Solubility

SCH 3U

Learning Goals

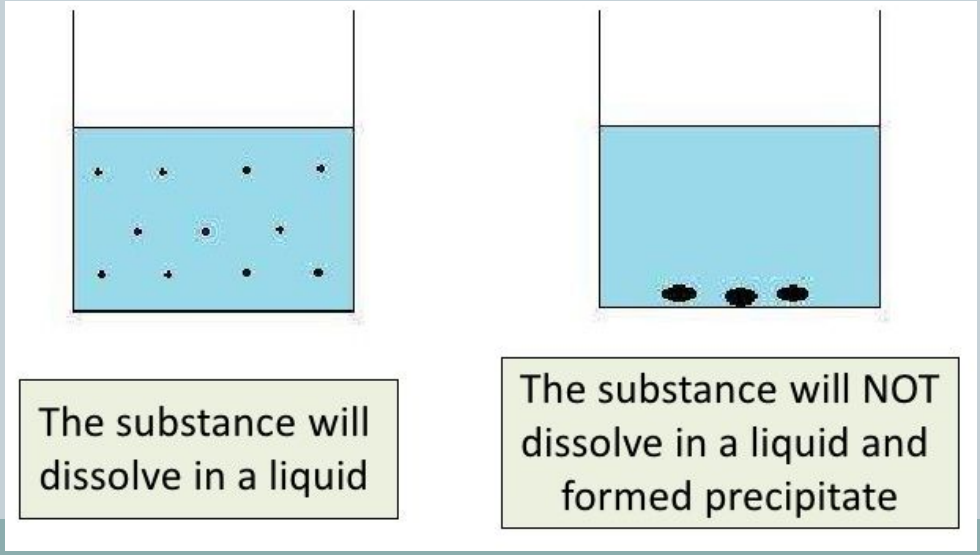
By the end of this lesson students will be able to:

- Explain the effects of changes in temperature and pressure on the solubility
- Explain the process of formation for solutions
- Write balanced net ionic equations to represent precipitation and neutralization reactions

Solubility

Solubility- the amount that dissolves in a given quantity of a solvent at a given temperature to produce a saturated solution

In other words: the solubility is how much will dissolve



Factors that Affect Rate of Dissolving

1. Temperature
   a. higher temp. = higher kinetic energy
   b. increase in collisions = increase in rate of dissolving

2. Agitation/ Mixing
   a. Agitation brings fresh solvent into contact with undissolved solute

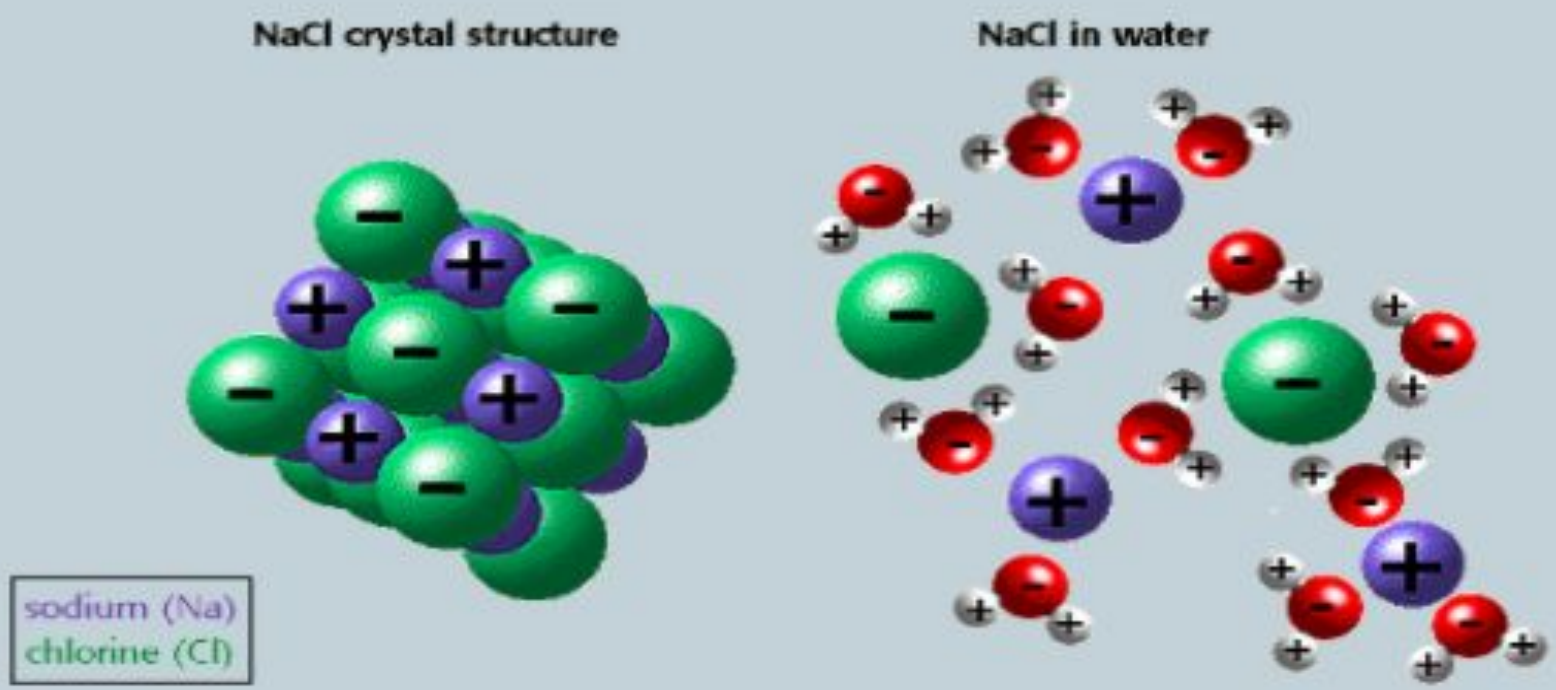
3. Surface area
   a. Increasing S.A = increases the rate of solubility
   b. For solids, a larger number of molecules come in contact with the solvent.

