Solutions

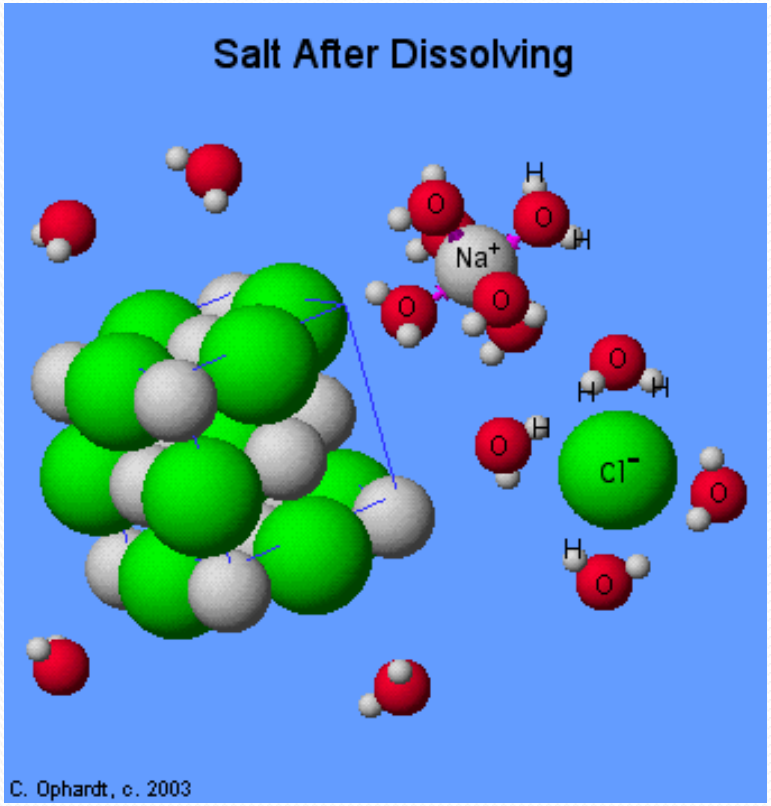
Chapter 16

Solutions

- A **solution** is a **homogeneous mixture**.
- A **solute** (usually either a gas or a solid, but sometimes a liquid) is what's *dissolved* into a liquid, called the **solvent**.
  - Example: Salt water
    - Solute: Salt
    - Solvent: Water
  - Example: Seltzer water
    - Solute: CO_2
    - Solvent: Water

Solutions Up Close

- On a molecular level, when something dissolves, water (or a different solvent) completely surrounds the solute particles.



“Like Dissolves Like”

- Non-polar solutes dissolve best in non-polar solvents:
  - Fats, steroids, waxes into benzene, hexane, toluene.
- Polar and ionic solutes dissolve best in polar solvents:
  - Inorganic salts and sugars into water, small alcohols, acetic acid.

Solutions

- Solutions are considered *aqueous*, but the solute does not actually change state.
  - For example, sugar stays a solid when dissolved into tea; carbon dioxide stays a gas in soda.

