Water and Solubility

Unit 10

TOPIC 2 - SOLUBILITY

- When oil spills in a body of water, where does it go?
- Clean-up?
- Why is this hard?
- What is oil?
- Compare oil to water…
- Why do you think they don’t mix?

SOLUBILITY - TABLE F REVIEW

- Soluble = CAN dissolve in water. Remain as ions in solution.
- Insoluble = CANNOT dissolve in water. Precipitates as a solid.
- **Practice**

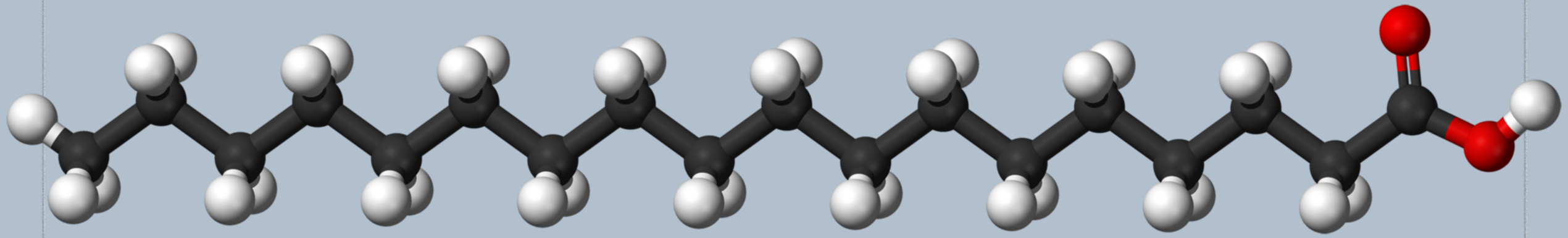
$Pb(NO_3)_2$	$BaSO_4$	ZnS	NH_4NO_3
Soluble	*Insoluble*	*Insoluble*	*Soluble*

"LIKE DISSOLVES LIKE"

- Polar molecules/substances will dissolve in polar solvents (water)
  - Ex: NH_3 will dissolve in H_2O
- Non-polar molecules/substances will dissolve in non-polar solvents (oil)
  - Ex: C_4H_{10} (butane) will dissolve in C_8H_{18} (octane)

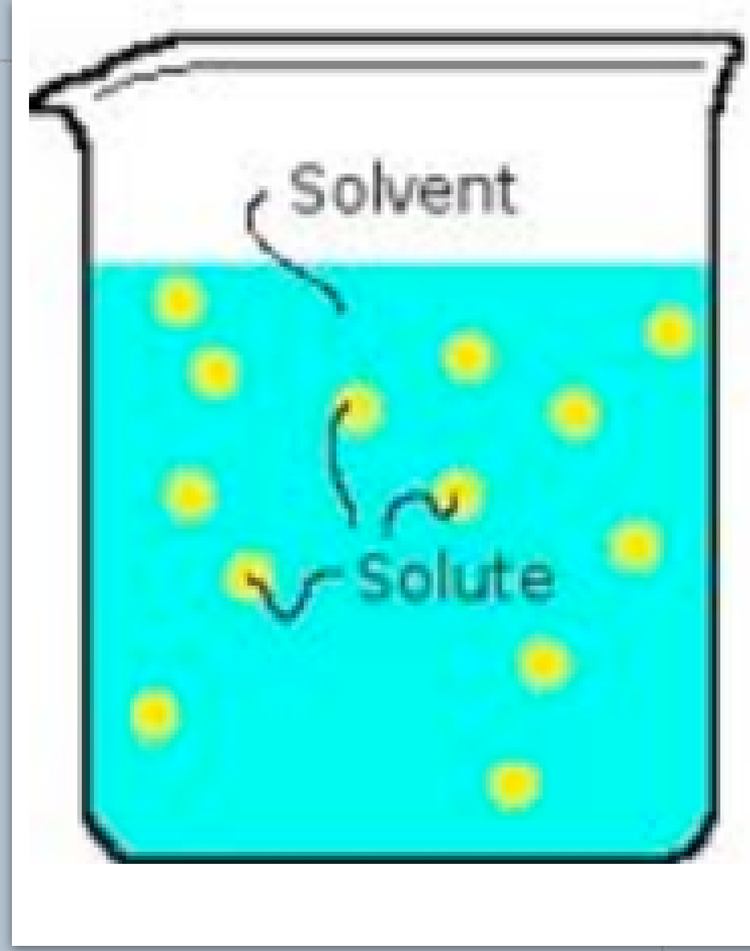
WHAT IS SOAP?

- Soap attaches to the oil and grease molecules and carries them down the drain with the water.



SOLUBILITY

- Solubility = **how much solute will dissolve at a given temperature.**
- **Solute**: the substance being dissolved.
- **Solvent**: the substance doing the dissolving.
- What are 2 things we can do to get a solute to dissolve *faster*?
  - stir / increase surface area
- What is 1 thing we can do to get *more* solute to dissolve in a solvent?
  - increase temperature



SOLUBILITY
TOPIC 2

- **Increasing temperature** will allow more solid or liquid to dissolve in a solvent (not gases)

