Unit 6

Solutions

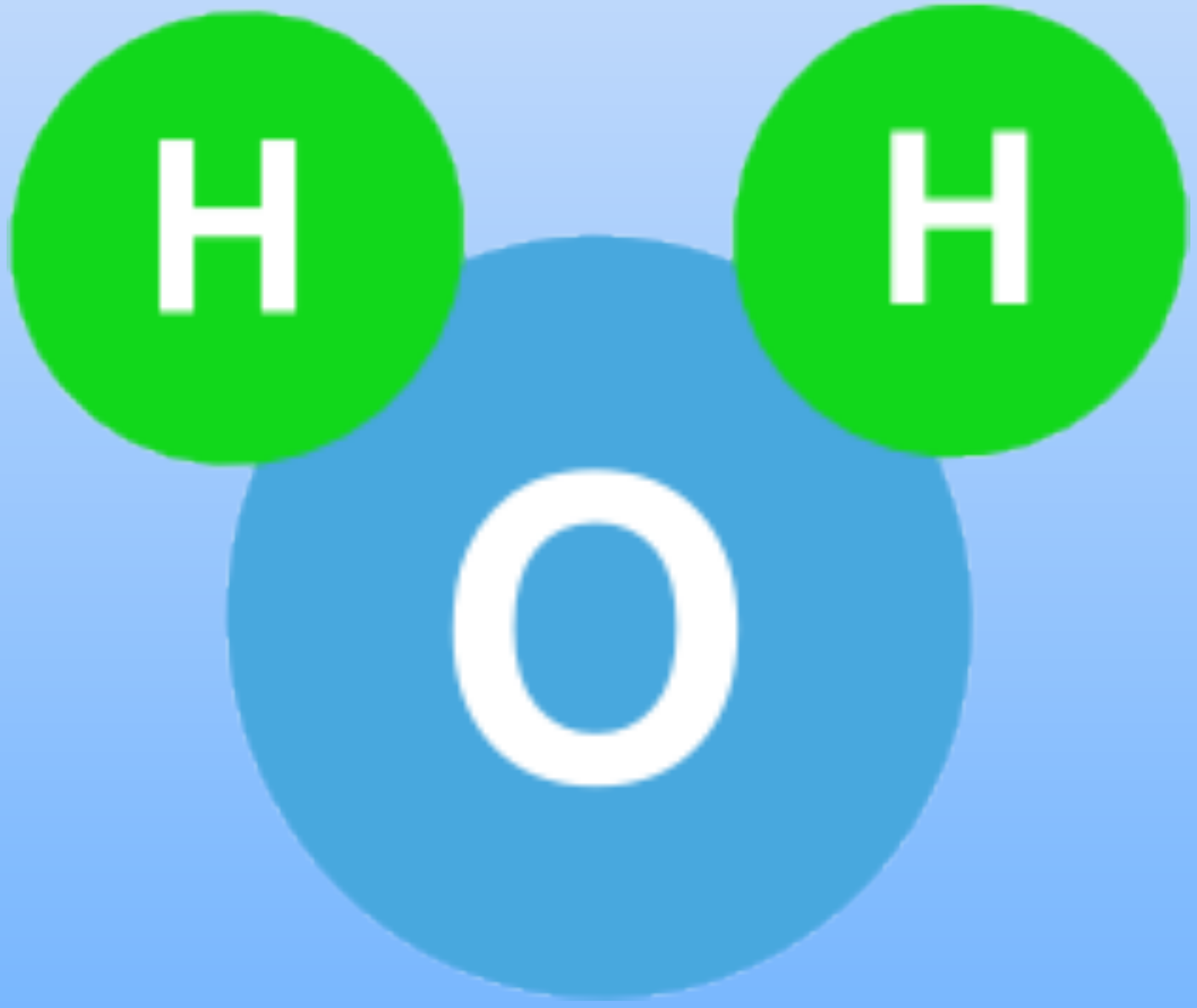
Topic 1 (Review)