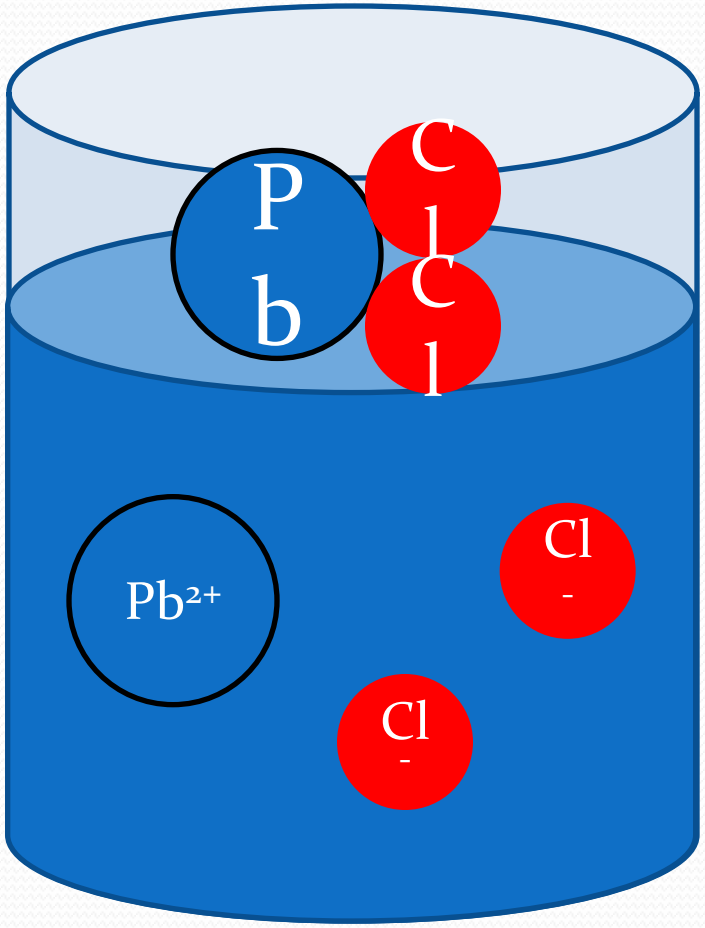
- **Solubility** is the word chemists use to describe the maximum amount of solute that can dissolve in a certain quantity of solvent.

IMPORTANT

- Ionic compounds will **<u>dissociate</u>** (break down) into their component ions in solution.

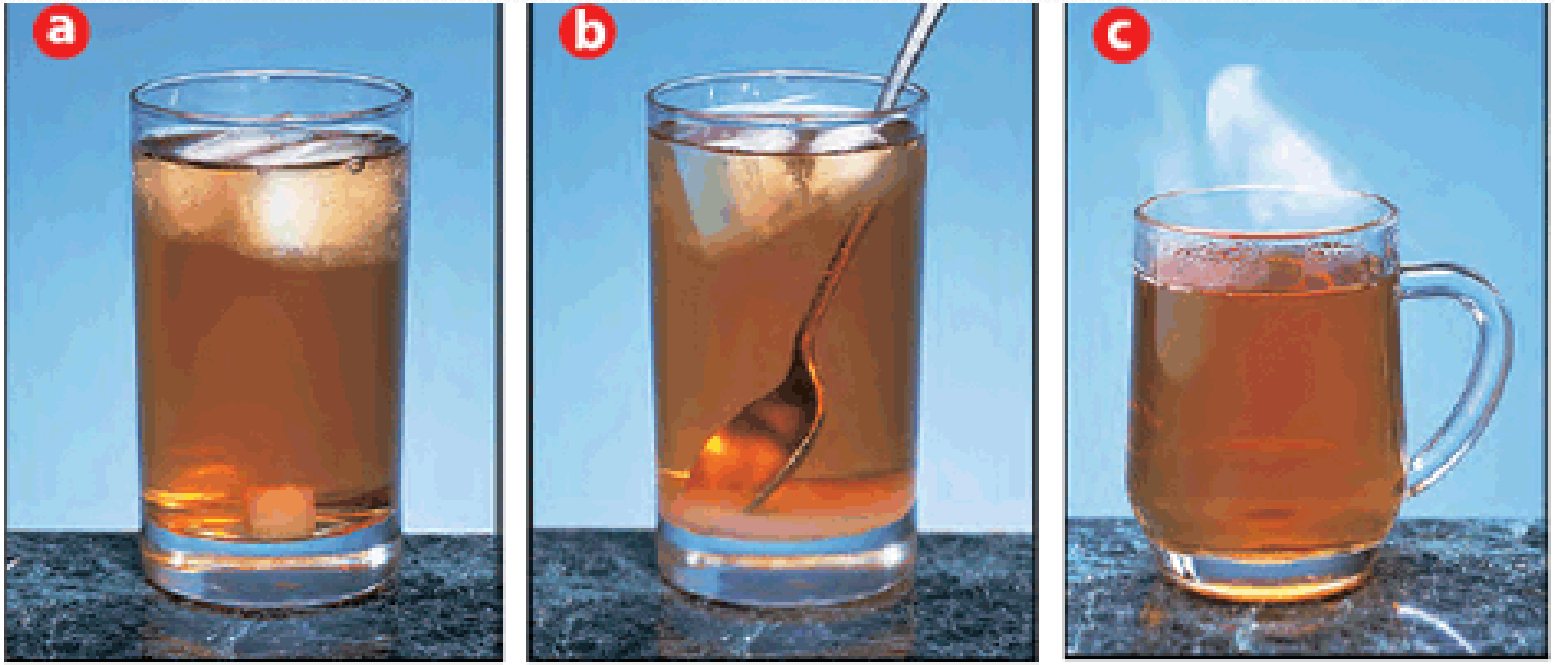
- Example:
  - NaCl becomes Na^+ and Cl^- in water.

