TOPIC 7.1

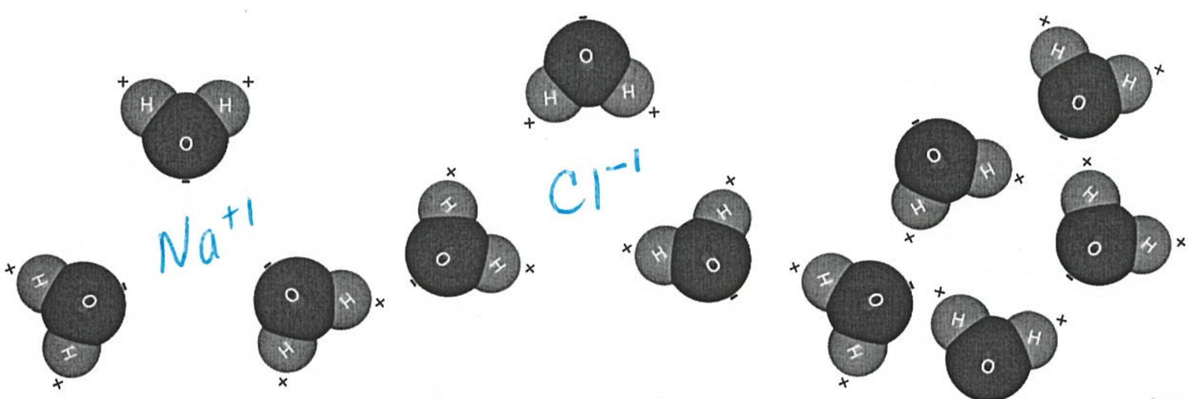
Polarity and Solubility

What types of substances are most likely to dissolve in water?

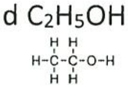
★ "Like dissolves like" ★

What does that mean?

Water is a polar **molecule, so it is most likely to dissolve** polar **substances.**

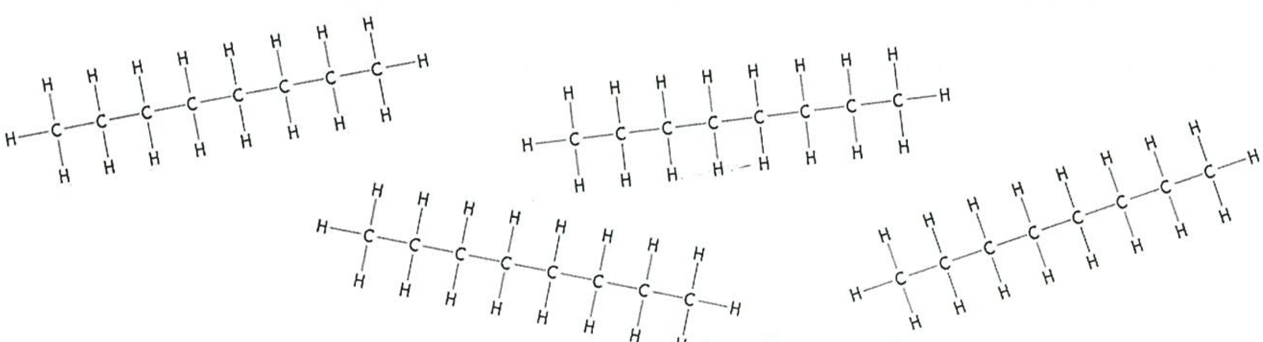


*Examples of **soluble** substances:* NaCl (ionic - polar) and C_2H_5OH (asymmetrical-polar)



*Examples of **insoluble** substances:* oil (symmetrical-nonpolar)

Octane (gasoline) is a nonpolar **molecule, so it is most likely to mix with** nonpolar **substances.**



*Examples of **soluble** substances:* naphthalene (symmetrical-nonpolar)

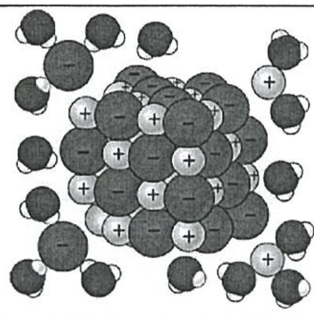
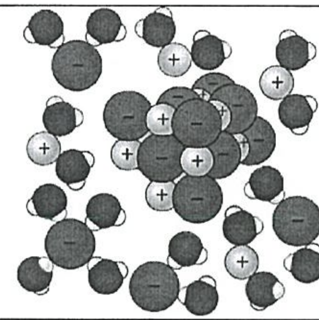
*Examples of **insoluble** substances:* H_2O (asymmetrical-polar) and NaCl (ionic - polar)

TOPIC 7.2

Solubility and Dissociation

What does it mean to "dissolve"?