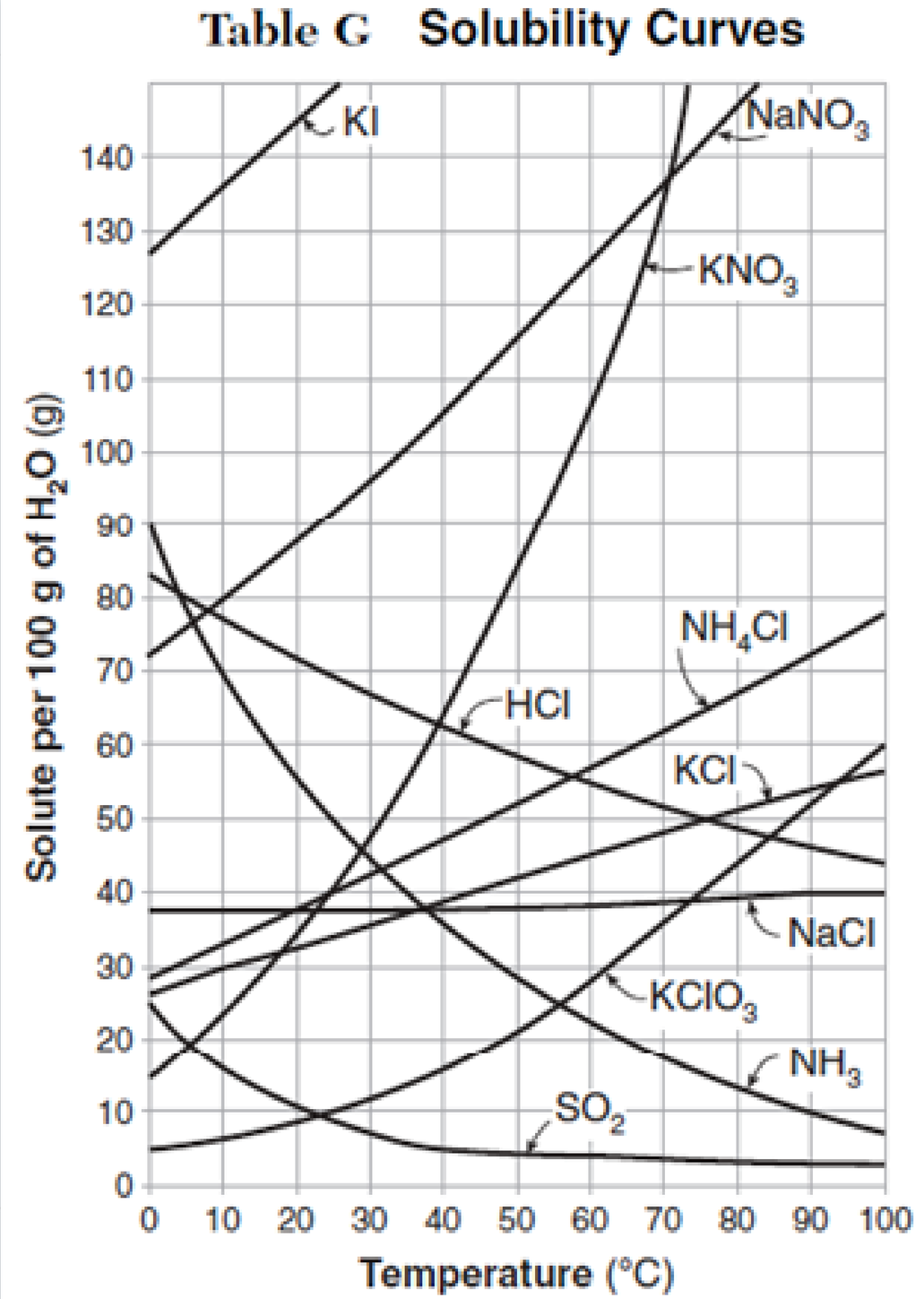


TABLE G

- How much of a substance can dissolve in **100 grams of water!**
- If you're asked how much of a substance can dissolve in **200 grams of water**, you need to DOUBLE YOUR READING
- If you're asked how much of a substance can dissolve in **50 grams of water**, you need to CUT YOUR READING IN HALF!

