Solutions:

Unit 7

Chapter 14 in textbook

GOALS: Students will be able to answer the questions: What is a solution? How can the concentration of a solution be expressed? How does the addition of solutes affect the freezing and boiling points of the solvent?

LEARNING TARGETS:I CAN…

1. Explain that a solution is a homogeneous mixture of a solute dissolved in a solvent. The solubility of a solute in a given amount of solvent depends on the temperature, pressure and the chemical nature of the solvents.
2. Explain the differences in properties such as density, particle size, molecular polarity, boiling and freezing point and solubility permit physical separation of the components of a mixture.
3. Define an electrolyte as a substance, which when dissolved in water, forms a solution capable of conducting an electric current. The ability of a solution to conduct an electric current depends on the concentration of ions.
4. Describe the preparation of a solution, given the molarity.
5. Apply the saying "like dissolves like" to real world situations, such as dry cleaning
6. Interpret solution concentration data:
   a. Given an amount of solute and an amount of solvent, determine whether the solution is saturated, unsaturated, or supersaturated.
   b. Given data for the amounts of solute and solvent in each solution, determine which solution is more concentrated.
7. Calculate solution concentrations in molarity (M), percent by mass, and parts per million (ppm)
8. Interpret and construct solubility curves
9. Use Solubility curves to distinguish among saturated, unsaturated and supersaturated solutions.
10. Use table F to determine what ions and compounds are soluble or insoluble.
11. Describe the effect adding a solute has on the boiling and freezing points of the solvent.
12. Compare/ contrast the effect of a molecular solute with the effects of ionic solutes on the boiling and freezing points a solvent.

	Vocabulary term	Definition	EITHER definition in your own words or picture/ formula
1	Solution	a homogeneous mixture with one substance dispersed uniformly throughout another. CAN NOT be separated by filtration.	
2	Solute	the substance that is dissolved. If two liquids are mixed, the liquid present in the smaller amount is the solute	
3	Solvent	the substance that des the dissolving, usually water. If two liquids are mixed, the liquid present in the larger amount is the solvent.	
4	Soluble	something CAN dissolve	
5	Insoluble	something cannot dissolve	
6	Solubility	the maximum amount of a substance that can be dissolved in a specific amount of a solvent at a particular temperature	

		Definition	EITHER definition in your own words or picture/ formula
7	Saturated	a solution in which no more solute can be dissolved	
8	Unsaturated	a solution in which you can dissolved more solute	
9	Supersaturated	a solution that contains more dissolved solute than a saturated solution contains under the same conditions. This happens when a solution which was saturated at one temperature is cooled to a lower temperature; the addition of a single grain of solute will cause the unstable solution to precipitate solute until the solution is just saturated at the lower temperature.	
10	Electrolyte	a substance that , when dissolved in water, produce a solution that conducts electricity due to the presence of mobile ions. Soluble ionic substances are electrolytes	
11	Non-Electrolyte	Cannot conduct electricity when dissolved in water. Molecular substances are NON-electrolytes.	
12	"Like dissolves Like"	a general rule describing which substances will dissolve in another substance. Two molecular (covalent) substances are likely to dissolve in each other as they are alike in their boning type. An ionic substance won't dissolve in a molecular substance as they are unlike in their bonding type. Water is an exception; because it is such a strongly polar molecular compound, many ionic substances will dissolve in it, making it the "universal solvent"	
13	Concentration	a measure of the quantity of solute dissolved in a given amount of solvent or solution	
14	Precipitate	A solid produced during a chemical reaction between two solutions	
15	Molarity	a measure of concentration; the number of moles of solute per liter of solution.	
16	Parts Per Million	(ppm) a measure of concentration used to express very low concentrations. A 1 ppm solution would contain 1 gram of solute per million grams of solution. Jeopardy	
17	Colligitive Properties	boiling point elevation and freezing point depression are dependent on the concentration of solute in solution.	

