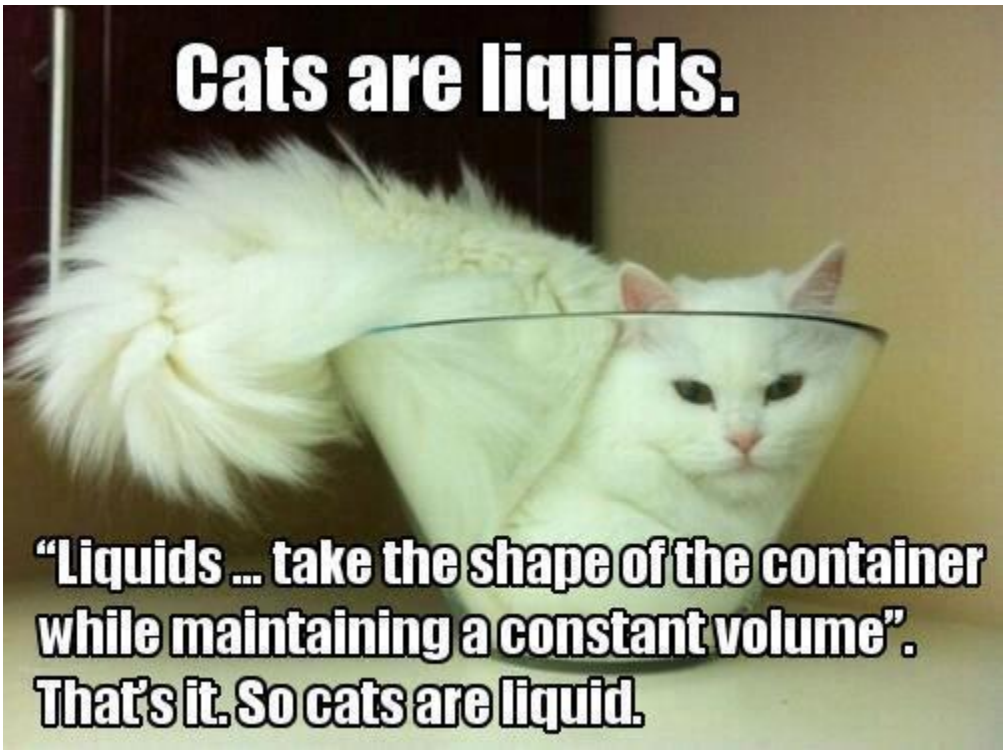
Name:

Regents Chemistry:

Notes: Unit 9 Solutions



KEY IDEAS

- Matter is classified as a pure substance or as a mixture of substances. (3.1q)
- Mixtures are composed of two or more different substances that can be separated by physical means. When different substances are mixed together, a homogeneous or heterogeneous mixture is formed.(3.1s)
- The proportions of components in a mixture can be varied. Each component in a mixture retains its original properties. (3.1t)
- The three phases of matter (solids, liquids, and gases)have different properties.(3.1kk)
- Differences in properties such as density, particle size, molecular polarity, boiling point and freezing point, and solubility permit physical separation of the components of the mixture. (3.1nn)
- A solution is a homogeneous mixture of a solute dissolved in a solvent. The solubility of a solute in a given amount of solvent is dependent on the temperature, the pressure, and the chemical natures of the solute and solvent. (3.1oo)
- The concentration of a solution may be expressed as molarity (M), percent by volume, percent by mass, or parts per million (ppm). (3.1pp)
- The addition of a nonvolatile solute to a solvent causes the boiling point of the solvent to increase and the freezing point of the solvent to decrease. The greater the concentration of particles, the greater the effect. (3.1qq)

Vocabulary:

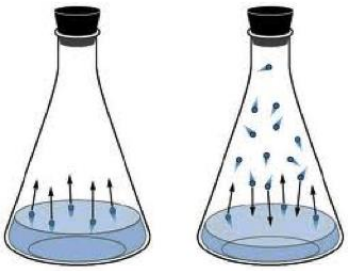
Word	**Definition**
Aqueous	A solution in which the solvent is water.
Colligative property	A property of a solution that is dependent on concentration. Examples include boiling point, freezing point and vapor pressure.
Concentration	A measure of the amount of substance per unit volume.
Electrolyte	A substance which when dissolved in water conducts electricity.
Mixture	Matter of different types that are in physical proximity to each other, yet not chemically combined.
Molarity	The concentration of a solution measured in moles of solute per liter of solution.
Nonelectrolyte	A substance which when dissolved in water does not conduct electricity.
Parts per million	The concentration of a solution measured in mass of solute per mass of solution multiplied by one million.
Percent by mass	The concentration of a solution measured in mass of solute per mass of solution multiplied by one hundred.
Percent by volume	The concentration of a solution measured in volume of solute per volume of solution multiplied by one hundred.
Precipitate	A solid produced during a chemical reaction in a solution.
Saturated	A solution that has the maximum concentration of solute possible in a given quantity of solvent at a given temperature, a solution at equilibrium.
Solubility	The maximum quantity of solute that can be dissolved in a given quantity of solvent at a given temperature to make a saturated solution.
Solute	A substance that is torn apart and kept separate by solvent particles.
Solution	A homogeneous mixture formed from a solute dissolved into a solvent.
Solvent	A substance that attaches to solute particles, tears them apart from each other and keeps them apart.
Supersaturated	A solution in which there is an excess of solute beyond the solubility point for a given temperature. Either the excess will precipitate or it will remain precariously dissolved until the solution is agitated, whereupon the excess will precipitate out.
Unsaturated	A solution in which there are still solvent particles free to attach to and dissolve more solute particles.

Objective:

- ***Differentiate between evaporation and boiling***
- ***Determine effects of vapor pressure on boiling point***

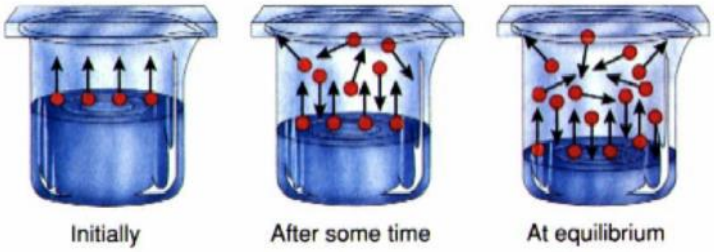
EVAPORATION: Molecules at the surface of liquid gain enough energy to overcome their IMF's and change to gas which causes pressure to build up above liquid (vapor pressure)

VAPOR PRESSURE: The pressure exerted by vapor (gas) above a liquid at equilibrium



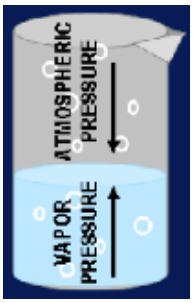
LIQUID-VAPOR EQUILIBRIUM: Some of the gas particles condense and then we find <u>both evaporating and condensing occurs at the same rate.</u>

Rate of Evaporation = Rate of Condensation



BOILING:

- Boiling occurs when the **vapor pressure** becomes **equal** to or greater than the **atmospheric pressure**.
- At normal atmospheric pressure, we call this **<u>normal boiling point</u>**.



PRESSURE EFFECTS ON BOILING PT:

- At higher altitudes, such as Denver Colorado, air pressure is much lower due to decreases in amount of air molecules. Therefore, water boils at a lower temperature and food takes longer to cook.
- At lower altitudes the opposite is true.

BOILING AND ATTRACTIVE FORCES (IMF'S):

Boiling occurs when heat energy overcomes attractive forces between molecules.