  - $PbCl_2$ becomes Pb^{2+} and $2Cl^-$ in water.
    - Note that there is a **<u>coefficient of 2</u>** in front of Cl^-, since there are twice as many chloride ions as lead ions in solution.



Solubility Rate

- Some solvents can hold a lot of a certain substance, some can't hold any.



Solubility Trends

- Solubility of (most) **solids** increases with:
  - Increase in temperature
  - Increase in surface area

- Solubility of **gases** increases with:
  - Decrease in temperature
  - Increase in pressure

Therefore…

- Solids dissolve best when:
  - Heated
  - Stirred
  - Ground into small particles

- Gases dissolve best when:
  - Chilled
  - Under high pressure

Gas Dissolution in Soda

- When a soda bottle is capped, vapor pressure above the liquid keeps the carbon dioxide dissolved.

- Opening the bottle decreases the pressure allowing CO_2 to escape.

Aside: The Bends

- "The bends," also known officially as **<u>decompression sickness</u>**, occurs when divers go to extreme depths.
- At these depths, water pressure force-dissolves nitrogen gas into blood vessels.
- If those divers then rise to the surface too quickly, the nitrogen gas bubbles out of the blood (like CO_2 from a freshly-opened soda bottle).
  - These N_2 bubbles restrict oxygen flow and cellular function.
- The result? Crippling pain forcing people to *bend* over, resulting in permanent damage or even death.

Terms to Describe a Stadium

- If a stadium seats 50,000 people and there are 50,000 people there, how do we describe it?
  - At capacity.
- If a stadium seats 50,000 people and there are 49,999 people there, how do we describe it?
  - Under capacity.
- If a stadium seats 50,000 people and there are 60,000 people there, how do we describe it?
  - Over capacity.

Terms to Describe Solutions

- **Saturated**
  - Full of solute.
- **Unsaturated**
  - Not full of solute.
    - It can have *some* solute, just not the *maximum*.
- **Supersaturated**
  - More solute than can dissolve (all dissolved).
    - Typically, a supersaturated solution has been heated.