Calendar for unit 7 Regents Chemistry: Red (2 & 3A) and Yellow (9 &8A) classes

2/5	6	7	8	9
S	A	B	C	D
Topic 7.1: Properties of water HW: Real world assignment (separate packet)	Topic 7.2 Types of saturation & POGIL table G	Topic 7.3 Factors that affect solubility & mini-lab 7.1 HW- Assignment #2	Topic 7.4 The solution process HW: Assignment #3	Topic 7.5 Soluble vs insoluble “ using Table F” POGIL HW: Pre-lab due Monday
	Topic 7.2 continued HW= Assignment #1		Chemistry Work Period	
2/12	13	14	15	16
E	S	A	B	C
Lab 7.2	Topic 7.6 Electrolytes HW: Assignment #4 (review for quiz)	Quiz Begin topic 7.7 (Molarity POGIL) HW: Assignment #5	Topic 7.7 Molarity (continued) & topic 7.8 parts per million	Topic 7.8 Colligative properties/ Lab
Lab/ table F work time HW: lab due ______		Chemistry Work Period		Chemistry Work Period
February Break!!!				
2/26	27	28	3/1	3/2
D	E	S	A	B
Topic 7.8 continued	Practice with Solutions	Unit 7 Test		
	Review for test			

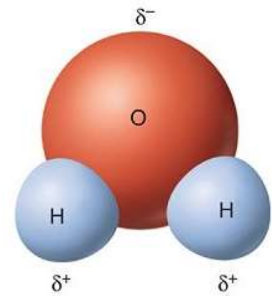
Calendar for unit 7 Regents Chemistry: Blue (5 & 4B) and Green (7 & 8B) Classes:

2/5	6	7	8	9
S	A	B	C	D
Topic 7.1: Properties of water HW: Real world assignment (separate packet)	Topic 7.2 Types of saturation & POGIL table G HW= Assignment #1	Topic 7.2 continued	Topic 7.4 The solution process HW: Assignment #3	Topic 7.5 Soluble vs insoluble “using Table F” POGIL HW: Pre-lab due Monday
Chem. work period		Topic 7.3 Factors that affect solubility & mini-lab 7.1 HW- Assignment #2		Chemistry Work Period
2/12	13	14	15	16
E	S	A	B	C
Lab 7.2	Lab/ table F work time HW: lab due ______	Quiz Begin topic 7.7 (Molarity POGIL) HW: Assignment #5	Topic 7.7 Molarity (continued) & topic 7.8 parts per million	Topic 7.8 Colligative properties/ Lab
	Topic 7.6 Electrolytes HW: Assignment #4 (review for quiz)		Chemistry Work Period	
February Break				
2/26	27	28	3/1	3/2
D	E	S	A	B
Topic 7.8 continued	Review for test	Chemistry Work Period		
Practice w/ Solns		Unit 7 Test		

Topic 7.1 **Properties of Water:** What do we know about water in the real world and how is this connected to the chemical structure of water?

A. What do we know about water?

a. Let's draw its Lewis Dot diagram



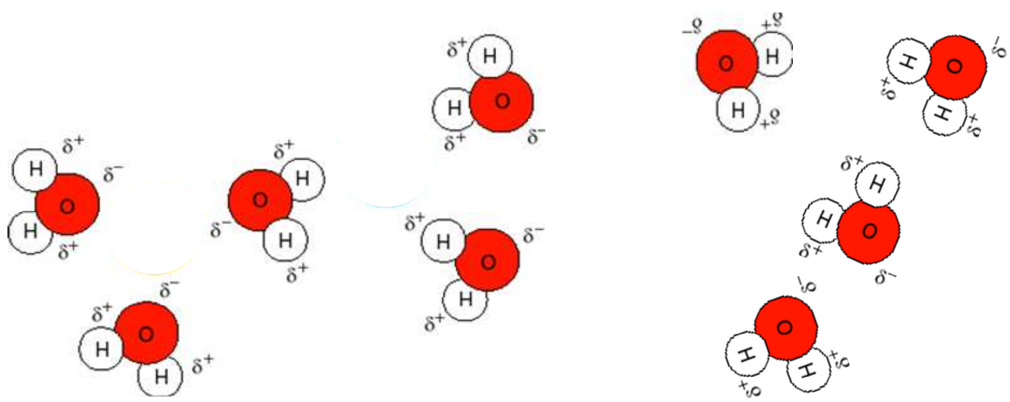
b. Water molecules are "pulled" or given partial charges due to differences in ________________________________ which results in _________________ ________________.

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

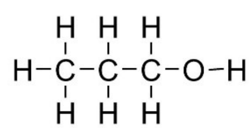
"_________________________dissolves ________________________"

What does this mean?

a. We just determined that water is a __________________________ molecule, so it is likely to dissolve _____________ substances. Because it has __________________________ (partial ____ and partial __) it can also dissolve ________________ substances.