Light Bulb Demo

Add NaCl to water… What is occurring?

Dissolving Ionic Compounds

- For the light bulb to light up the solution had to conduct electricity
  - Proof that ions (Na+ and Cl-) are released when sodium chloride dissolves in water
- In order for NaCl to dissolve, the ionic bonds within the the sodium crystal must be broken
- Recall: Ionic bonds are so strong not even a bunsen burner flame can melt NaCl… Yet NaCl readily dissolves in water…**Why?**



Water is highly polar, so as the water molecules approach the NaCl crystal they reorient themselves

- Negative oxygen is attracted to the nearby positively charged sodium
- Positive hydrogen is attracted to nearby negative chlorine

What is Occurring?

- Dissociation- the separation of individual ions from an ionic compound as it dissolves in water

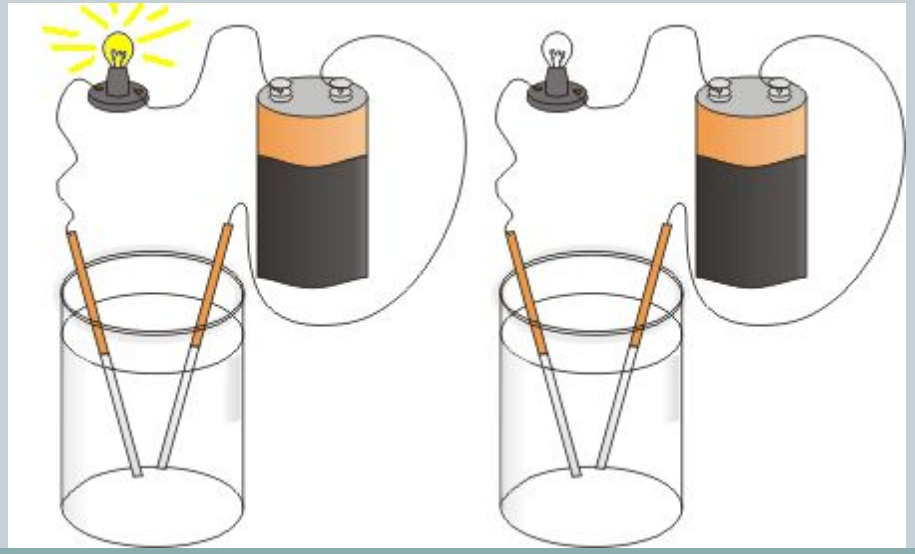
- Hydration- Process in which ions are surrounded by water molecules; this helps stabilize the ions

$$NaCl(s) \rightarrow Na^{+}(aq) + Cl^{-}(aq)$$

Properties of Aqueous Solutions

- Electrolytes- are solutes that form solutions that conduct electricity.
- Non-electrolytes- are solutes that form solutions that do not conduct electricity.

