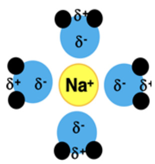
Dissolving and Solubility

Read from **Lesson 1: Model of Solutions** in the **Chemistry Tutorial Section, Chapter 13** of **The Physics Classroom**:
Part c: The Dissolving Process
Part d: Solubility, Temperature, and Pressure
Part e: Dissociation of Ionic Compounds

Part 1: Dissolving

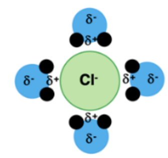
When a solid dissolves in water, its particles—usually ions or molecules—separate and spread evenly throughout the water, forming a solution. This dissolving process includes a key step known as **solvation**. During solvation, solvent molecules (like water) use their intermolecular forces to surround and interact with the particles of the solid.



For **ionic compounds**, the process includes **dissociation**—the separation of ions from the solid structure. Look at sodium chloride dissolving in water.

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

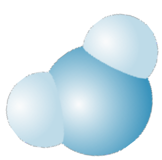
Solid NaCl is held together by strong ionic bonds between positively charged sodium ions (Na^+) and negatively charged chloride ions (Cl^-). If the attraction between water molecules and these ions is strong enough to overcome the ionic bonds, the water pulls the ions away from the crystal, allowing them to mix uniformly into the solution.



To write a dissociation equation, you must include:

- A reactant formula—the ionic compound being dissolved
- Two product formulas—one for the cation and one for the anion
- Appropriate charges—indicating the oxidation state of each ion
- State symbols—(s) for the solid reactant and (aq) for the aqueous products
- Balanced coefficients—ensuring conservation of atoms and charge

For example, the dissociation equation for aluminum sulfate is: $\mathbf{Al_2(SO_4)_3}(s) \rightarrow \mathbf{2\ Al^{3+}}(aq) + \mathbf{3\ SO_4^{2-}}(aq)$



Water can also dissolve **polar compounds**, like sugar, by forming hydrogen bonds or dipole interactions with the polar regions of the molecules. Once separated, the particles are surrounded by water molecules and become evenly distributed, forming a homogeneous solution.

For **Questions #1-10**, determine whether each solute placed in water is an **ionic** or **covalent** compound.

- **If the solute is a covalent compound**, then (a) write "**Covalent**", and (b) identify the **intermolecular forces** it experiences (e.g., hydrogen bonding, dipole-dipole interactions, or London dispersion forces).
- **If the solute is an ionic compound**, then (a) Write the **formula** of the solid, and (b) Write the **balanced dissociation equation** showing the salt dissolving in water.

Solute	**(a)**	**(b)**
1. Glucose		
2. Sodium carbonate		
3. Calcium acetate		
4. Dichlorine heptoxide		
5. Ammonium phosphite		
6. Aluminum dichromate		

Solutions

7. Magnesium permanganate		
8. Sulfur hexafluoride		
9. Copper (II) sulfate		
10. Lead (IV) hydroxide		

Part 2: Solubility

Solubility refers to the maximum amount of **solute** that can dissolve in a specified amount of **solvent**. A **solubility curve** is a graph that illustrates how a substance's solubility changes with **temperature**. The standard units for solubility are **grams of solute per 100 grams of water**.

Solutions are classified into three types based on the amount of dissolved solute:

- **Unsaturated solution** – Can dissolve more solute.
- **Saturated solution** – Holds the maximum amount of solute at a given temperature.
- **Supersaturated solution** – Contains more solute than typically possible, often created by carefully cooling a saturated solution.

Solubility trends vary based on the type of substance:

- For **solids**, solubility generally **increases** with temperature.
- For **gases**, solubility **decreases** as temperature rises but **increases** under higher pressure.

Solubility Questions

1. Zen Harmony is making hot tea and adds sugar to it. She notices that sugar dissolves more easily in hot water than in cold.
   a. Explain why sugar dissolves better in hot water than in cold water.

   b. If Zen refrigerates her tea, what will happen to the dissolved sugar?

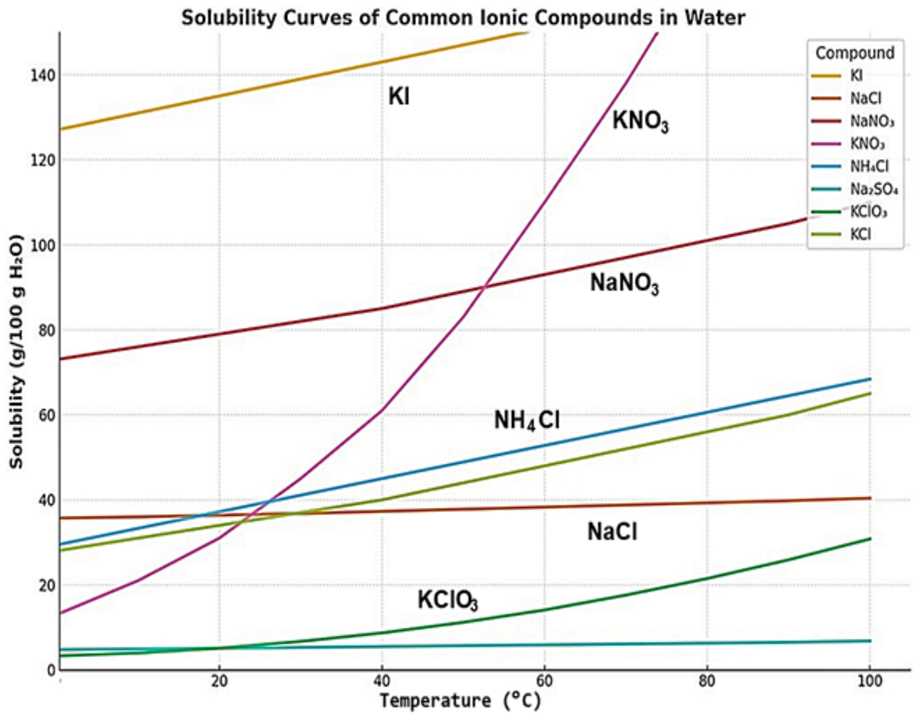
   c. How could Zen create a supersaturated sweet tea solution?

2. Fish living in deep oceans rely on dissolved oxygen in water. How would the solubility of oxygen change if they were moved to warmer, shallow waters? Explain the role of temperature and pressure in gas solubility.

Solutions

<u>*Use the solubility curve to answer the following questions.*</u>

3. What compound, KI, KNO_3, $NaNO_3$, NH_4Cl, or NaCl, has the least change in solubility as temperature increases?



4. Which compound is most soluble in water at 20°C?

5. At what approximate temperature does sodium nitrate and potassium nitrate have the same solubility?

6. At what temperature can you dissolve 80 grams of sodium nitrate in 100 g water?

7. How many grams of potassium nitrate can dissolve in 100 grams of water at 50°C?

8. How many grams of ammonium chloride can be dissolved in 200 g of water at 80°C?

9. At 30°C, 90 g of sodium nitrate is dissolved in 100 g of water. Is this solution saturated, unsaturated, or supersaturated? Explain how you know.

10. A saturated solution of potassium nitrate is formed from 100 g of water. If the saturated solution is cooled from 60°C to 20°C, how many grams of precipitate are formed?