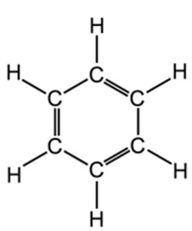


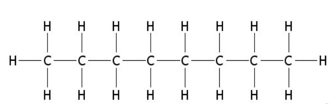
Examples of **soluble** substances in water are NaCl (________________________) and C_3H_7OH (________________________________).

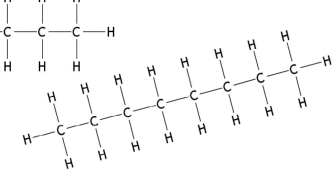


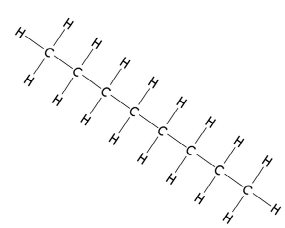
Examples of insoluble substances: Oil (____)

b. What about octane (gasoline) which is a ____________________________ molecule. It is most likely to mix with _______________________________ substances.









Examples of **soluble** substances in gasoline: benzene (_________________________)

Examples of insoluble substances: H_2O (______________________) and NaCl (_________________________)

Topic 7.2

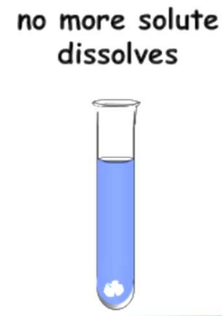
Types of Saturation: How do we know the type of solution and what does this mean about the amount of solute versus solvent? How can table G help to determine these answers?

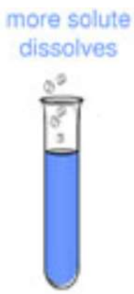
A. What are the 3 different types of solutions?

1. Saturated Solution-____

____

Ex. adding any more solute to a solution will cause the solute to settle on the bottom of the container – this is how you can determine if a solution is saturated.





2. Unsaturated Solution-____

____

____

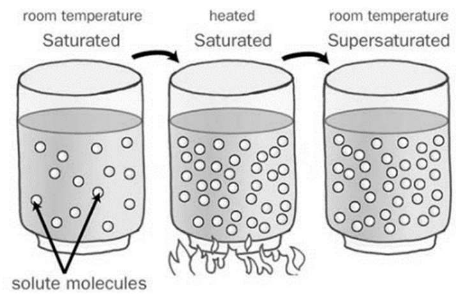
Ex. adding more solute will dissolve

3. Supersaturated Solution-____

____

____

Ex. can only be produced by heating a saturated solution, dissolving more solute, and then cooling it very slowly and carefully. If you did this carefully enough, you could keep the excess solute dissolved for a while.



POGIL Time

Learning targets:

– I can learn how solubility varies with temperature
– I can read table G and explain what each section represents
– I can use definitions discussed in this unit to determine how temperature can influence solubility

Table G POIGL is printed here in student packets, but not displayed here.

Topic 7.2 (continued)

How can we summarize what we've seen in our POGIL about table G? How does temperature and volume influence solubility?

A. Solubility is defined as the amount of ______________________________ that can dissolve in a given solvent.
B. Temperature and solubility:
  a. Solids:
    i. As the temperature rises, the solubility of a solid ___________________________.
    ii. What real world example is there from your POGIL to help you remember this?

  b. Gases:
    i. The 3 gases on table G can be identified because from left to right their curves________________.
      1. The three gases are:

    ii. This means that as the temperature rises, the solubility of gases _____________________.
    iii. Think of a cup of pop sitting at room temperature- what starts to happen?

C. What does table G tell us?
  a. If a solution's concentration is at a point <u>**on**</u> it's curve, that solution is __________________________.
  b. If a solution's concentration is at a point <u>**below**</u> it's curve, that solution is ________________.
  c. If a solution's concentration is at a point <u>**above**</u> it's curve, that solution is ________________.
  d. Practice with table G: Answer the following questions related to table G asking for help and connecting it to real world scenarios as suggested in the question.
    1. What is unusual about the curve for NaCl dissolving in water?
      a. Why is this important? (connect to real world- where do we find NaCl(aq)?)
    2. How much KI can be dissolved in 100mL of water at 10°C?
    3. If 50 grams of KI was dissolved in 100mL of water at 10°C, would the solution be unsaturated, saturated, or supersaturated?_______________________________
    4. If 150 grams of KI was dissolved in 100mL of water at 10°C, would the solution be unsaturated, saturated, or supersaturated?_______________________________

CHECKPOINT! (look for instructions on the screen or ask your teacher)

Topic 7.2
(continued)

How can we summarize what we've seen in our POGIL about table G? How does temperature and volume influence solubility?