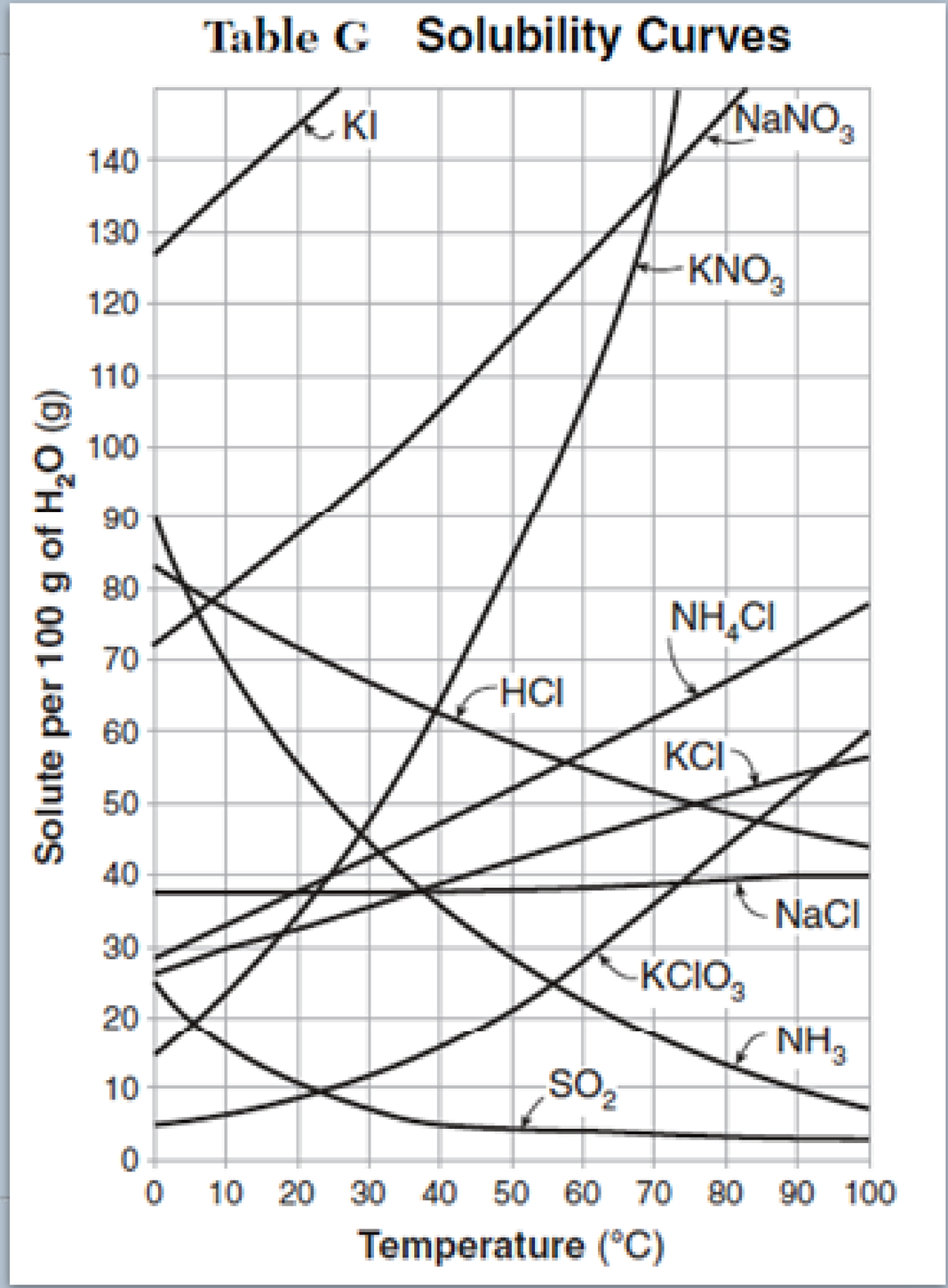


TABLE G - KNO_3

- The curve, shown in red, indicates the amounts of KNO_3 that will be dissolved in 100 grams of solute in a **SATURATED** solution.
- Saturated means? FULL
- The area in blue below the curve, represents possible UNSATURATED SOLUTIONS
- Unsaturated means? NOT FULL
- The area in yellow above the curve represents the amount of dissolved solute required to have a SUPERSATURATED SOLUTION.

