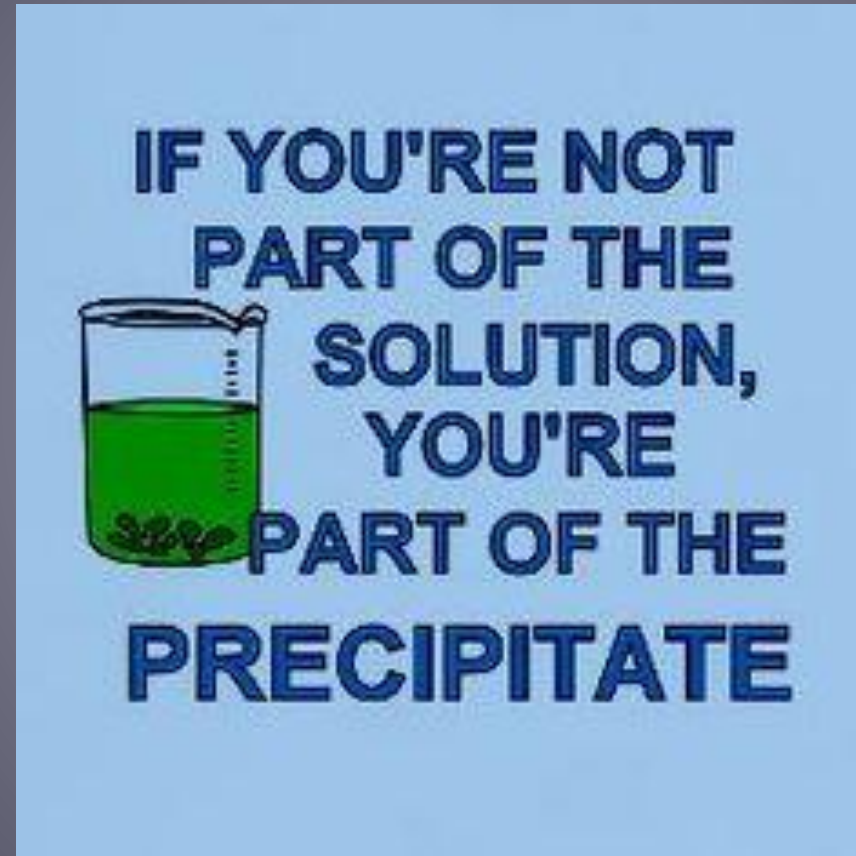# Solubility and Precipitation

Outcomes:

1-01 Explain observed examples of solubility and precipitation at the molecular and symbolic levels.

1-02 Use a table of solubility rules to predict the formation of a precipitate.

Solubility

Is the ability and the extent that a substance will dissolve...

- Some compounds are highly **SOLUBLE**, others are **INSOLUBLE**.
- The solubility of **DIFFERENT COMPOUNDS** is determined **EXPERIMENTALLY**
  → *Solubility Table*

Precipitation

When two solutions are mixed together, a **PRECIPITATE** may be formed when ions **JOIN** together to make an **INSOLUBLE** compound.

Precipitation Reactions

Ex) Reaction of silver nitrate and sodium chloride produces a white precipitate:

$$AgNO_{3(aq)} + NaCl_{(aq)} \rightarrow AgCl_{(??) \, (s)} + NaNO_{3(??) \, (aq)}$$

One of the compounds formed may be **INSOLUBLE**, but which one?

(See solubility chart)

- NO_3^- is completely **SOLUBLE** with all **CATIONS** and
- Na^+ is completely **SOLUBLE** with all **ANIONS**

→ Therefore, $NaNO_3$ **CANNOT** be the **PPT** since they are completely **SOLUBLE** with each other.

The **PPT** must be from the **Ag⁺** and **Cl⁻** ions. If we look at the table, we see that they form an insoluble compound.

→ Therefore **AgCl** is the ppt., and the Na^+ and NO_3^- ions remain in solution as **SPECTATOR IONS.**
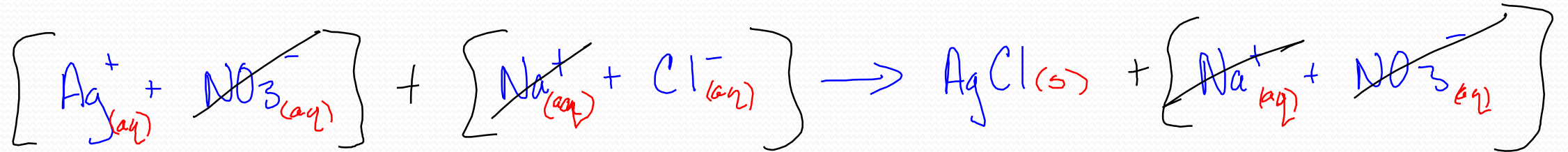
Precipitation Reactions