Supersaturated Solutions

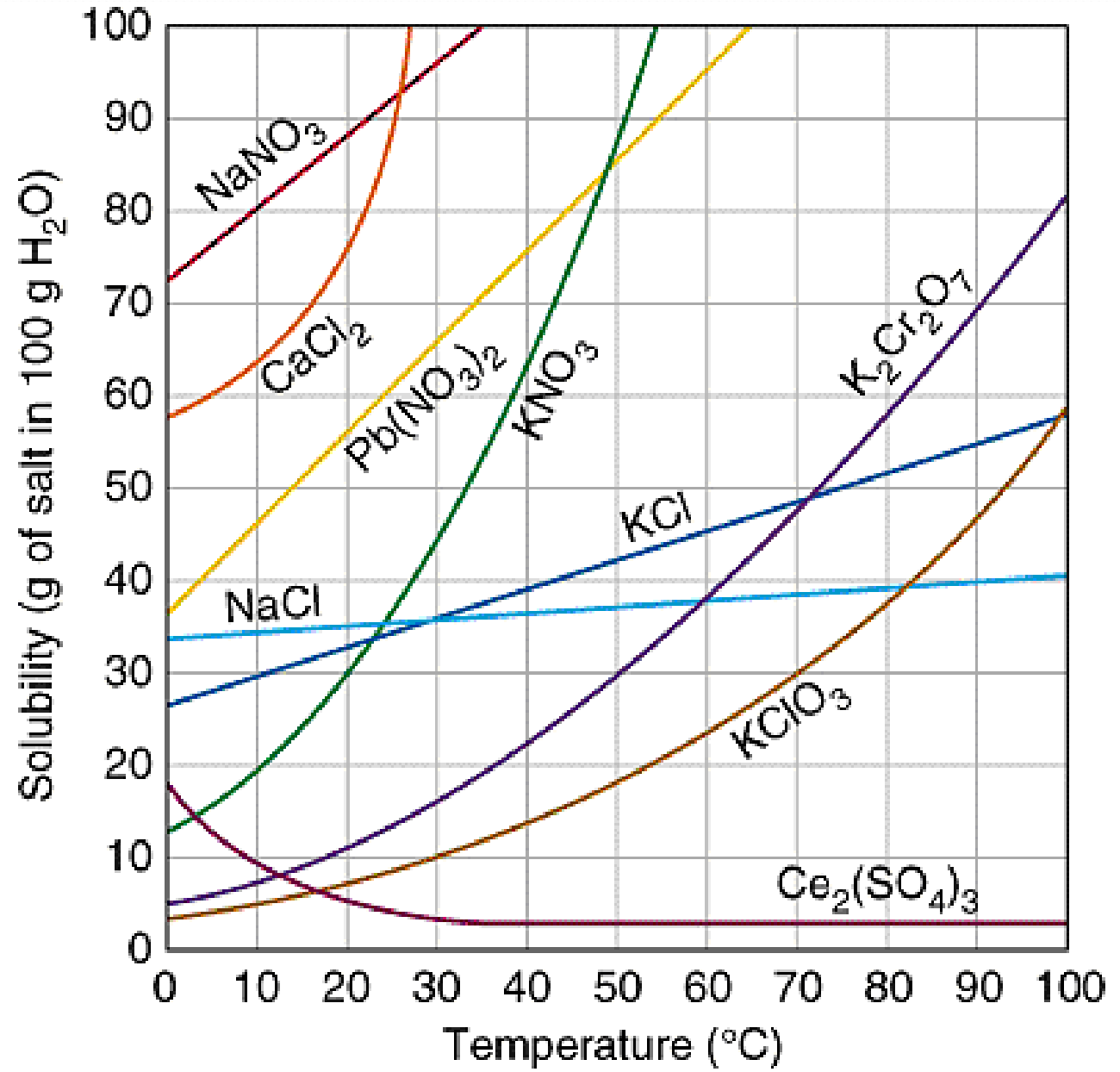
- Making a supersaturated solution is like putting 60,000 fans in a 50,000 seat stadium ***and getting them all in seats.***

- Supersaturated solutions aren't very stable. The solute will actually *fall out of solution* (precipitate) if disturbed.
  - *AKA those extra 10,000 fans stand up.*