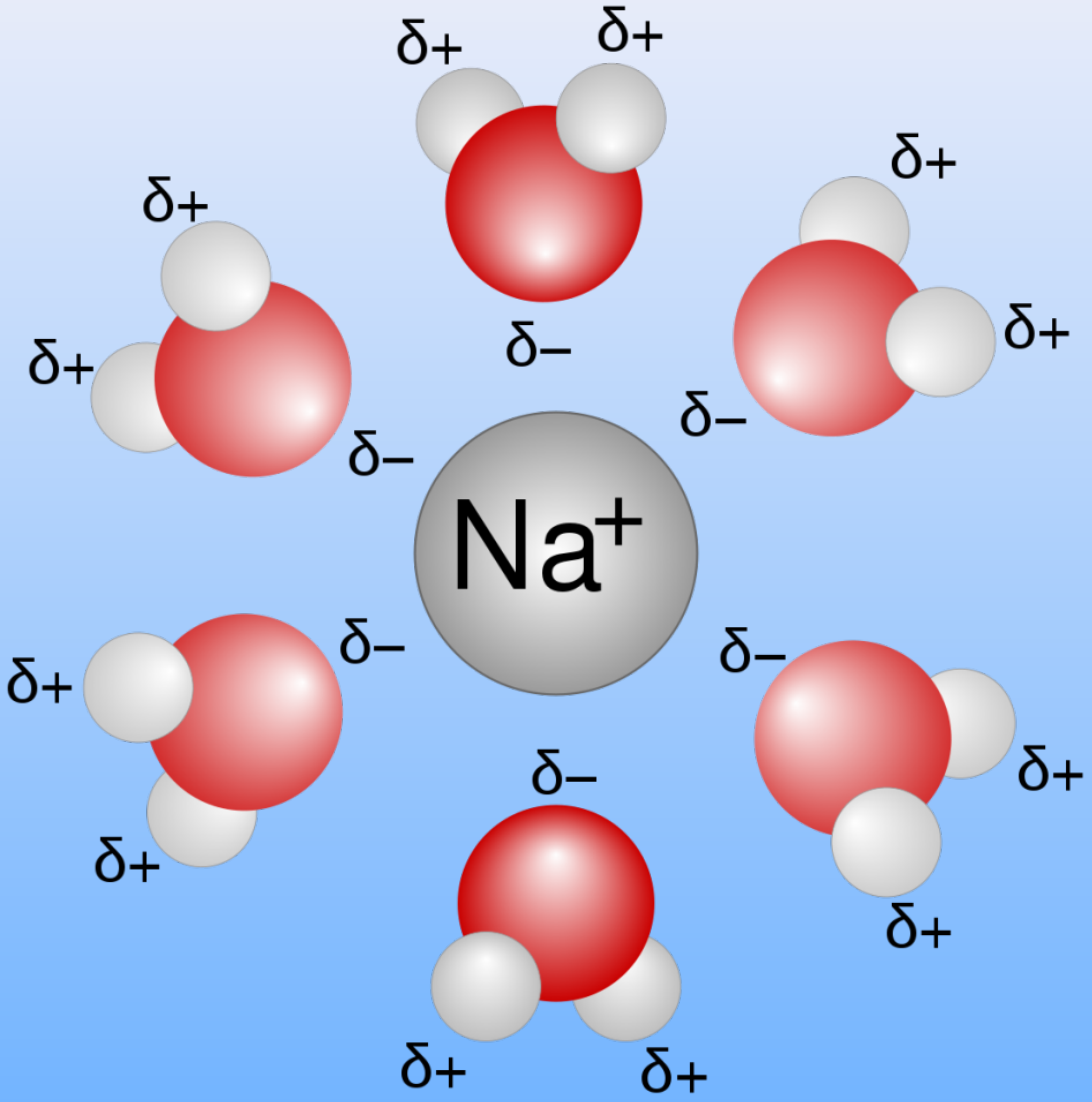
- What does (*aq*) mean? -- dissolved in water.
- **Solution**: a homogeneous mixture; solutes dissolved in solvents
- **Solute**: dissolved particles in a solution (i.e. NaCl)
- **Solvent**: the dissolving medium in a solution (H_2O)
- **Saturated**: a solution containing the maximum amount of solute for a given amount of solvent at a constant temperature and pressure.