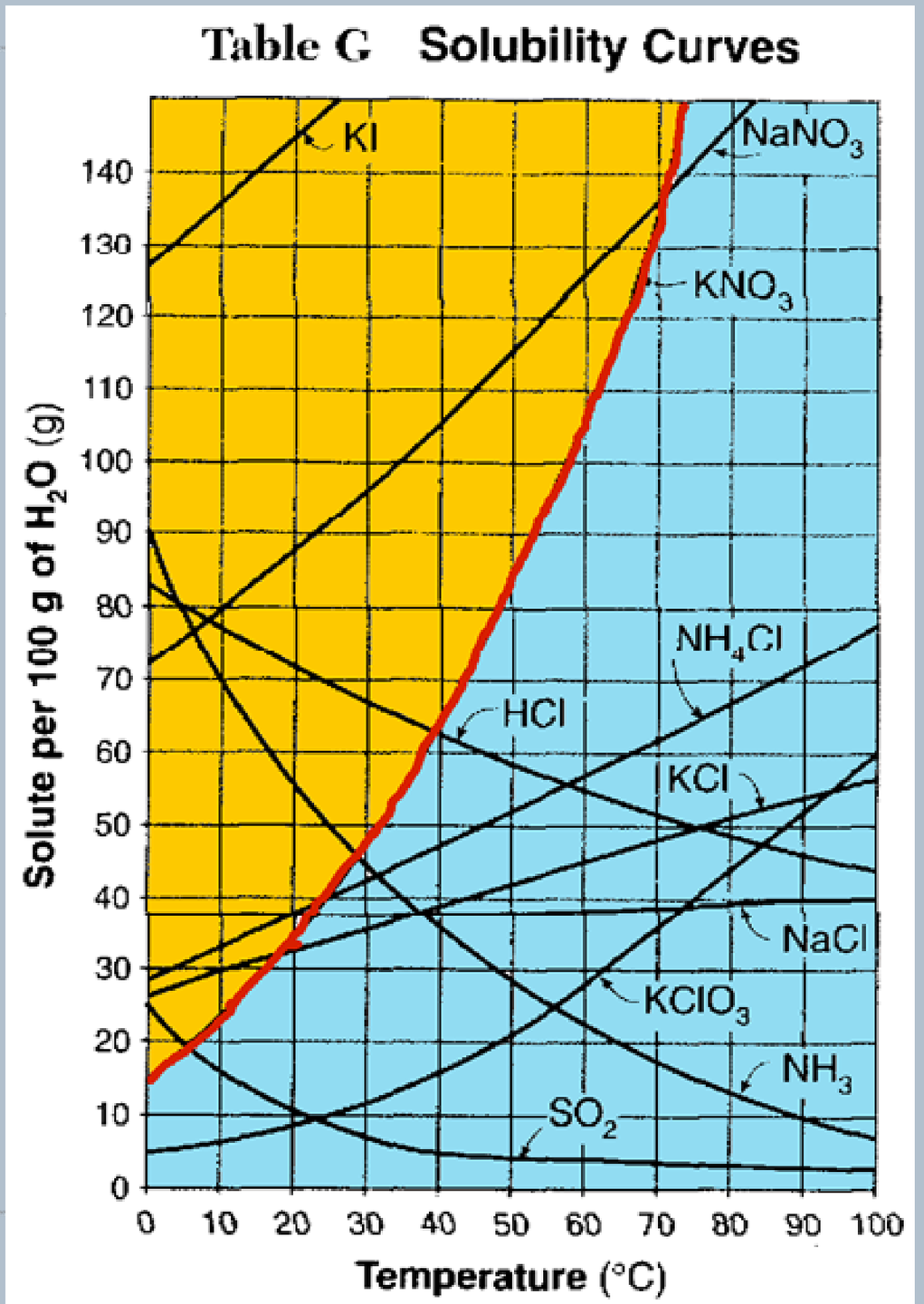


TABLE G - KNO_3

<u>Practice questions</u>:

1. What happens to the solubility of solid KNO_3 as the temperature increases?
2. How many grams of KNO_3 can be dissolved in 100 g of water at 60˚C?
3. How many grams of KNO_3 can be dissolved in 200 g of water at 30˚C?
4. If you try to dissolve 80 grams of KNO_3 at 40˚C, how much will remain undissolved?
5. If a saturated solution of KNO_3 at 70˚C is cooled to 50˚C, how much KNO_3 will precipitate if you started with 100 g of water?
6. If you have an unsaturated solution made from 60 g of KNO_3 and 100 g of water at 50˚C, what are 2 ways you could make this solution saturated?

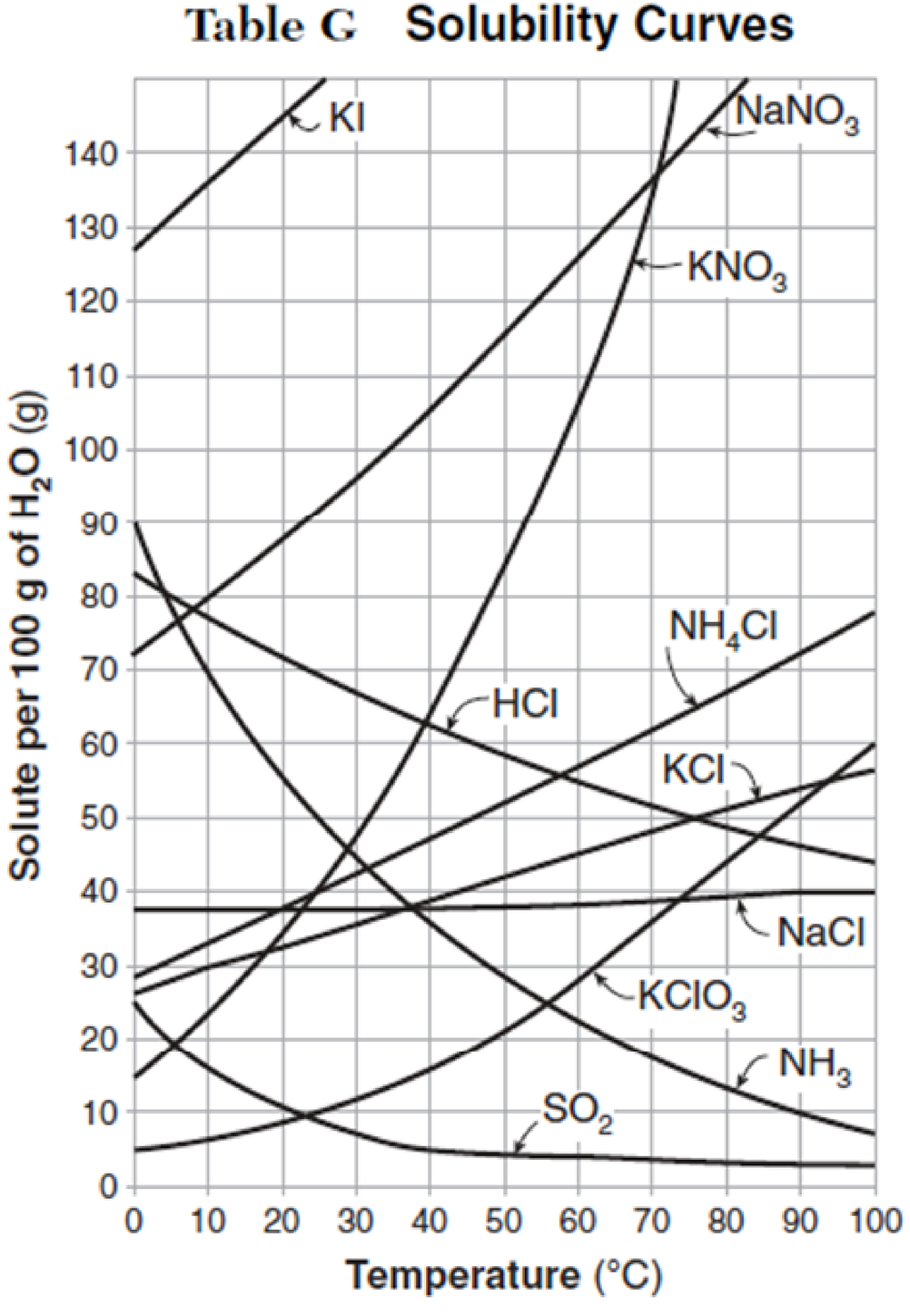
SOLUBILITY OF GASES

- Think about gas particles and how they behave…
- Do you think gas particles dissolve easily into liquids?
- Do you think raising the temperature of a gas will make *more* of it dissolve in liquid (increase solubility) or make *less* of it dissolve in liquid (decrease solubility)?