Solubility Curves

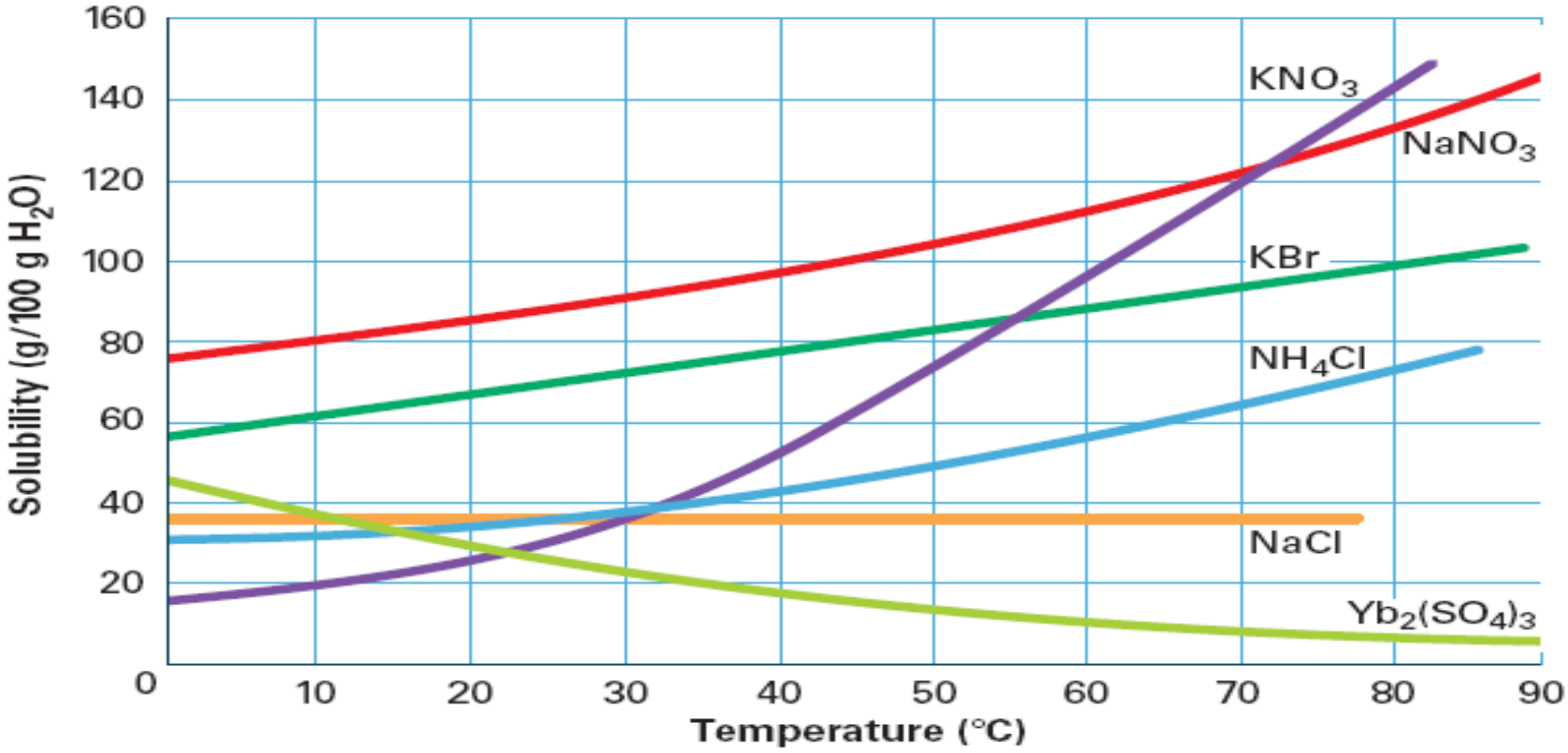
- **Solubility curves** represent the point at which a given quantity of a solvent is **saturated** at a given temperature.