Solubility of Ionic Compounds

Topic 2

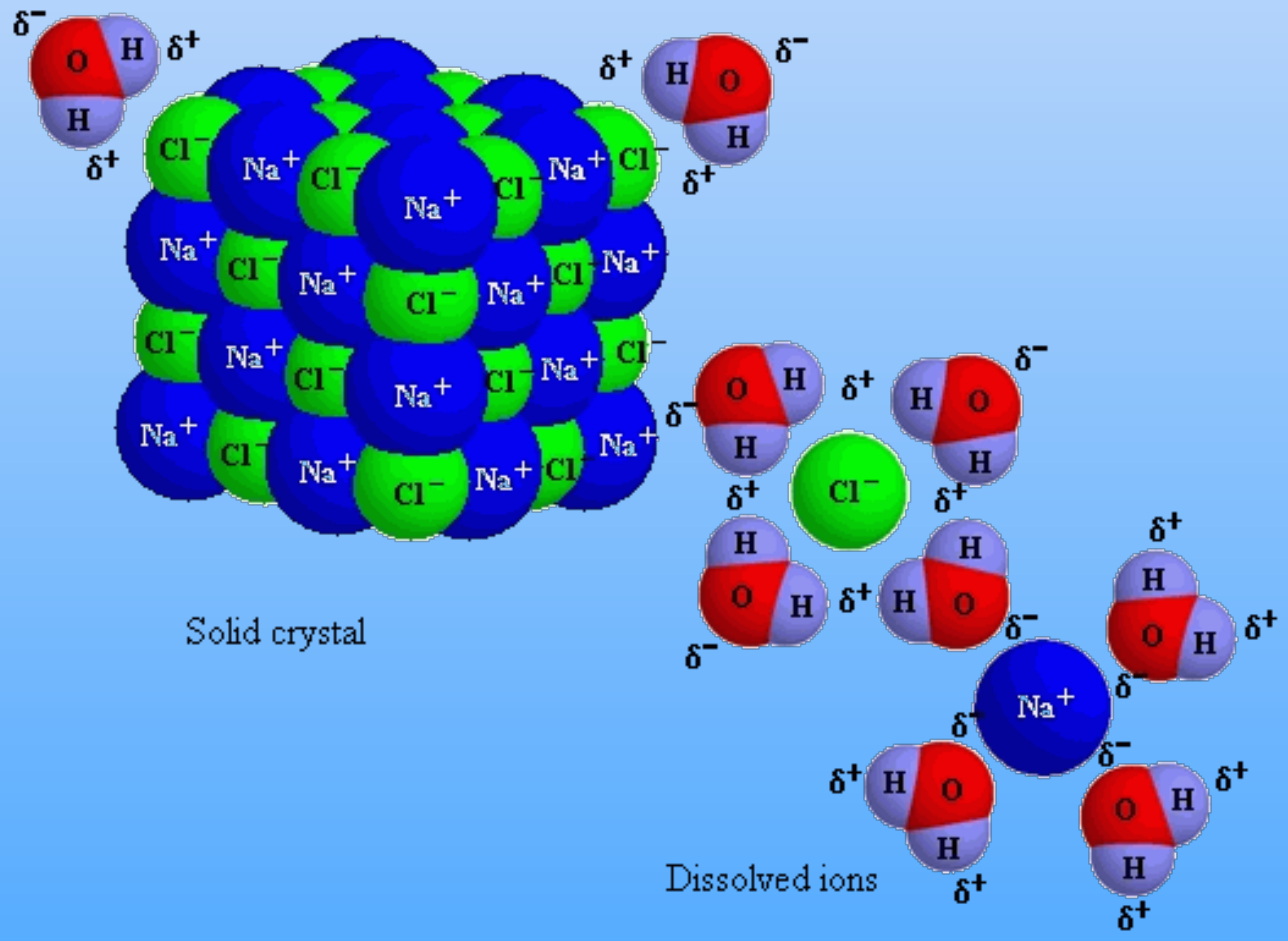
- Water molecules have a **negative** and a **positive** end.





Water Molecules in Solution

- When certain IONIC COMPOUNDS (compounds made of two or more ions) are added to water, they will break apart, or **DISSOCIATE**.
- Examples:
  - $NaCl_{(s)} \rightarrow Na^{+}_{(aq)} + Cl^{-}_{(aq)}$
  - $CaCl_{2(s)} \rightarrow Ca^{+2}_{(aq)} + 2Cl^{-}_{(aq)}$
  - $AgNO_3 \rightarrow$
  - $Be(NO_3)_2 \rightarrow$



Solubility Rules

- TABLE F
- **Soluble:** will dissolve in water
- **Insoluble:** will *NOT* dissolve in water