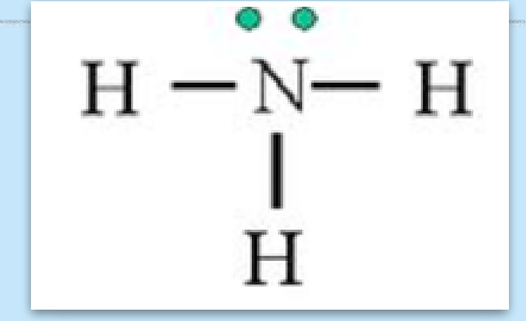
*With higher temperature, the particles move even faster –> gas **really** wants to be free!!*

GASES ON TABLE G

- Which substances on Table G are gases? Explain how you know *in terms of particle behavior*?



TOPIC 3 - ACIDS & BASES

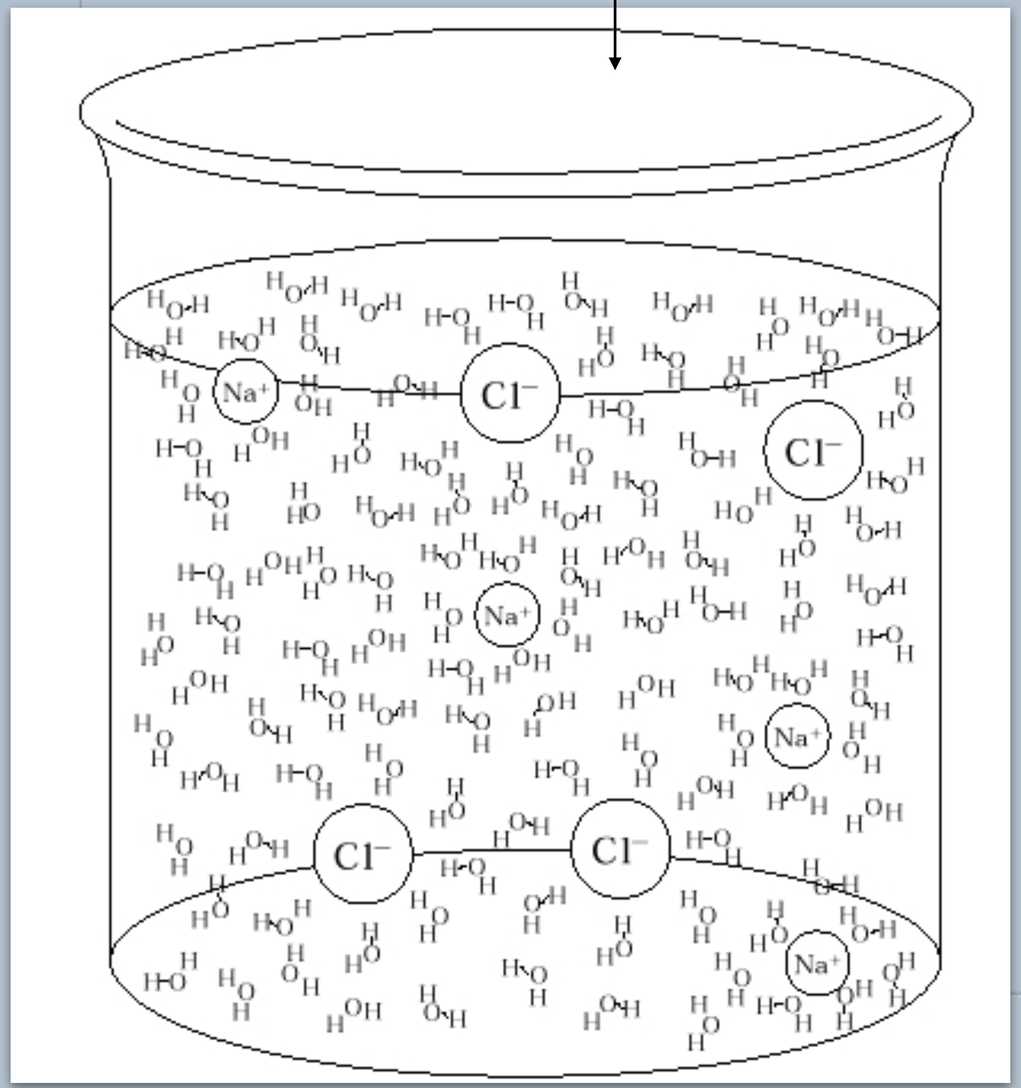


- Remember the Arrhenius theory of acids and bases?
- Which ion do acids make in solution? *H^+ (H_3O^+ hydronium)*
- Which ion do bases make in solution? *OH^- (Hydroxide, table E)*
- Look at Table L. Which base does not fit the Arrhenius theory of bases? Why not?
- What do scientists do if they have a piece of information that does not fit a theory?

New theory?

Adjust theory?