IMF	Effect on Boiling Pt	Reason
The stronger the IMF	The higher the boiling pt	Takes **MORE** energy to break the forces of attraction (IMF's) between particles
The weaker the IMF	The lower the boiling pt	Takes **LESS** energy to break the forces of attraction (IMF's) between particles

EVAPORATION VS BOILING:

- Evaporation occurs on the surface
- Boiling occurs throughout the sample

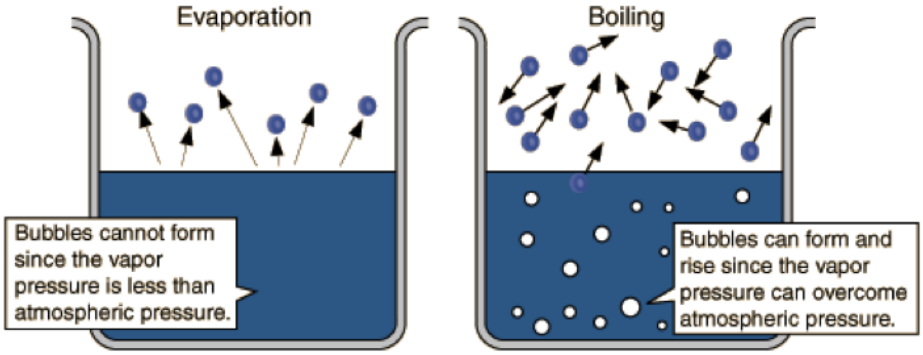
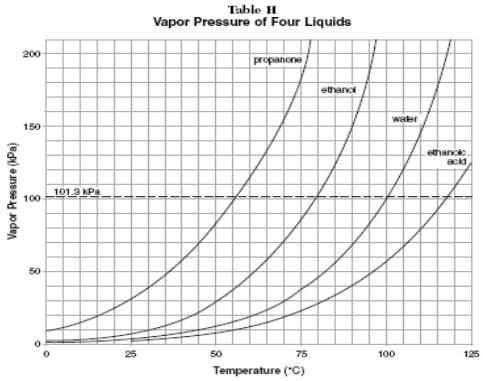
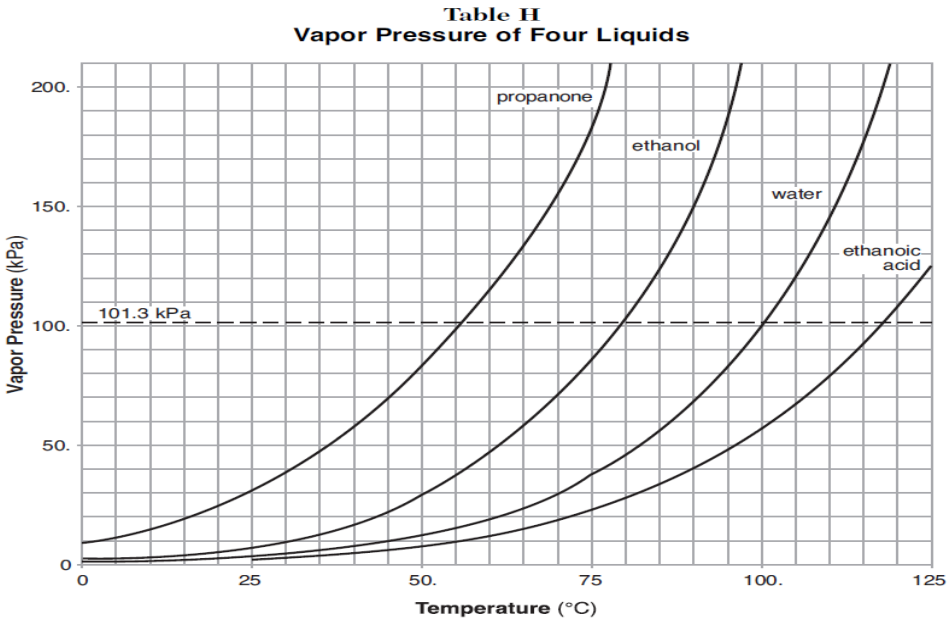


TABLE H: VAPOR PRESSURE

- The dotted line represents normal boiling point



EXAMPLE: What is the vapor pressure of ethanol at 40°C?