Table F
Solubility Guidelines for Aqueous Solutions

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

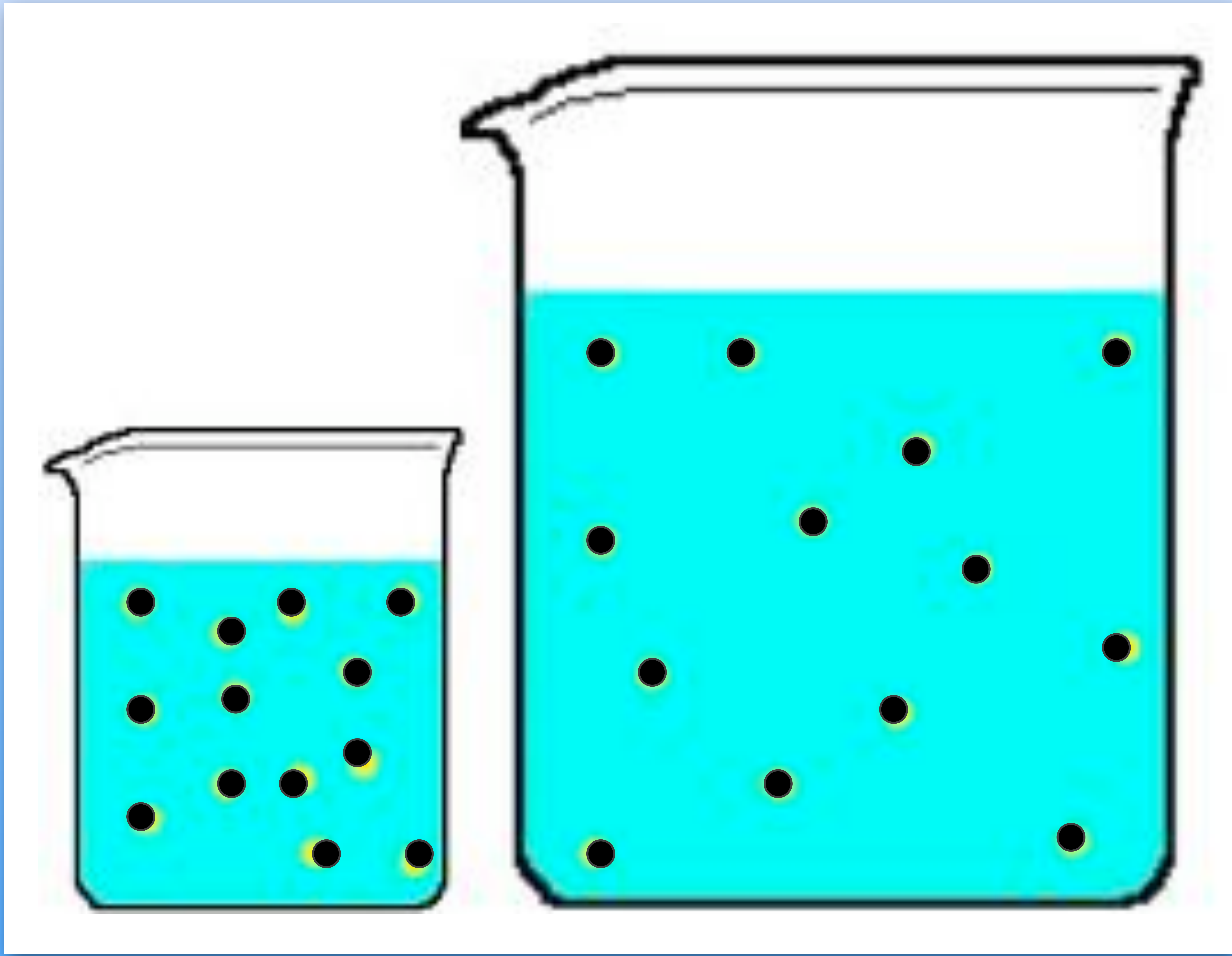
Practice the Solubility Table / Rules

- NaBr — Soluble in water
- $Fe(PO_4)$ — NOT Soluble in water
- $(NH_4)_2S$ — Soluble in water
- $CaSO_4$ — NOT Soluble in water

Solution Concentration

Topic 3

- Which solution has the higher concentration?
- Explain how you know, in terms of particles.



<u>Molarity</u> - Concentration Defined

- Quantitative measurements of solution concentration:
  - **Molarity (M)**
  - % Composition by Mass
  - Parts Per Million (ppm)
- Table T
- Make sure volume is in LITERS (convert mL into L)
- If you are given grams, you will need to convert them to moles. Let's review this…

$$\text{molarity} = \frac{\text{moles of solute}}{\text{liter of solution}}$$

78.65 g $CaCl_2$ = ___________ **moles $CaCl_2$**

Molarity Calculations Practice

- What is the molarity of a solution in which 58 g of NaCl are dissolved in 2.0 L of solution?

- What is the molarity of a solution in which 2.5 moles of $AgNO_3$ is dissolved in 500 mL of solution?

More Molarity Practice

- How many grams of KNO_3 should be used to prepare 2.00 L of a 0.500 M solution?

- To what volume should 5.0 g of KCl be diluted in order to prepare a 0.25 M solution?

Electrolytes

Topic 4

The Electric Pickle!!

Make observations of the pickle.

What is it soaking in?

OBSERVATIONS…

Why do you think this happened?

What is an Electrolyte?

- **electrolytes** it must be able to dissolve in water!
- Forms **ions** in solution by dissociation
  - (ionic = metal + nonmetal)
- CONDUCT ELECTRICITY….but how?
- **An ‘electrolyte’ is a substance that ‘breaks’ into ions when dissolved in water and conducts electricity.**
  - **They can do this because the ions are mobile!**
- Covalent compounds are *never* electrolytes; they do not dissociate into ions. When they dissolve, they stay together as <u>**molecules**</u>

Big Idea

Conductivity

1. There must be ***CHARGED PARTICLES***
   - (ions are an example of a charged particle)
2. The charged particles must be ***ABLE TO MOVE FREELY***
   - (like in a water solution)

Categories of Electrolytes

Electrolytes are classified according to the types of ions formed by the substance when it dissolves.