When a substance dissolves, two things must happen:

	
• Break attractions within the Solute • Break attractions within the Solvent	• Form new attractions between Solute and Solvent
REQUIRES/ABSORBS ENERGY	RELEASES ENERGY

These two process battle it out, as it were, to either absorb or release energy overall. We can write the end result as a **dissociation equation** (need help? Not enough info? Look to Table ______)

$MgCl_2(s) \xrightarrow{H_2O} Mg^{+2}_{(aq)} + 2\,Cl^{-1}_{(aq)} + 73\text{ kJ}$ Endothermic OR Exothermic?

$NaOH(s) \xrightarrow{H_2O} Na^{+1}_{(aq)} + OH^{-1}_{(aq)} + 445$ Endothermic OR Exothermic?

$NaCl(s) + 3.88 \xrightarrow{H_2O} Na^{+1}_{(aq)} + Cl^{-1}_{(aq)}$ Endothermic OR Exothermic?

In an exothermic reaction, energy is released into the surroundings as heat. As a result, the temperature of the surroundings increases.

In an endothermic reaction, energy is absorbed from the surroundings. As a result, the temperature of the surroundings drops.

TOPIC **7.3**

Using Table F

Do all ionic substances dissolve?

Though we know like dissolves like, some *possible* dissociations just aren't favorable enough to *actually* happen. Table F tells us when ions (or *combinations* of ions) can or cannot dissolve.

Table F
Solubility Guidelines for Aqueous Solutions

(aq)

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+}

(s)

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

Determine which of the following ionic compounds would be able to dissolve in water. Justify your answer with a possible dissociation equation and evidence from Table F.

$NaNO_3 \xrightarrow{H_2O} Na^{+1}_{(aq)} + NO_3^{-1}{}_{(aq)}$ Will it dissolve? YES NO

$PbS_2 \xrightarrow{H_2O} Pb^{4+} + 2\cancel{S}^{2-}$ Will it dissolve? YES NO

$PbCl_2 \xrightarrow{H_2O} \cancel{Pb^{2+}} + 2Cl^{-1}$ Will it dissolve? YES NO

$K_2CO_3 \xrightarrow{H_2O} 2K^{+1}_{(aq)} + CO_3^{2-}{}_{(aq)}$ Will it dissolve? YES NO

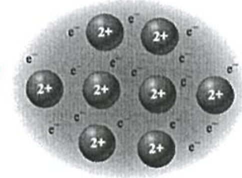
TOPIC 7.4

Electrolytes

What properties of the solute change when substances dissolve?

Dissolving in water is a physical change. However, when this physical change takes place, so can something *magical!**

When we looked closely at metals, we found that they were good conductors of electricity. That property was a result of their structure. ☆ mobile electrons →