Lesson 2: Solutions and Solubility

Objective:

- ***Use Table F to determine solubility***
- ***Compose double replacement reactions and determine the precipitate***

SOLUTION: Homogenous Mixture

- **SOLUTE:** dissolved substance
- **SOLVENT**: substance solute is dissolved in

Ex. $NaCl_{(s)} + H_2O_{(l)} \longrightarrow NaCl_{(aq)}$

SOLUBILITY: Ability to dissolve (physical property)

- SOLUBLE: substance dissolves well
- INSOLUBLE: substance doesn't dissolve (stays solid)

TABLE F: Tells you whether ionic compounds are soluble or **<u>insoluble</u>** ***(precipitate)***

- If substance is in **<u>soluble</u>** column it dissolves in H_2O (aq)
- If substance is in **<u>insoluble</u>** column it doesn't dissolve (s) this is called a ***precipitate.***

***If substance is in exceptions column it is the opposite

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

EXAMPLE: Is $AgNO_3$ soluble or insoluble?

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*compounds having very low solubility in H_2O

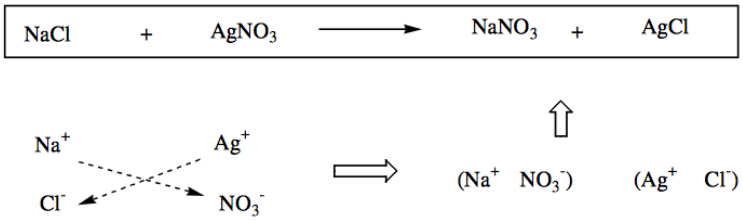
EXAMPLE (EXCEPTION): Determine which product is the precipitate.

$AgNO_{3(aq)} + PbCl_{2(aq)} \longrightarrow AgCl + Pb(NO_3)_2$

DOUBLE REPLACEMENT REACTIONS:

- 2 aqueous IONIC compounds mixed together
- Reactants Switch partners
- 1 product must form a precipitate (insoluble solid) for reaction to take place
- Table F tells you whether products are soluble or insoluble

How to complete a Double Replacement Reaction



1. Positive ions switch partners
2. Look up oxidation states and perform criss cross to make new products.
3. Use table F to determine which (if any) product forms a precipitate.

EXAMPLE: Complete the following double replacement rx and determine the insoluble product:

$NaNO_{3(aq)} + AlPO_{4(aq)} \longrightarrow$

EXAMPLE: Complete the following double replacement rx and determine the insoluble product:

$NaCl_{(aq)} + Ag_2SO_{4(aq)} \longrightarrow$

Objective:

- ***Identify the factors which affect solubility of a solute in a solvent.***
- ***Identify factors that affect the rate of dissolving.***

FACTORS THAT AFFECT SOLUBILITY

1. NATURE OF THE SOLVENT:

"Like Dissolves Like"

- Polar solutes dissolve in polar solvents
- Non polar solutes dissolve in non polar solvents

***Unlike Substances DO NOT Dissolve:

- Ex. Oil (non-polar) and Water (polar)

2. TEMPERATURE: SOLIDS

- As Temperature INCREASES Solubility INCREASES
  Example: Sugar in water
  Why?
- Energy (heat) is required to break the bonds holding the molecules in the solid together

TEMPERATURE: GASES

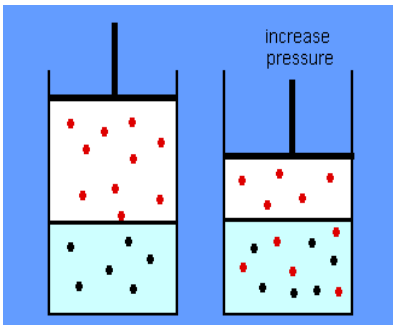
- As Temperature INCREASES Solubility DECREASES
  Example: Warm soda goes flat
  Why?
- Higher temp INCREASES Kinetic Energy (movement) which breaks the IMF's and allows molecules to escape from solution as gas.