Electrolyte

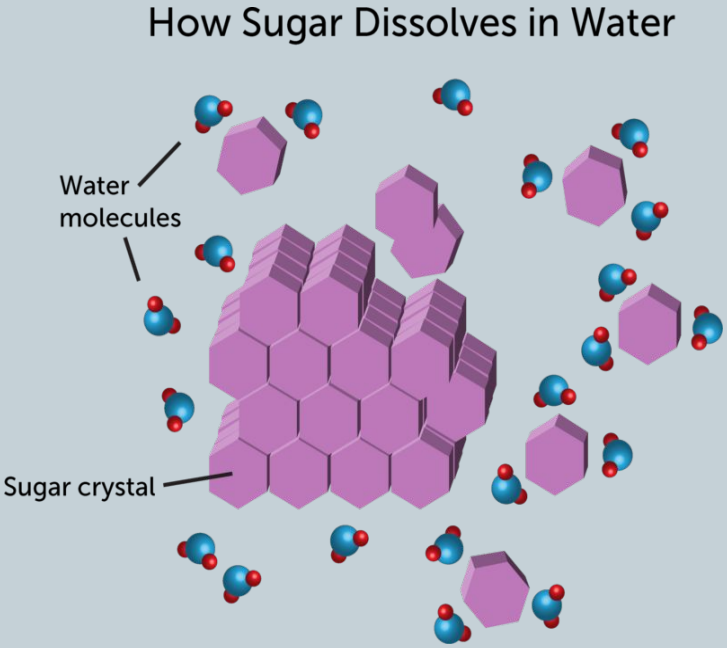


Non-Electrolyte

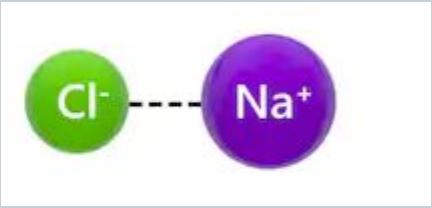
Dissolving Molecular Compounds

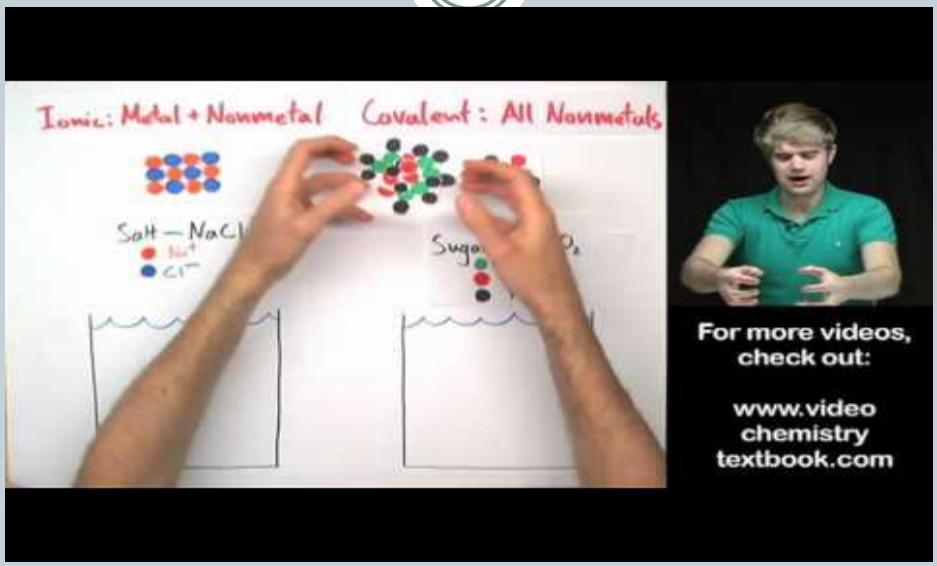
- Molecular compounds vary in the degree in which they dissolve in water