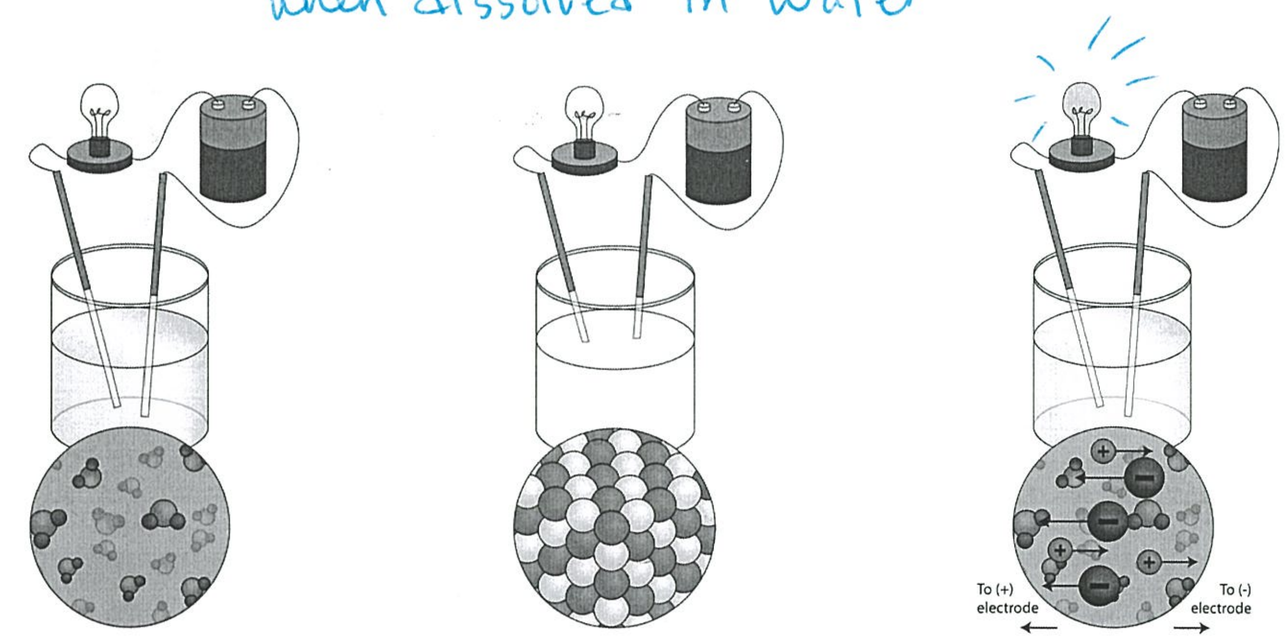


A metallic bond contains mobile electrons—moving charged particles that create a functional "path" for electricity to "flow" through.

As it turns out, all electricity needs to be able to "flow" is a "conveyor belt" of moving charges. So if we could get the ions of an ionic substance moving, we'd get a way to conduct electricity! There are two ways to do that:

1. ___melt___ the ionic substance
2. ___dissolve___ the ionic substance

Electrolyte: a substance that can conduct electricity when dissolved in water



A Distilled water does not conduct a current.

B Positive and negative ions fixed in a solid do not conduct a current.

C In solution, positive and negative ions move and conduct a current.

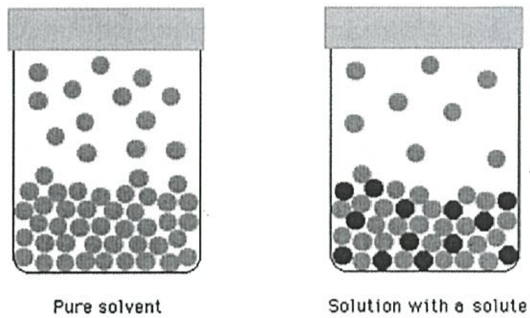
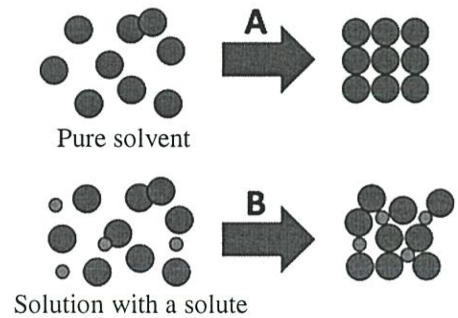
All ___soluble___ substances on Table ___F___ are electrolytes!

Circle the electrolytes: H_2O NaBr $CaCO_3$ KCO_3 HBr C_2H_5OH

*Not magical, just scientific.

TOPIC 7.5	**Colligative Properties** *What properties of the solvent change when a substance dissolves?*

When solutes dissolve in water, not only can their physical properties change, the properties of the solvent (water) change as well. Let's look at those changes from the perspective of the pure liquid or the solution.

Gettin' hot in here. Time to boil!	**So cold. Time to freeze!**
	
Boiling point increases	Freezing point decreases
The solute "blocks" solvent particles from escaping as gas. Vapor pressure is lower than normal, so it takes more energy to get the liquid to boil.	The solute awkwardly inserts itself into the geometric crystal that is trying to form. Potential energy must be decreased even more than normal to get the solid to form.