3. **PRESSURE: SOLIDS/LIQUIDS**

   As Pressure changes, solubility does not change

PRESSURE: GASES

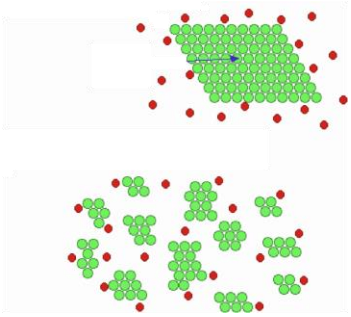
- As Pressure INCREASES Solubility INCREASES
  Why?
- The increase in pressure forces gas particles into solution



<u>FACTORS THAT AFFECT SPEED (RATE) OF DISSOLVING</u>

1. **SURFACE AREA:** As surface area INCREASES rate of dissolving INCREASES

   Example: Sugar granules vs sugar cubes



2. **STIRRING:** Stirring INCREASES the RATE of dissolving. Makes solute come in contact with solvent faster

Objective:

- ***Determine if a solution is saturated, unsaturated or supersaturated using Table G***
- ***Determine how much of a solute can dissolve, will precipitate etc. using Table G***

TYPES OF SOLUTIONS:

UNSATURATED: More solute can be dissolved

SATURATED: No more solute can be dissolved

SUPERSATURATED: Becomes unstable, crystals form

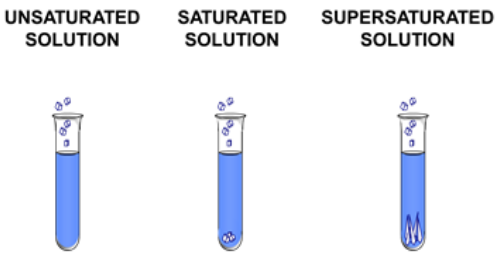
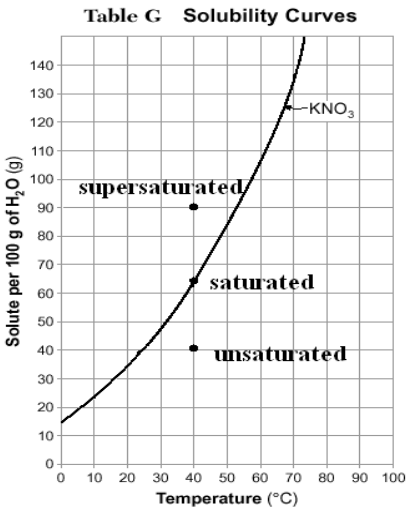


Table G: Solubility Curves

Gases on Table G:

- Three lines show decreasing solubility with increasing temperature. These three lines represent gases NH_3, HCl, and SO_2.
- Remember the solubility of all gases decreases with increasing temperature. Why?



To determine type of solution Table G:

1. locate the temp. in the question
2. go up the temp. line
3. STOP when you reach the grams of solute in question
   - ☐ If you stop ON the curve Saturated
   - ☐ UNDER the curve Unsaturated
   - ☐ ABOVE the curve Supersaturated

EXAMPLE 1: TYPE OF SOLUTION

If you dissolve 50g of $NaNO_3$ at 30°C what type of solution did you make?

Unsaturated

EXAMPLE 2: HOW MUCH WILL DISSOLVE?

According to table G, what is the maximum amount of KNO_3 that can be dissolved in 100 g H_2O at 60°C?

105 grams

EXAMPLE 3: ADDING SOLUTE TO AN UNSATURATED SOLUTION

A solution of KCl contains 20.g of KCl in 100g of H_2O at 30. C. How many more grams of KCl must be added to make it saturated?

15 grams

EXAMPLE 4: COOLING A SOLUTION HOW MUCH WILL PRECIPITATE OUT?

A saturated solution of KNO_3 is cooled from 70. C to 25. C. How much of the KNO_3 will precipitate (become solid, settle out)?

95 grams

EXAMPLE 5: IF PROBLEM DOES NOT USE 100 GRAMS OF SOLVENT (H_2O)

According the reference table G, the amount of NH_3 that can be dissolved in 200g of water at 30°C is?