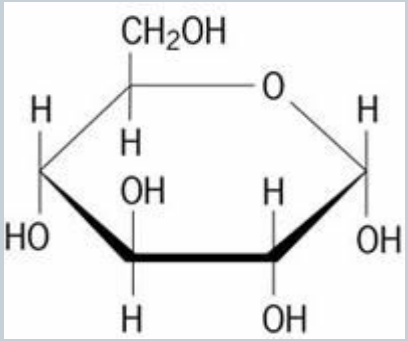
- Molecular solids are made up of covalently bonded atoms or molecules held together by London dispersion forces, dipole-dipole forces, or hydrogen bonds
  - ex. Glucose $C_6H_{12}O_6$



Dissolving Compounds







- In ionic compounds forces between ions are broken
- In molecular compounds forces between molecules are broken

Solubility Rules

Why is a substance more soluble in one solvent than another?

"Like Dissolves in Like"

a. Polar compounds will dissolve in polar solvents
b. Non-polar compounds will dissolve in non-polar solvents

Ions That Form *Soluble* Compounds	Exceptions
Group 1 ions (Li^+, Na^+, etc.)	
ammonium (NH_4^+)	
nitrate (NO_3^-)	
acetate ($C_2H_3O_2^-$ or CH_3COO^-)	
hydrogen carbonate (HCO_3^-)	
chlorate (ClO_3^-)	
halides (Cl^-, Br^-, I^-)	when combined with Ag^+, Pb^{2+}, or Hg_2^{2+}
sulfates (SO_4^{2-})	when combined with Ag^+, Ca^{2+}, Sr^{2+}, Ba^{2+}, or Pb^{2+}

Ions That Form *Insoluble* Compounds*	Exceptions
carbonate (CO_3^{2-})	when combined with Group 1 ions or ammonium (NH_4^+)
chromate (CrO_4^{2-})	when combined with Group 1 ions, Ca^{2+}, Mg^{2+}, or ammonium (NH_4^+)
phosphate (PO_4^{3-})	when combined with Group 1 ions or ammonium (NH_4^+)
sulfide (S^{2-})	when combined with Group 1 ions or ammonium (NH_4^+)
hydroxide (OH^-)	when combined with Group 1 ions, Ca^{2+}, Ba^{2+}, Sr^{2+}, or ammonium (NH_4^+)

*compounds having very low solubility in H_2O

Total Ionic Equations

$$BaCl_{2(aq)} + Na_2SO_{4(aq)} \rightarrow BaSO_{4(s)} + 2\,NaCl_{(aq)}$$

Total Ionic Equation- Chemical equation in which all highly soluble ionic compounds are written as dissociated ions

Like all chemical equations a total ionic equation must be balanced! To do this you must account for:

1. The total number of atoms of each element must be the same on both sides of the arrow
2. The sum of the charges must also be equal on both sides

Total Ionic Equations

$$BaCl_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2\,NaCl\,(aq)$$

For the reaction, represent each soluble compound by its dissociated ions.

Example:

$$Ba^{2+}(aq) + 2Cl^-(aq) + 2Na^+(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s) + 2Na^+(aq) + 2Cl^-(aq)$$

$1\,(+2) \quad + \quad 2(-1) \quad + \quad 2\,(+1) \quad + \quad 1\,(-2)$ $\qquad$ $2(+1) \quad + \quad 2\,(-1)$

Total Charge = 0 $\qquad$ Total Charge = 0

Note the sum of the charges are the same, but they do not have to equal zero

Net Ionic Equations

Spectator Ions- ions that are not involved in a chemical reaction

$$Ba^{2+}(aq) + 2Cl^{-}(aq) + 2Na^{+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s) + 2Na^{+}(aq) + 2Cl^{-}(aq)$$

In this reaction which are the spectator ions?

- Na^+ and Cl^-.
- These ions can be omitted from the total ionic equation to give us a simpler equation called a net ionic equation.

Net Ionic Equation

Total Ionic Equation:

$$Ba^{2+}(aq) + \cancel{2}Cl^{-}(aq) + \cancel{2}Na^{+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s) + \cancel{2}Na^{+}(aq) + \cancel{2}Cl^{-}(aq)$$

Net Ionic Equation:

$$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$$

- Net ionic equation describes the chemical change that occurs in a reaction involving ions
- However it does not specify which substances were mixed to result in this reaction

Homework

- Complete the solubility and saturation worksheet