In summary:

More dissolved particles (or ions) = higher **boiling point**
(higher or lower)

lower **freezing point**
(higher or lower)

Think back to the last lesson: As more *ions,* specifically, are dissolved, what should happen to the conductivity of the solution (higher or lower)?

In which sample would the conductivity be highest in? 0.1 M NaCl (aq) OR 0.1 M $CaCl_2$
Explain your choice in terms of mobile ions.

more mobile ions

TOPIC 7.6	**Concentration: Molarity** *How can we use moles to compare concentrations of solutions?*

Take a sip of super weak Kool-Aid and Kool-Aid so potent it nearly overpowers your taste buds...keep the two contrasting scenarios in your head as you get these two words into your brain:

Dilute: less solute dissolved

Concentrated: more solute dissolved

But how do we measure exactly how dilute or concentrated a particular solution is? Well, there are three main ways so far as Regents chemistry is concerned. We'll look at one of those ways today.

Concentration	$\text{parts per million} = \dfrac{\text{mass of solute}}{\text{mass of solution}} \times 1\,000\,000$
	$\text{molarity} = \dfrac{\text{moles of solute}}{\text{liter of solution}}$

Molarity standardizes conversations about concentration. We can precisely compare how concentrated solutions are, regardless of what substance is dissolved and how much of the solution there is if we know its molarity.

Molarity: amount of substance per unit volume

$$\underset{(M)}{\text{molarity}} = \frac{\text{moles of solute}}{\text{liter of solution}} \quad \frac{mol}{L}$$

0.4 moles of $CuCl_2$ is dissolved into 0.5 L of solution. What is the concentration (M) of the $CuCl_2(aq)$?

$$M = \frac{0.4\,mol}{0.5\,L} = \boxed{0.8\,M}$$

1.6 moles of salt is dissolved into 700 mL of solution. What is the concentration (M) of the salt water?

→ 0.700 L

$$M = \frac{1.6\,mol}{0.700\,L} = \boxed{2.3\,M}$$

8 grams of sodium hydroxide is added to water to make 75 mL of solution. What is the molar concentration of the NaOH(aq)? (GFM = 40)

0.075 L

$$\#\,mol = \frac{8}{40} = 0.2\,mol$$

$$M = \frac{0.2\,mol}{0.075\,L} = \boxed{2.7\,M}$$

TOPIC 7.7

Concentration: Parts per Million

How can we describe concentration in specialized contexts?

Molarity is great and all; however, sometimes other ways about talking about concentration are preferred:

Concentration	$\text{parts per million} = \dfrac{\text{mass of solute}}{\text{mass of solution}} \times 1\,000\,000$
	$\text{molarity} = \dfrac{\text{moles of solute}}{\text{liter of solution}}$

You'll see parts per million used a lot when it comes to environmental regulations/limitations.

Parts per million (ppm): a way to express very dilute concentrations

$$\text{parts per million} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 1\,000\,000$$

A homeowner has a water quality report prepared for a sample of water taken from pipes in the home. According to the report, the 550.-gram sample contains 6.75 x 10^{-4} gram of dissolved Cu^{2+} ions.

Show a numerical setup for calculating the concentration, in parts per million, of dissolved Cu^{2+} ions in the sample of water tested.

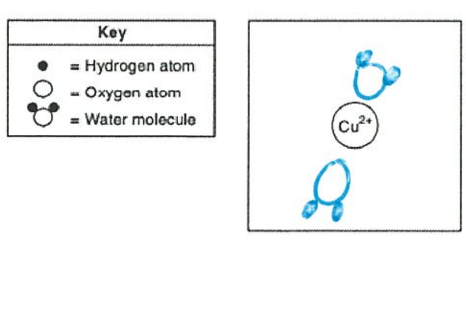
$$ppm = \frac{6.75 \times 10^{-4}\,g}{550.\,g} \times 1{,}000{,}000$$

The 550.-gram sample would be unsafe for drinking if the concentration was above 2 ppm. What is the total mass of Cu^{2+} ions in a 550.-gram sample with a concentration of 2 parts per million?

$$\frac{2\,ppm}{1{,}000{,}000} = \frac{x}{550\,g} \times \frac{\cancel{1{,}000{,}000}}{\cancel{1{,}000{,}000}} \qquad \frac{2 \times 10^{-6}}{1} = \frac{x}{550}$$

$$x = 1.1 \times 10^{-3}\,g$$

Using the key, draw two water molecules in the box, showing the orientation of each water molecule toward the Cu^{2+} ion.