D. Volume: How can we expand on Table G to determine the type of solution if the volume isn't 100 mL?

1. How much KCl must you dissolve in 500 mL of water to make a saturated solution at 60°C to make a saturated solution?

2. If 300 grams of KI was dissolved in 600mL of water at 10°C, would the solution be unsaturated, saturated, or supersaturated?______________________________

3. A solution of $NaNO_3$ containing 168 g of solution in 200 mL of water at 50°C is unsaturated, saturated, or supersaturated?________________________________

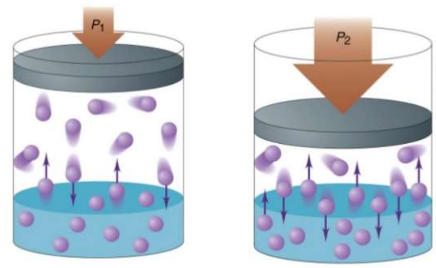
4. 100 mL of a saturated solution of KNO_3 at 50°C is cooled to 30°C. How much KNO_3 will precipitate?

E. Pressure:

a. For _____________________ solutes, pressure has **NO** effect.

b. For _____________________ solutes, as pressure ________________ solubility _______________________.

i. For example



Assignment 7.1

___ 1. According to Table *G*, which substance forms an unsaturated solution when 80. grams of the substance are stirred into 100. grams of H_2O at 10.°C?

A) KNO_3 B) KI
C) NH_3 D) NaCl

___ 2. A solute is added to water and a portion of the solute remains undissolved. When equilibrium between the dissolved and undissolved solute is reached, the solution must be

A) dilute B) saturated
C) unsaturated D) supersaturated

___ 3. An unsaturated solution is formed when 80. grams of a salt is dissolved in 100. grams of water at 40.°C. This salt could be

A) $NaNO_3$ B) NaCl
C) KNO_3 D) KCl

___ 4. A solution contains 35 grams of KNO_3 dissolved in 100 grams of water at 40°C. How much *more* KNO_3 would have to be added to make it a saturated solution?

A) 4g B) 24 g C) 12 g D) 29 g

5. Which salt on table G is least soluble in water at 20°C?_____________

6. How many grams of potassium chloride (chemical formula of ______________) can be dissolved in **200g** of water at 80°C?

7. At 30oC, 90 g of sodium nitrate (chemical formula of ______________) is dissolved in 100g of water, Is this solution saturated, unsaturated or supersaturated?

8. Give the formula and phase of matter of ONE compound that shows a decrease in solubility from 0°C to 100°C.

Formula____________________

Phase of matter______________

9. Which salt is most soluble at 10°C?

10. Which salt is least soluble at 50 °C?

11. Which salt is least soluble at 90 °C?

12. A saturated solution of potassium chlorate is formed from one hundred grams of water. If the saturated solution is cooled from 80 °C to 50 °C, how many grams of precipitate are formed?

Topic 7.3 **Other factors that influence solubility. When and how quickly can substances dissolve?**

A. Definition:
Solutions are ___________________________________ mixtures that may be a solid, liquid or gas.

B. The composition the solute and solvent determines whether a substance will dissolve.
   a. The phrase "______________________ dissolves __________________" means that:

C. Substances that are ________________ will react MORE quickly than those that are ________________.

D. You can make a **solid** solute dissolve faster in three ways:

1. Grind up the solute to increase the _______________ ___________________.

2. __________________ the solution to increase the contact of solute with solvent

3. __________________ the solution to give the ions or molecules more **average** kinetic energy

***Note that if a substance is not soluble (aka _____________________), no amount of stirring will dissolve it. Stirring will speed up the dissolution rate, but does not determine the **amount** that a solvent can dissolve.

E. What if it's a gas? You can make a **gas** solute dissolve faster in two ways:

1. ___________________ the solution so that the gas particles stay strapped in the liquid for a longer time.

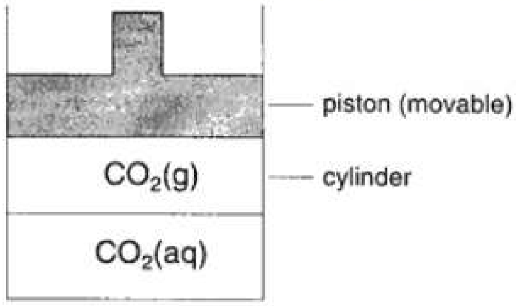
2. Increase the ___________________ on the system.