ACIDS & BASES REVIEW



- Define an electrolyte: *a solution that conducts electric current due to dissolved ions (dissociation)*

- *Why will an electrolyte conduct when dissolved?*

charged particles that can move freely

THREE TYPES OF ELECTROLYTES

- **Acid**: H^+/H_3O^+ ion only (+) ion in solution
- **Base**: OH^- ion only (–) ion solution
- **Salt**: any other ionic solution that is not an acid or a base

PROPERTIES OF ACIDS & BASES

Acid	Base
corrosive	caustic
low pH (<7)	high pH (>7)
reacts with metals to make H_2 gas	reacts with organic material
sour	bitter
H^+ / H_3O^+ ions	OH^- ions
	slippery

ACID / BASE THEORIES - SOME NEW STUFF HERE!

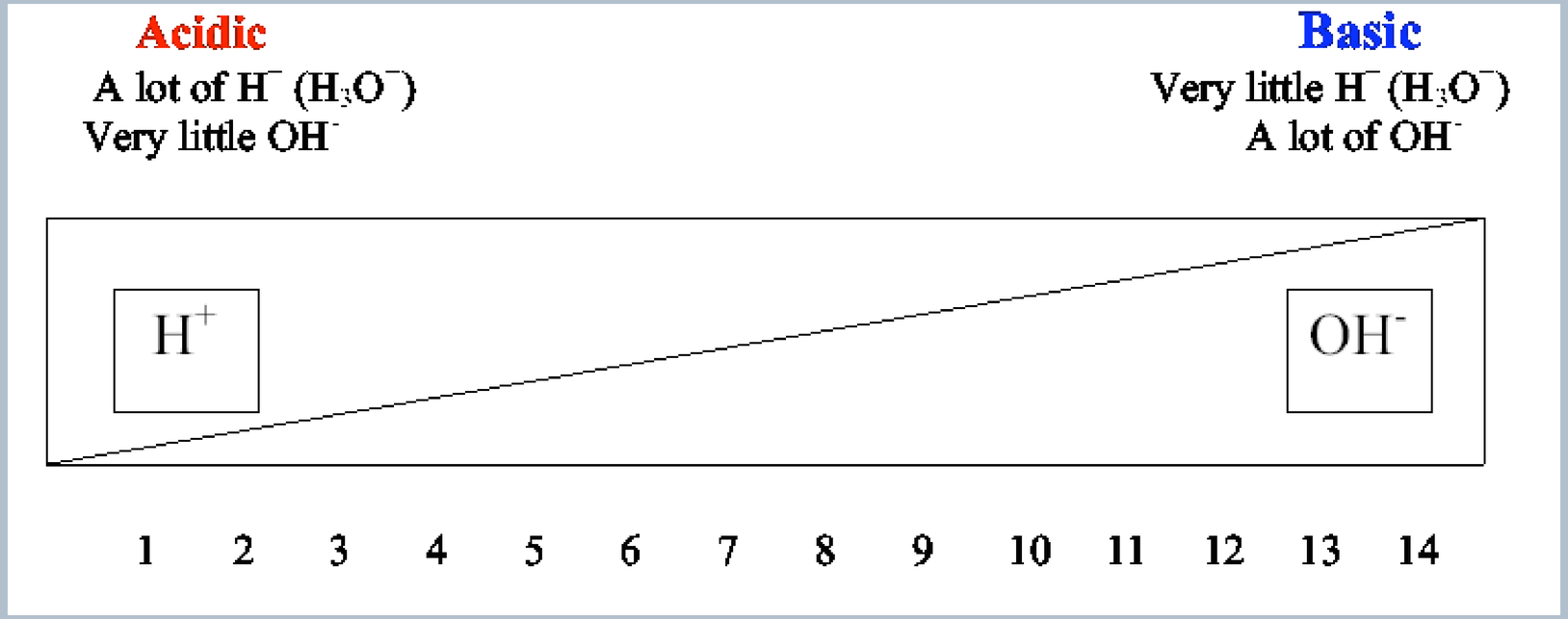
Ahhrenius

- Acid: H^+ only (+) ion
- Base: OH^- only (-) ion

Brønsted Lowry (Alternate Theory)

- *Acid: PROTON donor (H^+ = a proton)*
- *Base: PROTON acceptor (NH_3 can accept a proton to form the ammonium ion NH_4^+ ion)*

pH Scale



- A solution with a pH = 1 is 10 times more concentrated in [H⁺] than a solution with a pH = 2
- A solution with a pH = 2 is 100 times (more/less) concentration in [H⁺] than a solution with a pH = 4.

TABLES K, L, M

- **You drop methyl orange indicator into a solution with a pH of 5. What color is the methyl orange indicator?** *yellow*
- **If bromthymol blue turns yellow when added to a solution, the solution's pH must be:** *less than 6.0*
- ***Neutralization - a type of*** *double replacement* ***reaction.***

Acid + Base → Salt + water

1) $HCl + NaOH \rightarrow$

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

3) $H_3(PO_4) + 3LiOH \rightarrow$

NEUTRALIZATION EQUATION AND TITRATION

- $M_a \times V_a = M_b \times V_b$
  - Use this equation when you see the words neutralize or titrate/titration.
- Solve the Molarity of a solution of NaOH if 75 mL of 2.0 Molar HCl is required to neutralize 25 mL of the NaOH solution.