TOPIC 7.8

Factors that Affect Solubility

How is solubility affected by environmental conditions, like temperature and pressure?

Solubility: the ability of a Solute to dissolve in a Solvent

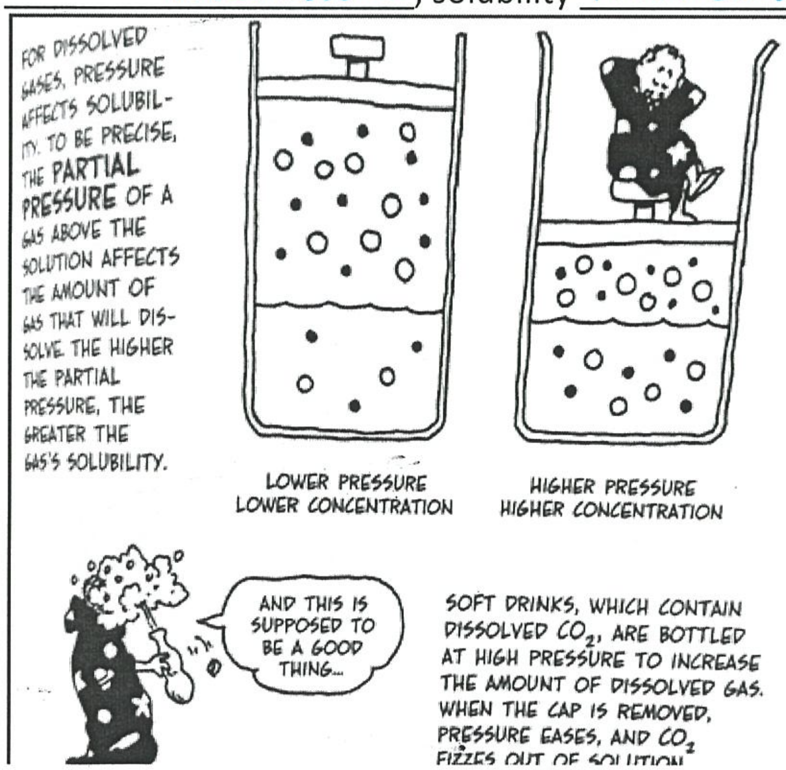
(Solubility usually refers to the maximum amount of solute that can dissolve in a given amount of solute at a certain temperature; we will look at this more closely in Topic 7.9)

Factors that Affect Solubility:

I. Nature of the Solute & Solvent
- Topic 7.1 – LIKE DISSOLVES LIKE
  - **Polar** solutes are soluble in **polar** solvents
  - **Nonpolar** solutes are soluble in **nonpolar** solvents

II. Temperature
- FOR SOLID SOLUTES:
  - As temperature increases, solubility increases
  - *Think of dissolving sugar in hot tea vs iced tea*
- FOR GASEOUS SOLUTES:
  - As temperature increases, solubility decreases
  - *Think of leaving a glass of soda at room temperature – it goes "flat"*

III. Pressure
- FOR SOLID SOLUTES
  - Pressure doesn't have an effect
- FOR GASEOUS SOLUTES
  - As pressure increases, solubility increases



TOPIC 7.9

Using Table G

What information can we gather from solubility curves?

