Insoluble Compounds	**Exceptions**
Salts of sulfides	Soluble paired with Mg^{2+}, Ca^{2+}
Hydroxides	Soluble $Ba(OH)_2$ Slightly soluble: $Ca(OH)_2$, $Sr(OH)_2$
Salts of CO_3^{2-}, PO_4^{3-}, CrO_4^{2-}, AsO_4^{3-}	None

Example 1: $(NH_4)_2S$ Ammonium is listed as soluble, while sulfides are insoluble. Since "*salts of NH_4^+ are soluble*" is higher on the list, then ammonium sulfide is soluble.

Example 2: $(NH_4)_3PO_4$ This is soluble as it contains an ammonium catium (Soluble: no exceptions)

Predict the solubility of each:

$Ca(C_2H_3O_2)_2$ ____________________

$AgNO_2$ ____________________

$(NH_4)_2CO_3$ ____________________

Fe_2S_3 ____________________

RbOH ____________________

$Al(OH)_3$ ____________________

Rules For Assigning Oxidation States

Note: Any contradiction in rules is resolved by a rule that is higher on the list.

Oxidation State is assigned per atom.

If the species is an ionic compound and doesn't show a charge, it is frequently useful and sometimes necessary to use the charge of one ion to predict the charge of the other ion and then if needed, apply the rules below to each ion separately.

1. The oxidation state of any atom in a free (uncombined) element is 0. This includes diatomic elements.

2. The total of the oxidation states of all the atoms in a neutral molecule or formula unit is 0. For an ion, this total is equal to the charge on the ion, both in magnitude and sign.

3. Monovalent metal cations will have an oxidation state equal to their normal charge, i.e., alkali metals (group IA) are +1, alkaline earth metals (IIA) are +2, aluminum is +3, silver is +1, zinc is +2, etc.

4. In its compounds the oxidation state of hydrogen is +1; that of fluorine is -1.

5. In its compounds oxygen has an oxidation state of -2.

6. In their binary compounds with metals, the elements of group VIIA have an oxidation state of -1; those of group VIA, -2; and those of group VA, -3.

Example 1: H_2O Apply Rule 4, so **H=+1**.
Apply Rule 2, so **O=-2** since $2\times(+1) + (-2) = 0$

Example 2: H_2O_2 Apply Rule 4, so **H=+1**
Apply Rule 2, so **O=-1** since $2\times(+1) + 2\times(-1) = 0$

Example 3: NaH First Apply Rule 3 since it is higher than Rule 4, so **Na=+1**
Rule 2 contradicts Rule 3, so apply Rule 2, so **H=-1** since $+1 + (-1) = 0$

Example 4: NH_4Br This is ionic with multiple atoms, so we separate into ions: $NH_4^+ + Br^-$
NH_4^+ Apply Rule 4, **H=+1**
Apply Rule 2, so **N=-3** since $4\times(+1) + -3 = +1$
Br^- Apply Rule 2, so **Br=-1**

Example 5: $KMnO_4$ This is ionic with multiple atoms, so separate into ions: $K^+ + MnO_4^-$
Na^+ Apply Rule 3 so **K=+1**
MnO_4^- Apply Rule 5, so **O=-2**
Apply Rule 2, so **Mn=+7** since $(+7) + 4\times(-2) = -1$

Nitrogen can have many oxidation states, depending on what species it forms. Determine the oxidation state of nitrogen in each species:

NO_2	N_2O	N_2H_4	NO	HNO_3	N_2