TOPIC 4 - DETERMINING CONCENTRATION

Percent Composition	$\%\ \text{composition by mass} = \dfrac{\text{mass of part}}{\text{mass of whole}} \times 100$
Concentration	$\text{parts per million} = \dfrac{\text{grams of solute}}{\text{grams of solution}} \times 1\,000\,000$
	$\text{molarity} = \dfrac{\text{moles of solute}}{\text{liters of solution}}$

MOLARITY (REVIEW)

- Remember to convert from grams to moles
- Volume must be in liters

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

MOLARITY PRACTICE

- What is the molarity of a solution made by dissolving 25. grams of $Ca(NO_3)_2$ in enough water to make 500 mL of solution

- How many moles of $Ca(NO_3)_2$ are needed in order to make 1.3 Liters of a 0.80 M solution?

MORE MOLARITY PRACTICE

- Which is more concentrated with HCl?
  500 mL of 1.00 M HCl OR 600 mL of 0.833 M HCl

- Which has more moles of HCl present?
  500 mL of 1.00 M HCl OR 600 mL of 0.833 M HCl

% COMPOSITION BY MASS

$$\%\ \text{composition by mass} = \frac{\text{mass of part}}{\text{mass of whole}} \times 100$$

- Doesn’t matter what the units are for mass, as long as top and bottom are the same.
- Mass of part is usually the SOLUTE
- Mass of whole must include mass of entire solution (Solute + Solvent)

% COMPOSITION BY MASS (PRACTICE)

- *What is the % NaCl by mass of a solution made up of 37 grams of NaCl in 200 grams of water?*

- *What is the % of KCl by mass in a saturated solution of KCl at 60°C? (Hint: use table G!)*

PARTS PER MILLION (PPM)

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

- Use same equation as "% mass" except multiply by 1,000,000 instead of 100
- ppm is only used for VERY dilute solutions, so mass of solute is usually VERY small compared to whole solution (so you don't need to include solute mass in the denominator).

PPM PRACTICE

- *What is the concentration in ppm of 0.0001 grams of KNO_3 in 100 grams of water?*

- *If 0.034 grams of mercury are found in 1000 grams of water, how many parts per million of mercury is present?*

PPM PRACTICE

- *If a sample of lake water is 0.025% by mass of toxic Pb^{+2} ions, what are the 'ppm' of lead ions in that water? (Hint: assume a 100 g sample)*

TOPIC 5 - COLLIGATIVE PROPERTIES

- ***Why do we put salt on the roads in the winter? What does it do?***

- ***Why do we put antifreeze in our cars? What does it do in the winter?***
- ***What does antifreeze do in the summer?***

- *Can you explain the effects of antifreeze or road salt in terms of particles?*

COLLIGATIVE PROPERTIES

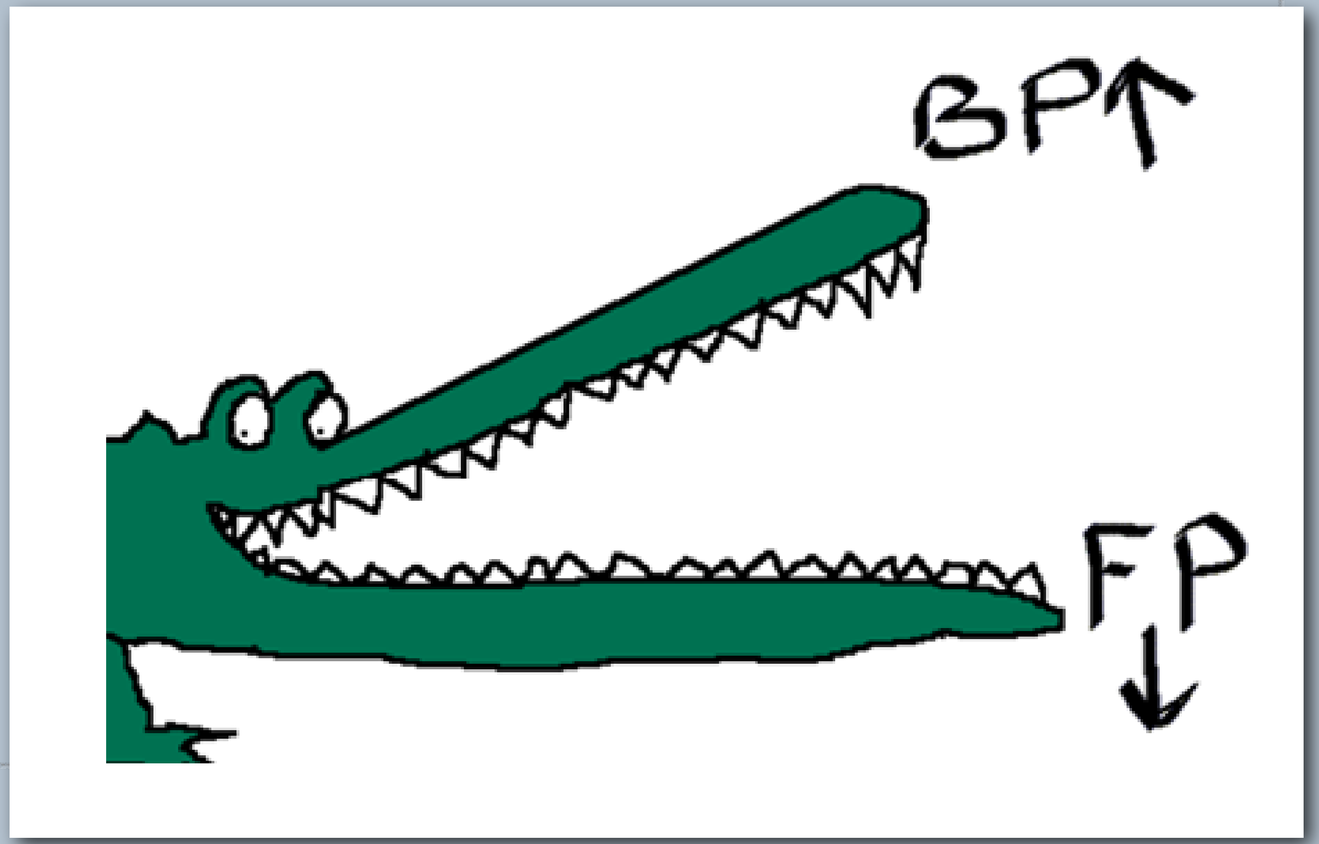
- *Adding a solute to a solvent results in Colligative Properties*
- *** The more solute particles you add, the greater the effect!!*