Table G
Solubility Curves at Standard Pressure

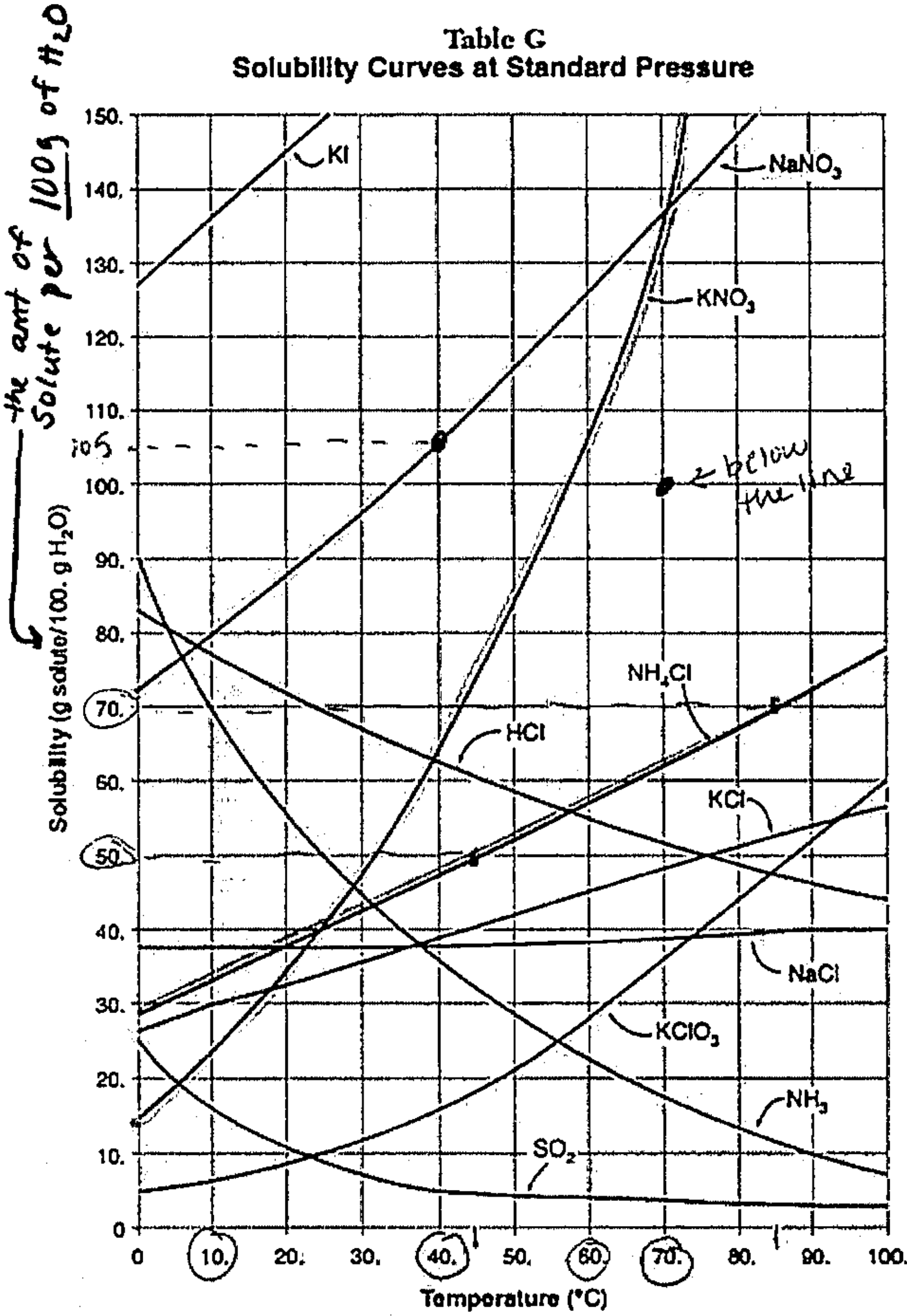


Table G might look a little scary at first because there are many curves. In fact, the solubility curves for 10 substances are given. Solubility curves allow us to determine the amount of solubility of certain compounds at different temperatures. Let's focus on just one: $NaNO_3$ (Sodium nitrate).

✓ The curves represent the **point of saturation** for the compound at any given temperature on the x-axis. Any point **on the curve** means the solution is saturated.

How many grams of $NaNO_3$ can be dissolved in 100 g of H_2O at 40°C to make a saturated solution?

105 g

✓ Any point **below** the curve means that the solution is unsaturated.

If you dissolved 100 grams of $NaNO_3$ into 100 grams of water at a temperature of 70°C, is the solution saturated or unsaturated?