Using the example above, we can write a variety of reaction equations to explain what is happening at the molecular level...
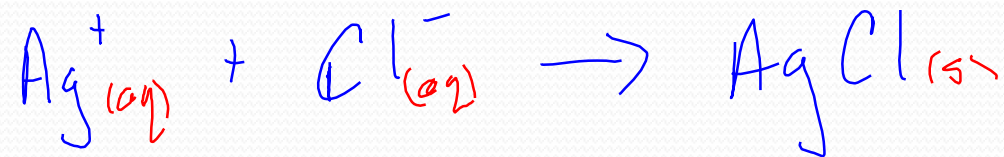
Molecular Equation: (normal equation**)**

$$AgNO_{3 (aq)} + NaCl_{(aq)} \longrightarrow AgCl_{(s)} + NaNO_{3 (aq)}$$

PPT

Total Ionic: (All ionic compounds are **DISSOCIATED)**

$$\left[Ag^+_{(aq)} + \cancel{NO_3^-}_{(aq)} \right] + \left[\cancel{Na^+}_{(aq)} + Cl^-_{(aq)} \right] \longrightarrow AgCl_{(s)} + \left[\cancel{Na^+}_{(aq)} + \cancel{NO_3^-}_{(aq)} \right]$$

Net Ionic: (what's left if we cancel the ions that exist on both sides)
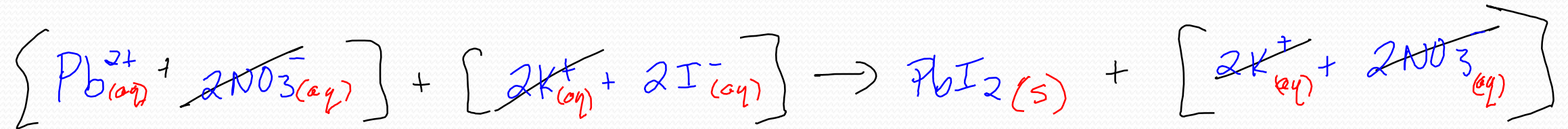
$$Ag^+_{(aq)} + Cl^-_{(aq)} \longrightarrow AgCl_{(s)}$$

Precipitation Reactions (Example 2)

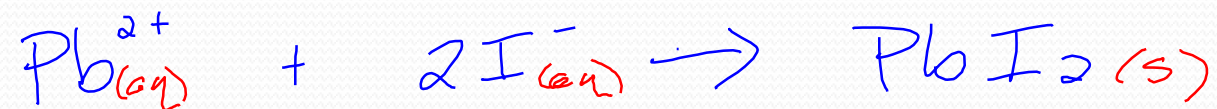Write the molecular, ionic and net-ionic equations for the reaction between $Pb(NO_3)_{2(aq)}$ and KI

Molecular Equation: (normal equation)

$$Pb(NO_3)_{2\,(aq)} + 2KI_{(aq)} \longrightarrow PbI_{2(s)} + 2KNO_{3\,(aq)}$$

Total Ionic: (All ionic compounds are **DISSOCIATED**)

$$\left\{ Pb^{2+}_{(aq)} + \cancel{2NO_3^-_{(aq)}} \right\} + \left\{ \cancel{2K^+_{(aq)}} + 2I^-_{(aq)} \right\} \longrightarrow PbI_{2\,(s)} + \left\{ \cancel{2K^+_{(aq)}} + \cancel{2NO_3^-_{(aq)}} \right\}$$

Net Ionic: (what's left if we cancel the ions that exist on both sides)

$$Pb^{2+}_{(aq)} + 2I^-_{(aq)} \longrightarrow PbI_{2\,(s)}$$

Here is this reaction seen at the molecular level...

Precipitation Reactions

Try this one…

Write the complete set of equations (molecular, ionic and net-ionic) showing the reaction between silver nitrate and sodium phosphate.

$$3AgNO_{3(aq)} + Na_3PO_{4(aq)} \rightarrow 3NaNO_{3(aq)} + Ag_3PO_4 \, (s)$$

$$[3Ag^+_{(aq)} + 3NO_3^-_{(aq)}] + [3Na^+_{(aq)} + PO_4^{3-}_{(aq)}] \rightarrow [3Na^+_{(aq)} + 3NO_3^-_{(aq)}] + Ag_3PO_{4\,(s)}$$

$$3Ag^+_{(aq)} + PO_4^{3-}_{(aq)} \rightarrow Ag_3PO_4 \, (s)$$