Solubility Curves



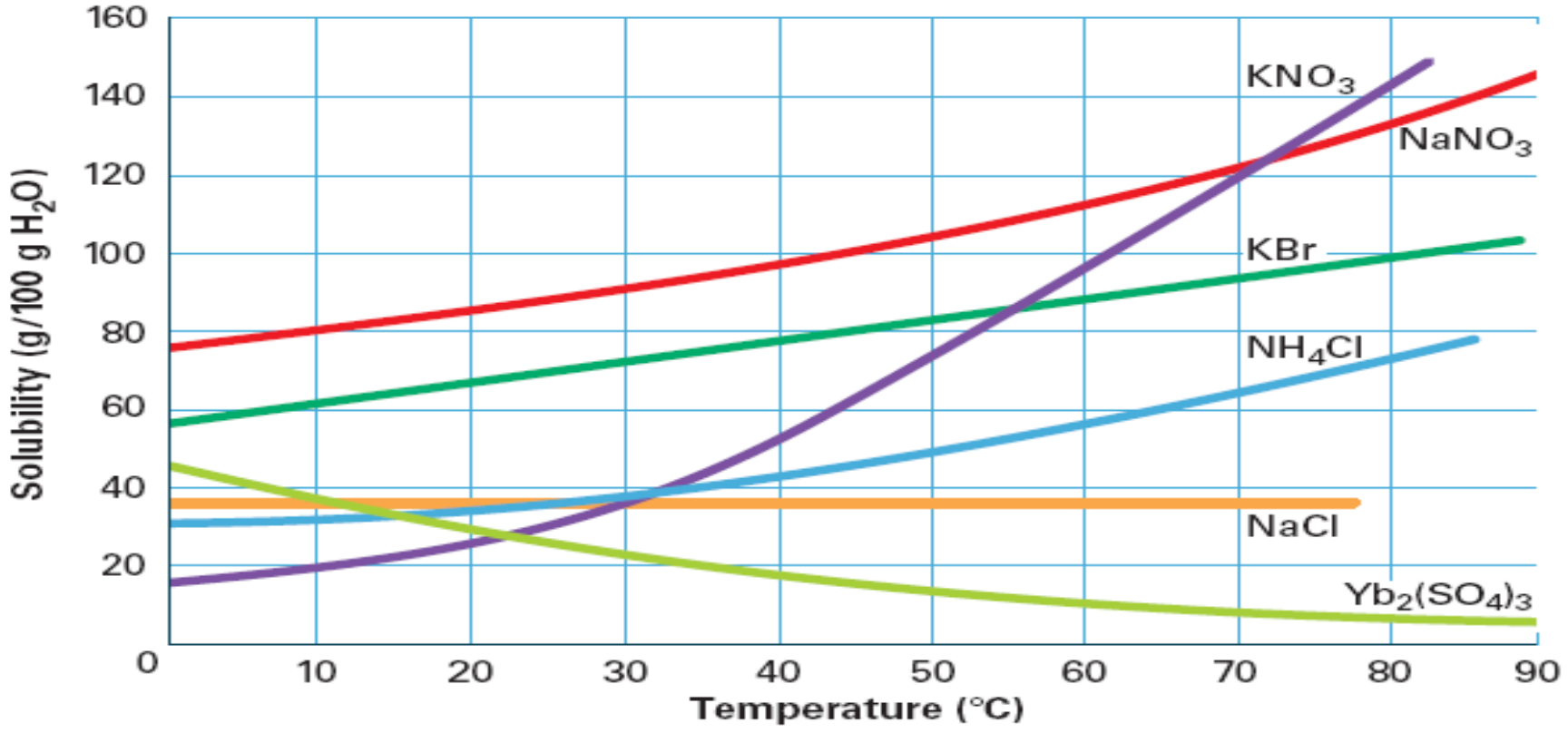
Solubility Curves

- How much potassium bromide can be dissolved in 100 g of H_2O at 80 °C?
  - About 100 grams.



Solubility Curves

- How much potassium bromide can be dissolved in 150 g of H_2O at 80°C?
  - About 150 grams.



Molarity

- At some point this year you may have seen me label acids or other liquids with something like:
  - "6 M HCl"
- The big capital M stands for Molar.
  - 6 M HCl is pronounced "Six **molar** hydrochloric acid."
- **Molarity** is another way to measure the concentration or dilution of a solution.
  - The higher the molarity, the stronger the solution.