✓ Any point **above** the curve means that the solution is Super saturated.

Give an amount of $NaNO_3$ at 10°C that represents a supersaturated solution.

any value above 80 g

Saturated Solution: a solution that contains the maximum amount of dissolved solute for a given amount of solvent at a specific temperature

Unsaturated Solution: a solution that contains less than the maximum amount of solute for a given amount of solvent at a specific temperature

Supersaturated Solution: a special case when more solute is dissolved than a saturated solution at a given temperature

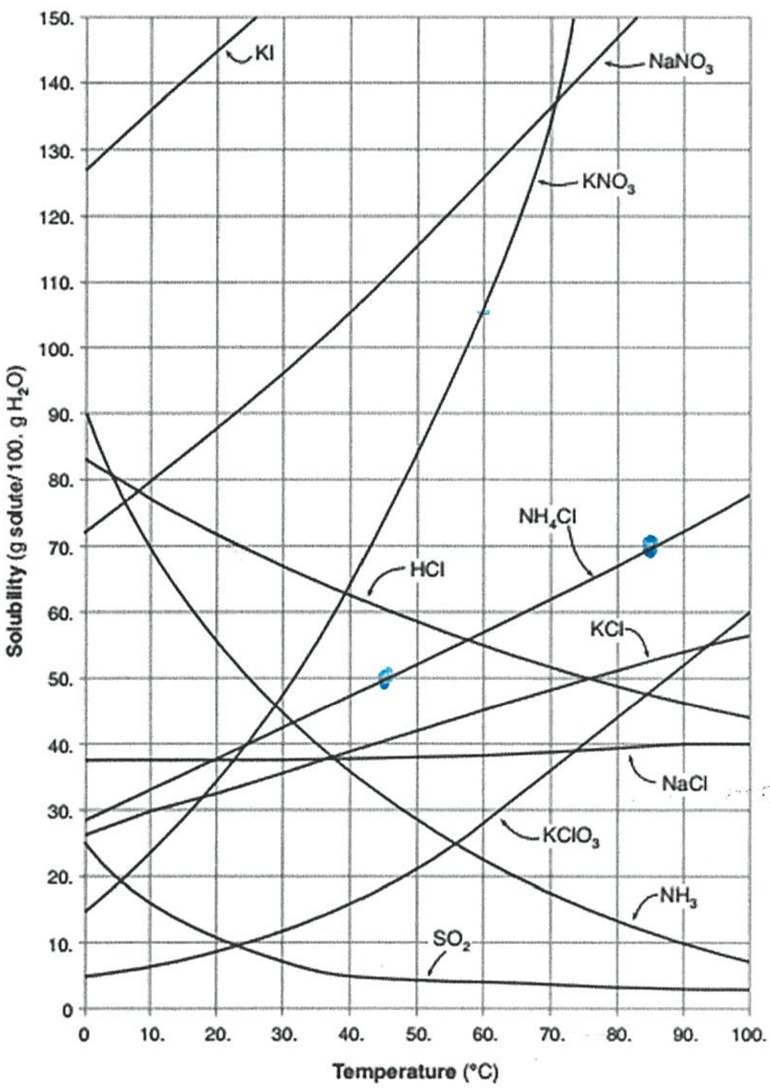
TOPIC 7.10	**Saturation and Temperature/Volume Changes (Table G)**
	How do changes in temperature and volume of water affect saturation levels?

How much stuff can get dissolved in water depends on a few things:

- The solute itself
- The water temperature
- The amount of water

We can use Table G to figure out how changing temperature and the amount of water will change solubility/saturation levels.

Table G
Solubility Curves at Standard Pressure



Temperature changes: all about plotting those points

A saturated solution of ammonium chloride at 85 ℃ is cooled by 40 degrees. How much solid (precipitate) will settle down to the bottom of the beaker?

70 − 50 = $\boxed{20\text{ g}}$

Solubility @85°C

Solubility @45°C

Amount of water changing: all about proportions

How much KNO_3 would be required to create a saturated solution at 60 ℃ in 200 grams of water?

×2 100 g H_2O → 105 g KNO_3

200 g H_2O → $\boxed{210\text{ g}}$