FREEZING POINT DEPRESSION

- *Depression means: getting lower, going down*
- *Adding solute lowers the freezing point!*

BOILING POINT ELEVATION

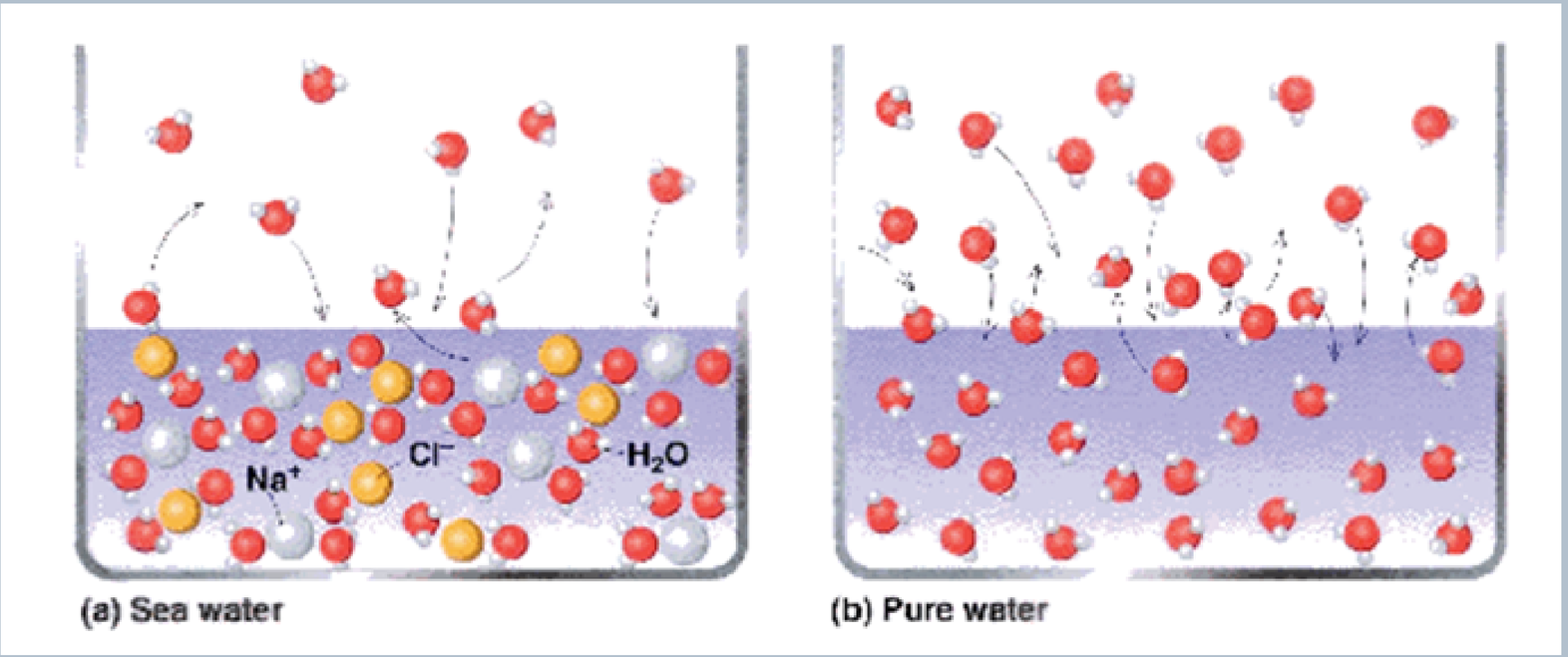
- *Elevation means: getting higher, going up*
- *Adding solute raises the boiling point!*



WHY?? HOW DO COLLIGATIVE PROPERTIES WORK?

- *Solute particles add 'clutter' to the solution (more particles = more clutter)*
- *Interferes with solvent particles*
- *Solvent can't easily crystallize into a solid (freeze) or escape as a vapor (boil)*

HOW THEY WORK …



- *The more ions a solute makes, the more 'clutter', so the greater the effect on lowering the freezing point or raising the boiling point … Let's practice…*

PRACTICE PROBLEMS

- *How many ions does $BeCl_2$ break apart into? Write the dissociation equation:*

- *How many ions does $Na_3(PO_4)$ break apart into? Write the dissociation equation:*

- *Which of the above solutes would have the greatest effect on colligative properties? Why?*

PRACTICE PROBLEMS

- *What about the following…. which would have the greatest effect on colligative properties? Why?*
  - *1.0 M LiBr*
  - *0.5 M LiBr*
  - *1.0 M $BeCl_2$*
  - *0.5 M $BeCl_2$*