Calculating Molarity

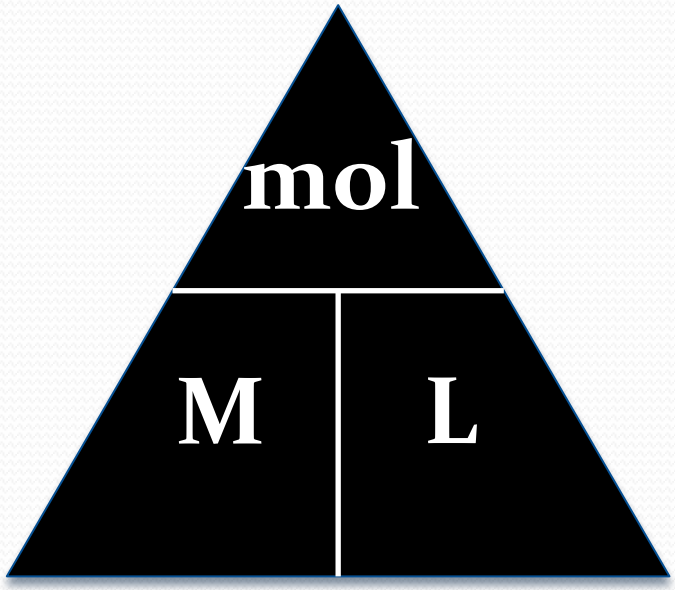
- M is the symbol for Molarity

- The equation:

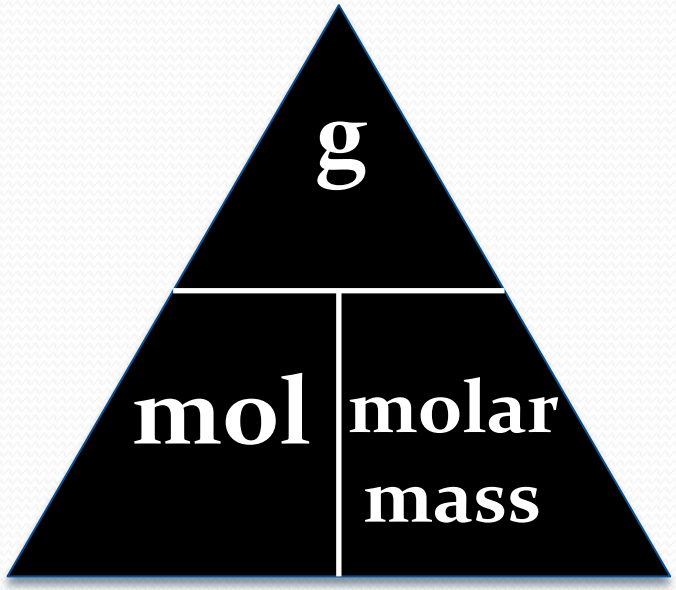
$$M = \frac{\text{moles of solute}}{\text{liters of solution}}$$

Need a Reminder?

Molarity Equation



Mole Conversion



Molarity Practice Problem 1

- Intravenous (IV) saline solutions are often administered to patients in the hospital. One saline solution contains 0.90 g NaCl in exactly 100 mL of solution. What is the molarity of the solution?

- Answer: 0.154 M

Molarity Practice Problem 2

- Household laundry bleach is a dilute aqueous solution of sodium hypochlorite (NaClO). How many moles of solute are present in 1.5 L of 0.70 M NaClO?

- Answer: 1.05 mol NaClO

Dilutions of Molar Solutions

- Sometimes chemists need to create dilutions using known molarities and volumes.

- For example, during our Baking Soda/HCl lab, I used 6 M HCl. However, the school receives hydrochloric acid in big jugs of 12 M HCl (nasty stuff).

Molar Dilutions

- Because we're not changing how much solute is around during a dilution (we're just adding water, the solvent), we can use the following formula:

- $M_1V_1 = M_2V_2$

- No change in the number of moles of solute!

Molar Dilution Practice Problem 1

- How many milliliters of aqueous 2.00 M $MgSO_4$ solution must be diluted with water to prepare 100.0 mL of aqueous 0.500 M $MgSO_4$?

- Answer: V_1 = 25 mL

Molar Dilution Practice Problem 2

- You put 2 moles of HCl into 312 mL of water. If you wanted to make a 1 M dilution, how many milliliters would you need to dilute with water?

- Answer: V_2 = 2000 mL

Computer Practice

- Okay, now it's time to do a little reinforcement using the computers.
- Head to *Quia* and open the quiz called:
  - *Salts and Solubility*
- From there, it's a pretty self-explanatory quiz that will have you visiting another page at the same time (PhET, an awesome website).
- You will be looking at various salts dissolving into water and making molarity calculations based on them.