45 grams in 100 grams water (If you double the solvent you can dissolve 2x as much solute)

Answer: 90 grams

Objective:

- ***Calculate the concentration of various solutions***

CONCENTRATION:

DILUTE: little solute in solution
CONCENTRATED: lots of solute in solution

Percent by Mass & Percent by Volume

EXAMPLE (PERCENT BY MASS):
What is the percent by mass of glucose if 2.8 grams of glucose is dissolved in a 100g solution?

$$\% \text{ mass} = \frac{2.8 \text{ g glucose}}{100 \text{ g solution}} \times 100 = 2.8 \% \text{ glucose}$$

EXAMPLE (PERCENT BY VOLUME):
What is the percent by volume of alcohol if 40.0 mL of acetone is diluted with water to form a total volume of 300. mL?

$$\frac{40.0 \text{ mL}}{300. \text{ mL}} \times 100 = 13.3 \%$$

PARTS PER MILLION (PPM)

EXAMPLE: *A sample of water is found to contain 0.010 g lead in 15. g solution. What is the concentration in ppm?*

$$ppm = \frac{0.010g}{15.g} \times 1{,}000{,}000 = 670 \text{ ppm}$$

MOLARITY

EXAMPLE: A solution has a volume of 2.5 liters and contains 0.70 mol of NaCl. What is the molarity?

$$M = \frac{.70 \text{ mol}}{2.5 \text{ L}} = 0.28M$$

Lesson 6: Colligative Properties.

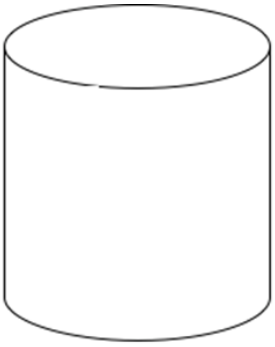
Objective:

- ***Differentiate between boiling point elevation and freezing point depression and the factors that influence them***

COLLIGATIVE PROPERTY: Property that depends on the **CONCENTRATION** of solute particles, not their identity

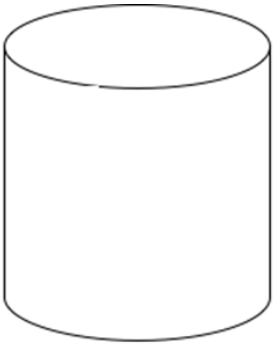
BOILING POINT ELEVATION: Boiling Point **INCREASES** when solute is added

- Ex: Adding salt to water allows you to boil pasta at 102-103ºC

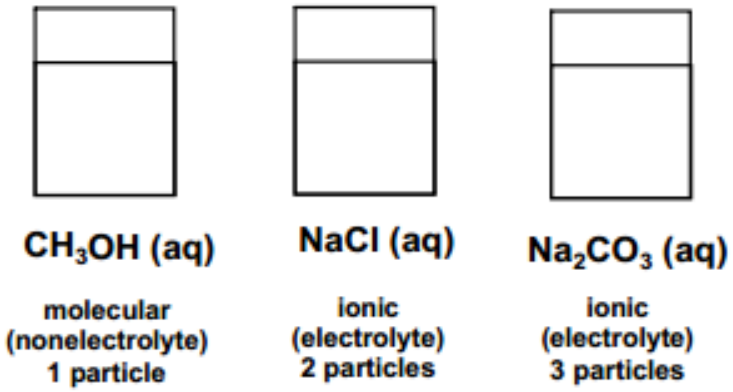


FREEZING POINT DEPRESSION: Freezing Point **DECREASES** when solute is added

- Ex: Putting salt on roads causes ice to melt because it drops the freezing point below 0ºC.



- The MORE PARTICLES the GREATER the effect on MP and BP



EXAMPLE:

Which compound when dissolved in water, will have the highest boiling point?

A. $CaCl_2$

B. NaCl

C. $C_6H_{12}O_6$

D. NaI