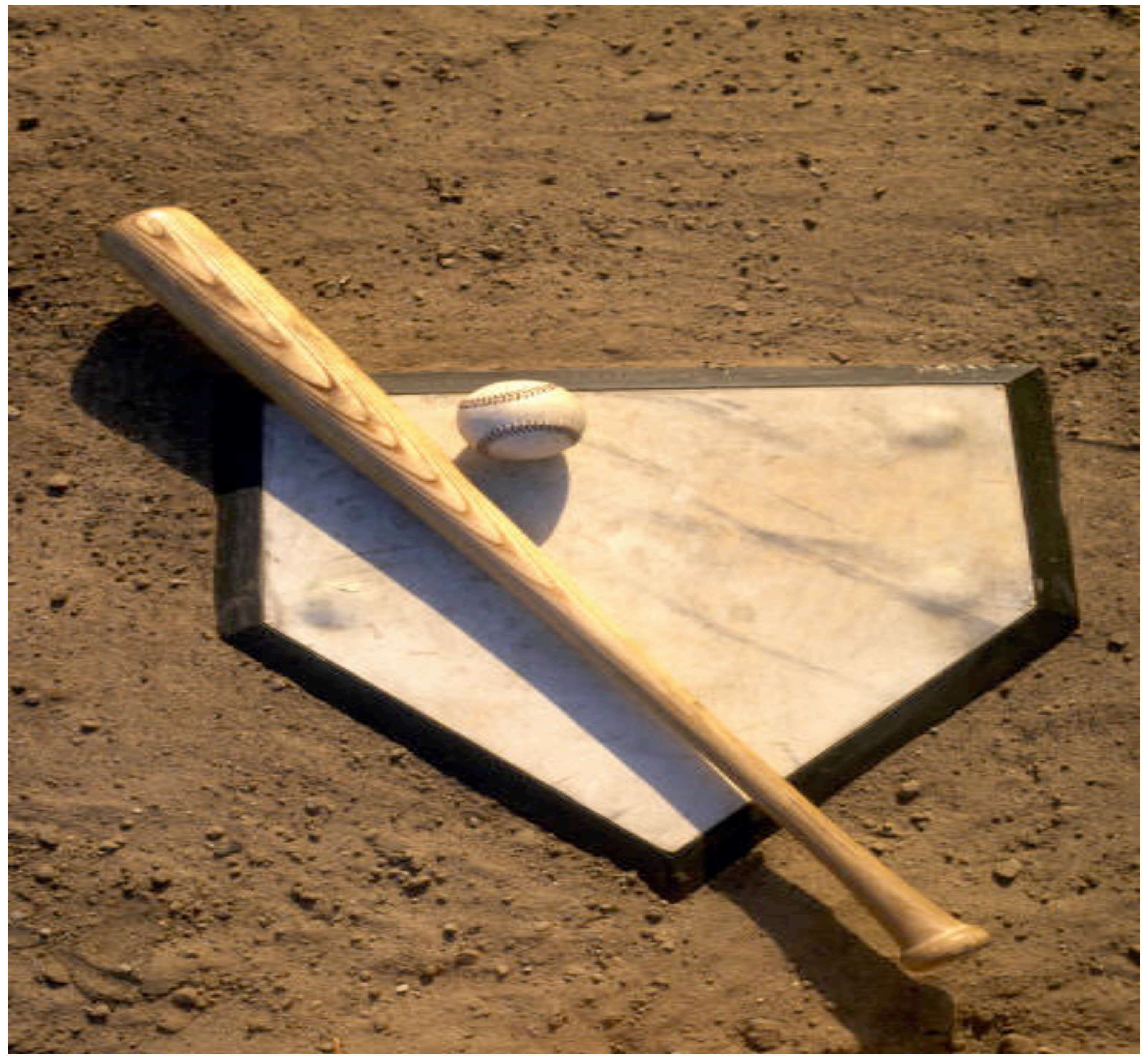
1. *Arrhenius* **Acid** - a substance that dissolves to form H^{+1} ion as the ONLY positive ion in solution. (Look at Table K.)

