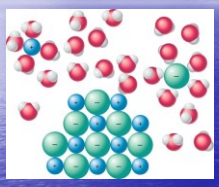
- Solubility usually increases with temperature
- **Supersaturated solutions** contain more solute than required for saturation at a given temperature
- They can be formed, for example, by careful cooling of saturated solutions
- Supersaturated solutions are unstable and often result in the formation of a **precipitate**

1

- A precipitate is the solid substance that separates from solution
- Precipitates can also form from reactions
- Reactions that produce a precipitate are called **precipitation reactions**
- Many ionic compounds dissolve in water
- Solutes that produce ions in solution are called **electrolytes** because their solutions can conduct electricity

2

- An ionic compounds **dissociates** as it dissolves in water



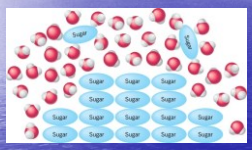
Ions separate from the solid and become **hydrated** or surrounded by water molecules.

The ions move freely and the solution is able to conduct electricity.

Ionic compounds that dissolve completely are **strong electrolytes**

3

- Most solutions of molecular compounds do not conduct electricity and are called **nonelectrolytes**



The molecules of a nonelectrolyte separate but stay intact. The solution is nonconducting because no ions are generated.

Some ionic compounds have low solubilities in water but are still strong electrolytes because what does dissolve is 100% dissociated.

4

- The dissociation of ionic compounds may be described with chemical equations

$$Na_2SO_4(s) \rightarrow 2\,Na^+(aq) + SO_4^{2-}(aq)$$

- The hydrated ions, with the symbol (*aq*), have been written separately
- Since physical states are often omitted, you might encounter the equation as:

$$Na_2SO_4 \rightarrow 2\,Na^+ + SO_4^{2-}$$

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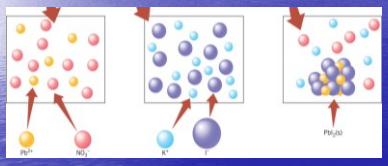
- Ionic compounds often react when their aqueous solutions combine



When a solution of $Pb(NO_3)_2$ is mixed with a solution of KI the yellow precipitate PbI_2 rapidly forms.

6

- This reaction may be represented with a **molecular**, **ionic**, or **net ionic equation**: $Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$

Molecular:

Ionic: $Pb^{2+}(aq) + 2NO_3^-(aq) + 2K^+(aq) + 2I^-(aq) \rightarrow PbI2(s) + 2K^+(aq) + 2NO_3^-(aq)$

Net Ionic: $Pb^{2+}(aq) + 2I^-(aq) \rightarrow PbI_2(s)$

- The most compact notation is the net ionic equation which eliminates all the non-reacting **spectator ions** from the equation

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- Criteria for balanced ionic and net ionic equations:
  1) Material balance – the same number of each type of atom on each side of the arrow
  2) Electrical balance – the *net* electrical charge on the left side of the arrow must equal the *net* electrical charge on the right side of the arrow

Remember that the charge on an ion must be included when it is not in a compound. Adding the charges on all the ions on one side of the arrow gives the net electrical charge.

8

- In the reaction of $Pb(NO_3)_2$ with KI the cations and anions changed partners
- This is an example of a **metathesis** or double **replacement reaction**
- **Solubility rules** allows the prediction of when a precipitation reaction will occur
- For many ionic compounds the solubility rules correctly predict whether the ionic compound is soluble or insoluble

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- Solubility rules for ionic compounds in water:
  - Soluble Compounds

1) All compounds of the alkali metals (Group IA) are soluble.
2) All salts containing NH_4^+, NO_3^-, ClO_4^-, ClO_3^-, and $C_2H_3O_2^-$ are soluble.
3) All salts containing Cl^-, Br^-, or I^- are soluble *except* when combined with Ag^+, Pb^{2+}, and Hg_2^{2+}.
4) All sulfates are soluble *except* those of Pb^{2+}, Ca^{2+}, Sr^{2+}, Hg_2^{2+}, and Ba^{2+}.

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- Insoluble compounds

5) All metal hydroxides and oxides are insoluble *except* those of Group IA and of Ca^{2+}, Sr^{2+}, and Ba^{2+}. When metal oxides do dissolve, they react with water to form hydroxides. The oxide ion, O^{2-}, does not exist in water.
6) All salts that contain PO_4^{3-}, CO_3^{2-}, SO_3^{2-}, and S^{2-} are insoluble, *except* those of Group IA and NH_4^+.

- A knowledge of these rules will allow you to predict a large number of precipitation reactions

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