Assignment 7.2

___ 1. The solubility of KCl(s) in water depends on the

A) pressure on the solution
B) rate of stirring
C) size of the KCl sample
D) temperature of the water

___ 2. Given the diagram below that shows carbon dioxide in an equilibrium system at a temperature of 298 K and a pressure of 1 atm:



Which changes *must* increase the solubility of the carbon dioxide?

A) decrease pressure and increase temperature
B) increase pressure and increase temperature
C) decrease pressure and decrease temperature
D) increase pressure and decrease temperature

___ 3. Which compound is *least* soluble in water at 60. °C?

A) KNO_3 B) $KClO_3$
C) NH_4Cl D) NaCl

___ 4. At STP, which of these substances is most soluble in H_2O?

A) CO_2 B) CCl_4
C) HCl D) N_2

___ 5. According to Reference Table G, which compound's solubility decreases most rapidly when the temperature increases from 50°C to 70°C?

A) NH_3 B) SO_2
C) HCl D) KNO_3

STOP STOP STOP STOP STOP

Topic 7.4 **The solution process. What does it mean to "dissolve"?**

STORY TIME!

Summary:

1. After watching the animation, how is my story related to the animation?

2. *What do you think this substance is? What do you notice about it that makes you think that?*

3. *After viewing the animation with sound, does this confirm or deny your thoughts from questions 2 and 3? Provide support*

Topic 7.4 (cont)

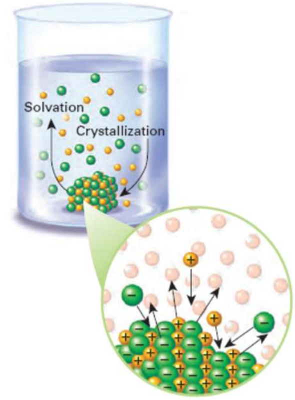
The solution process. What does it mean to "dissolve"?

Solubility:____

____

Answer the question about the diagram to the right here.

Figure 16.2 In a saturated solution, a state of dynamic equilibrium exists between the solution and the excess solute. The rate of solvation (dissolving) equals the rate of crystallization, so the total amount of dissolved solute remains constant. **Inferring** ***What would happen if you added more solute?***

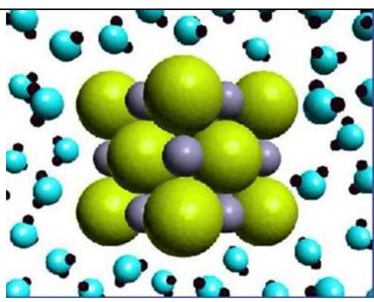
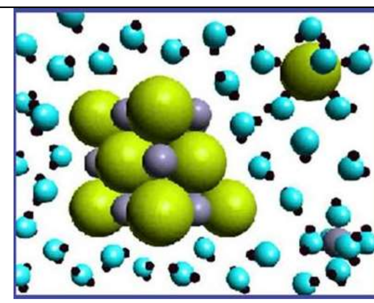


View Simulation: https://phet.colorado.edu/en/simulation/soluble-salts

After viewing the simulation, does your answer above agree? If no, explain WHAT happens.

When the solution is saturated and excess solute remains at the bottom, there is an EQUILIBRIUM occurring in which solute is dissolving at the same rate as it is crystallizing out of solution, so there is no net change in the solution concentration.

When a substance dissolves, two things must happen:

	
Break attractions within the ____________________________ Break attractions within the ____________________________	Form new attractions between ____________________________ and ____________________________.
This ______________________________________Energy	This ______________________________________Energy

These two processes are in opposition to each other and depending on which one is more "powerful" determines if energy is absorbed or released overall. We can write the final result as a dissociation equation (Used table ___________ to help with this!)

$NaOH(s) \xrightarrow{H_2O}$ +44.51 kJ Endothermic or Exothermic

$LiBr(s) \xrightarrow{H_2O}$ Endothermic or Exothermic

$NH_4Cl(s) \xrightarrow{H_2O}$ Endothermic or Exothermic

$KNO_3(s) \xrightarrow{H_2O}$ Endothermic or Exothermic

Assignment 7.3

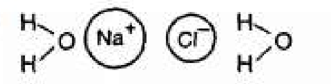
___ 1. The attraction between water molecules and an Na^+ ion or a Cl^- ion occurs because water molecules are

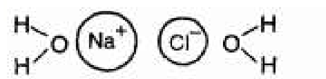
A) linear B) symmetrical C) nonpolar D) polar

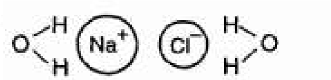
___ 2. In an aqueous solution of potassium chloride, the solute is

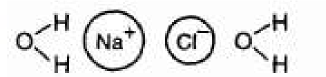
A) KCl B) Cl C) H_2O D) K

___ 3. Which diagram best illustrates the ion-molecule attractions that occur when the ions of NaCl(s) are added to water?