vinegar contains acetic acid

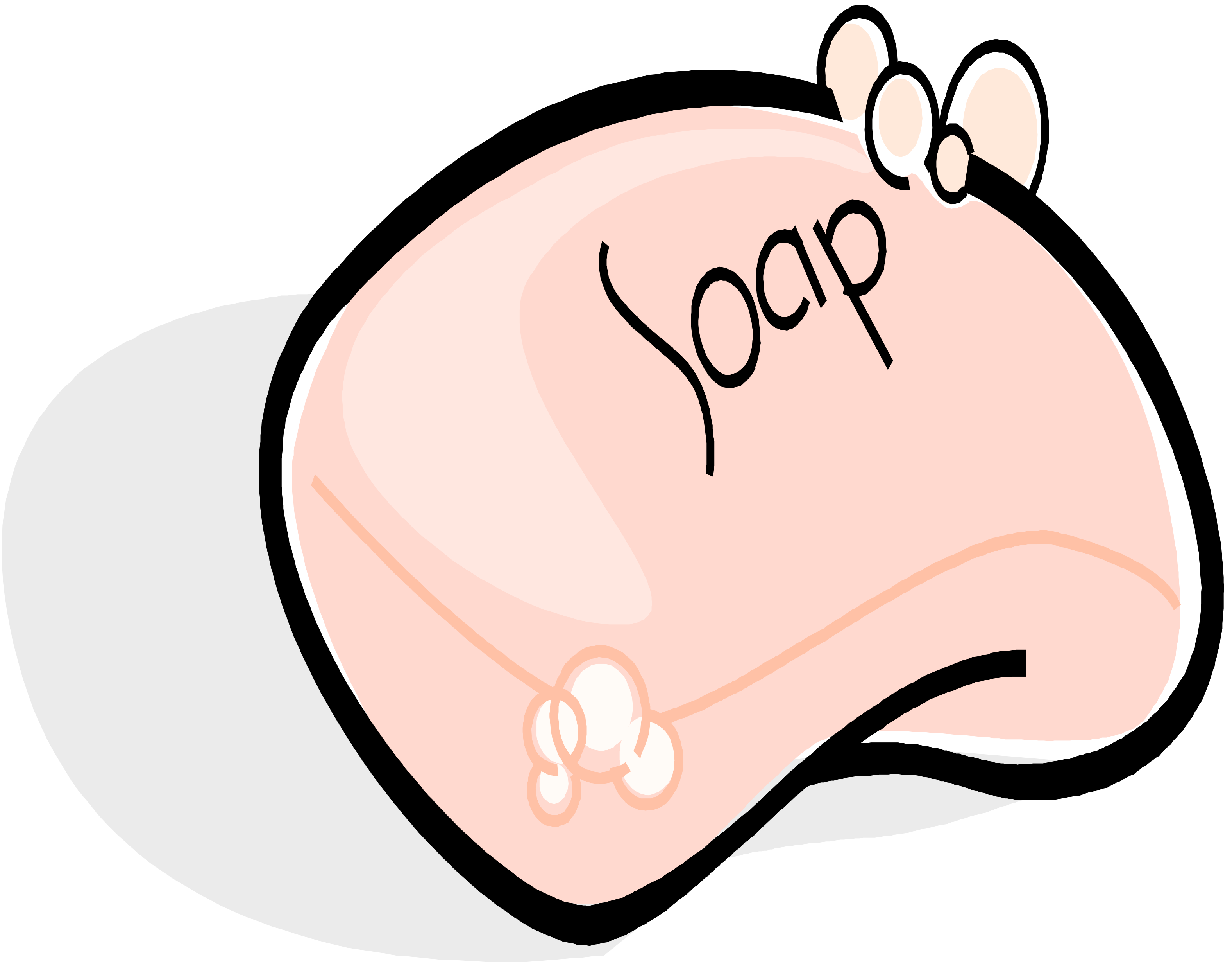
lemons contain vitamin C – ascorbic acid

Electrolyte Categories

2. Arrhenius **Base** - a substance that dissolves to form $(OH)^{-1}$ ion as the ONLY negative ion in solution. (Look on Table L.)



Not that kind of base!



Soap is a base

Electrolyte Categories

3. **Salts** - a substance that dissolves to form a positive ion other than H^{+1} and a negative ion other than $(OH)^{-1}$

Examples of Electrolytes!

Dissolving in water	Type of Electrolyte	Why?
$HCl_{(g)} \rightarrow H^{+1}_{(aq)} + Cl^{-}_{(aq)}$	acid	H^{+1} is the only positive ion in solution
$NaOH_{(s)} \rightarrow Na^{+1}_{(aq)} + (OH)^{-1}_{(aq)}$	base	$(OH)^{-1}$ is the only negative ion in solution
$K(NO_3)_{(s)} \rightarrow K^{+1}_{(aq)} + (NO_3)^{-1}_{(aq)}$	salt	Positive and negative ions other than H^{+1} and $(OH)^{-1}$ are present

Regents Practice!!!

Which formula represents a salt?

1. KOH
2. KCl
3. CH_3OH
4. CH_3COOH

Which substance can be classified as an Arrhenius acid?

1. HCl
2. NaCl
3. LiOH
4. KOH

Properties of Acids & Bases (pH)

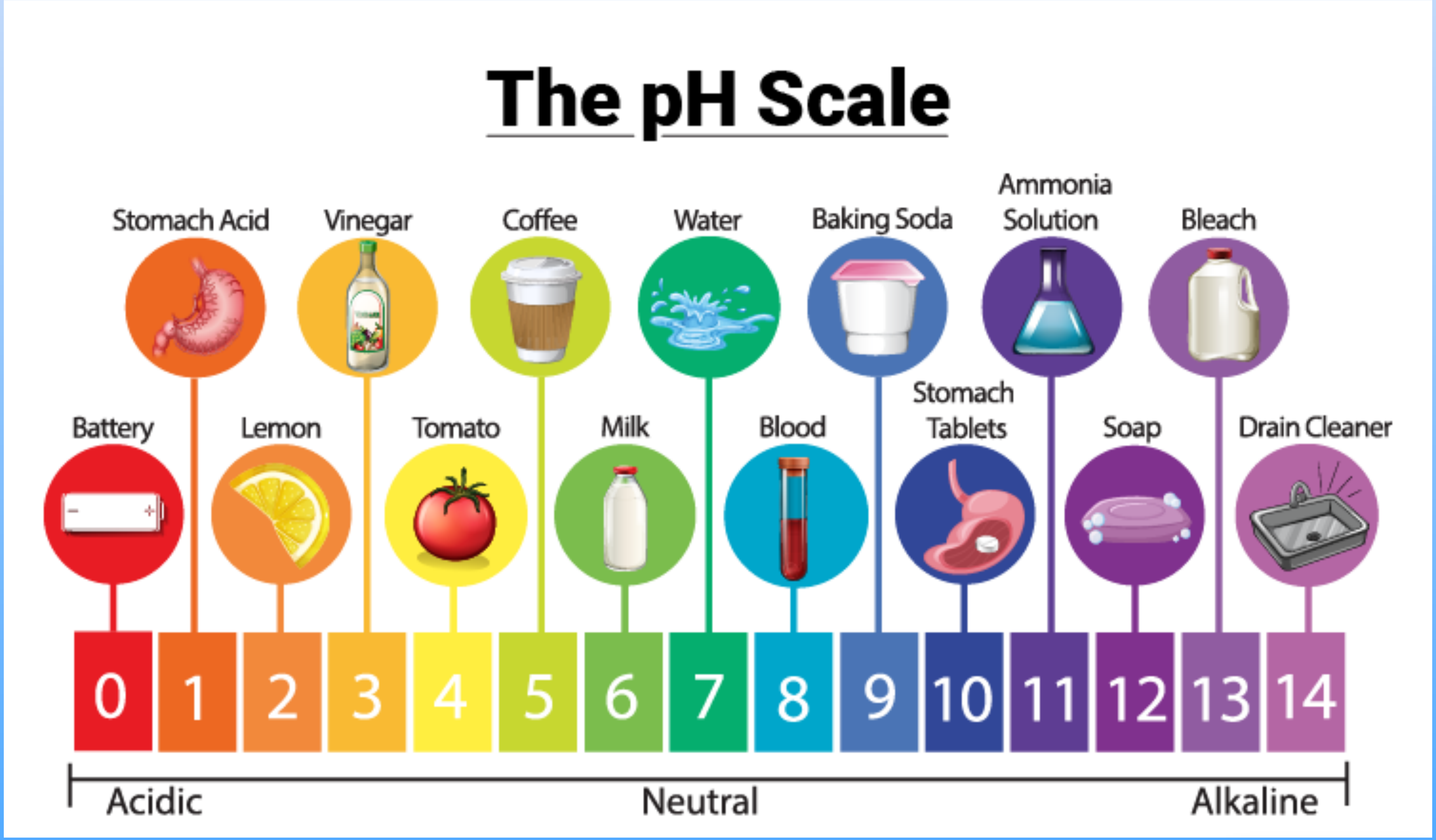
Topic 5

Acid: Dissociate in water to form H^{+1} ions (*H_3O^{+1} or hydronium ion*).

Base: Dissociate in water to form OH^{-1} (hydroxide ion)

There are different categories of acids and bases **depending on how many H^{+1} or $(OH)^{-1}$ ions are present in solution.**

- pH shows acidity or alkalinity of a solution; a pH of 7 is neutral, a pH of less than 7 is acidic, and a pH of greater than 7 is basic



IB: pH = -log[H^+]

- pH is a measure of the concentration of the H^+
- If [H^+] is 1×10^{-1} M, pH = **1**
- If [H^+] is 1×10^{-5} M, pH = **5**
- If [H^+] is 1×10^{-12} M, pH = **12**

Notice that as the [H^+] decreases, the pH increases (the solution becomes more basic)

Properties of Acids & Bases (pH)

Indicators

Table M
Common Acid–Base Indicators

Indicator	Approximate pH Range for Color Change	Color Change
methyl orange	3.2–4.4	red to yellow
bromthymol blue	6.0–7.6	yellow to blue
phenolphthalein	8.2–10	colorless to pink
litmus	5.5–8.2	red to blue
bromcresol green	3.8–5.4	yellow to blue
thymol blue	8.0–9.6	yellow to blue

Exponential Increases in Concentration

- As pH decreases by 1, the [H+] concentration increases by 10
- As pH decreases by 3, the [H+] concentration increases by 1000

Regents Practice

Which pH will turn methyl orange red?

1. 2.5
2. 3.5
3. 4.4
4. 6.7

Neutralization & Titrations

Topic 6

- A **neutralization reaction is a type of** **double replacement** **reaction.** *Salt* and *water* are always formed.

For example:	$Na(OH)$ **base**	+	$H(NO_3)$ **acid**	→	$Na(NO_3)$ **salt**	+	$H(OH)$ **water**

Label these:	H_2SO_4	+	$2\ NaOH$	→	$2\ HOH$	+	$Na_2(SO_4)$
	acid		base		water		salt

Neutralization

When an acid reacts with a base, an ionic salt and water are formed.

$HCl + NaOH \rightarrow$

$HBr + KOH \rightarrow$

$HNO_3 + NaOH \rightarrow$

$H_2SO4 + 2\ KOH \rightarrow$

$2\ HNO_3 + Mg(OH)_2 \rightarrow$

*A solution is neutral when the # of H_3O^+ ions = the # of OH^- ions

Neutralization Example

Example: $\underline{\mathbf{2}}$ HBr + $\underline{\mathbf{1}}$ $Mg(OH)_2$ → $\underline{\mathbf{1}}$ $MgBr_2$ + $\underline{\mathbf{2}}$ H_2O

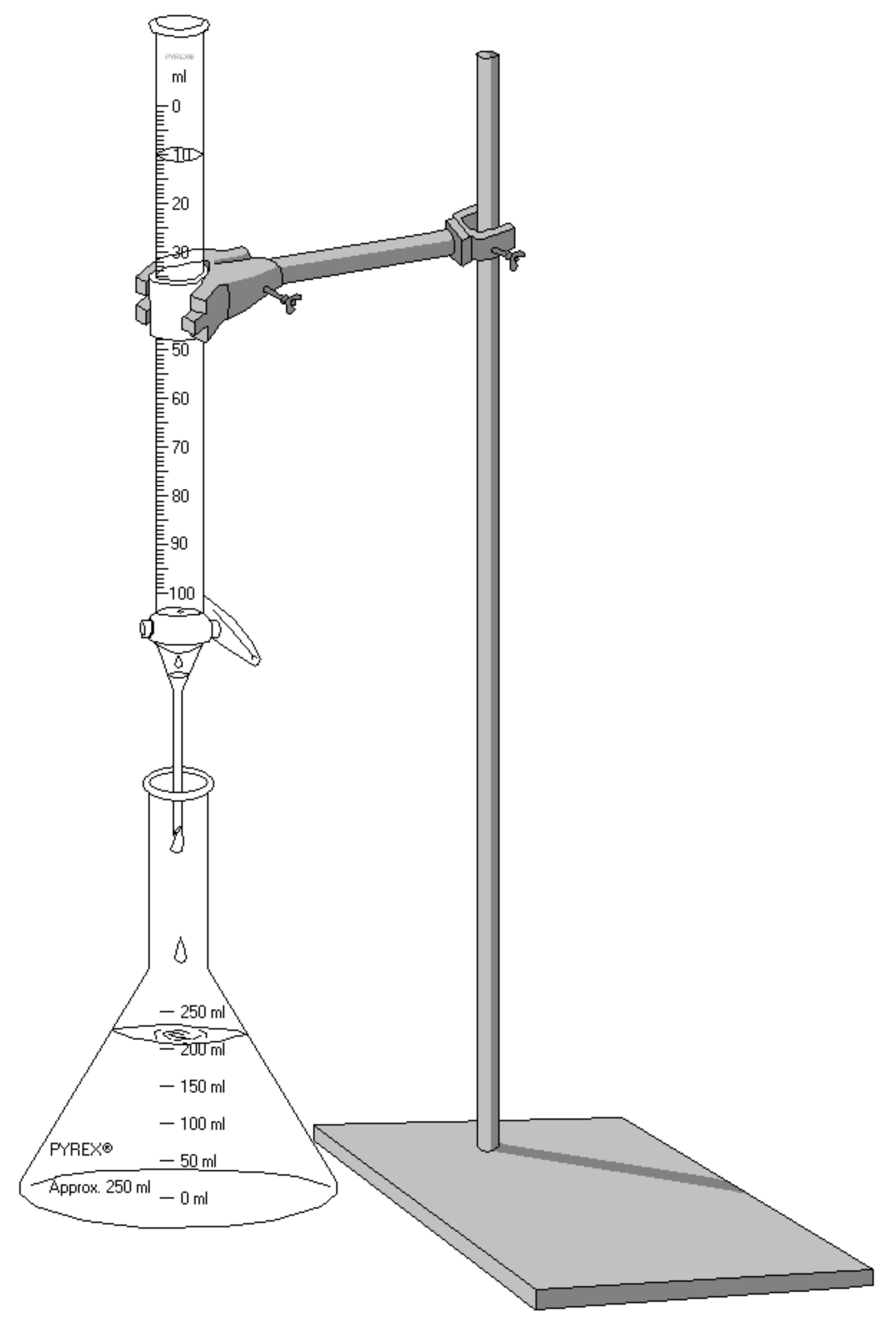
Your Turn → ___ HNO_3 + ___ KOH →

Titration

Online Tutorial

Titration: controlled neutralization (can be seen by a color change)

- Determine unknown concentration



****One unit of H^{1+} is required to wipe out (neutralize) one unit of $(OH)^{1-}$.**

Titrations

In a neutral solution, the moles of H^+ = moles of OH^-

 # moles = Molarity x Volume (# moles = M•V)

Therefore, in a neutral solution: $M_AV_A = M_BV_B$

Example:

If 50.0 milliliters of 3.0 M HNO_3 completely neutralized 150.0 mL of KOH, what was the molarity of the KOH solution?