A) 

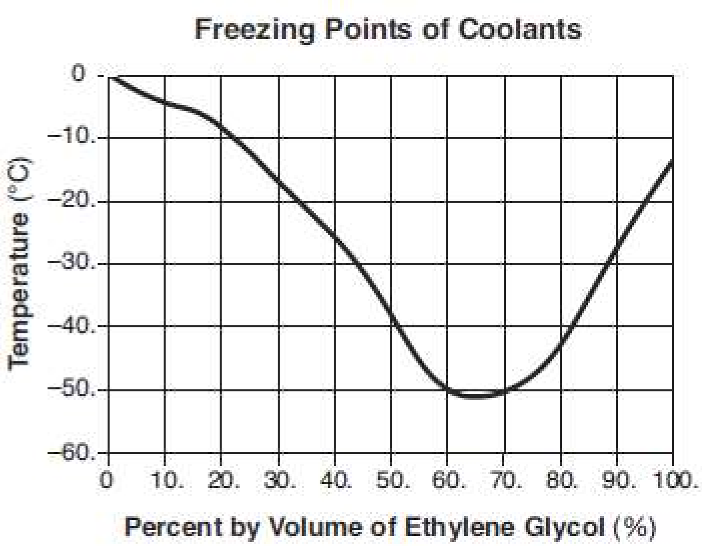
B) 

C) 

D) 

Base your answers to questions **4** through **7** on the information below and on your knowledge of chemistry.

A solution of ethylene glycol and water can be used as the coolant in an engine-cooling system. The ethylene glycol concentration in a coolant solution is often given as percent by volume. For example, 100. mL of a coolant solution that is 40.% ethylene glycol by volume contains 40. mL of ethylene glycol diluted with enough water to produce a total volume of 100. mL. The graph below



4. Explain, in terms of particle distribution, why a coolant solution is a homogeneous mixture.

5. Explain, in terms of the molecular polarity, why ethylene glycol dissolves in water to form a solution.

6. Identify the percent by volume of ethylene glycol in a solution that freezes at –10.°C.

7. One engine-cooling system has a volume of 6400 mL. Determine the volume of ethylene glycol in the completely filled engine-cooling system when the concentration of ethylene glycol is 50.% by volume.

Solubility Guidelines POGIL

I. Writing Double Replacement Reactions – remember this?!

Step 1: When switching ions in compounds, don't forget that + ions will only bond with – ions, and vice versa.

Example: $NaCl$ + MgO → Na (positive) will bond with O (negative)
Cl (negative) will bond with Mg (positive)

Step 2: When writing new compounds, first look up their oxidation states and criss cross their charges. Also – positive ions come first in ionic compounds!

Example: $NaCl$ + MgO → Na^{+} O^{-2} + Mg^{+2} Cl^{-}
Na_2O + $MgCl_2$

Step 3: Balance your equation, to account for conservation of atoms.

Example: 2 $NaCl$ + MgO → Na_2O + $MgCl_2$

Practice: For each set of reactants, determine the 2 products.

1. $FeSO_4$ + $NaCl$ →

2. $PbCl_2$ + $(NH_4)_2CO_3$ →

Check your charge on these on the left as they must remain the same on the right

3. $(NH_4)Cl$ + $Mg(OH)_2$ ⟶

II. Imagine if there was a way to predict if students will turn in their homework on time. The tables/guidelines to follow might look something like this: On the left side of the first table are the students that WILL turn in their homework on time. We know that sometimes there are conditions that cause a student to turn in their homework late. You see those conditions to the right, in the "Unless" column. In the second table, there are students that will NOT turn in their homework on time. But sometimes these students do shock us all and turn in their homework on time, so there is also an "Unless" column to account for these exceptions.

Students that WILL turn in their homework on time	Unless . . .
Shirley	
Joe	
Linda	
Brenda	She loses her planner
Lori	Her dog eats it
Margaret	She has a soccer game the night before

Students that will NOT turn in their homework on time	Unless . . .
Paula	
Tyler	
Jake	
Raymond	He has no sports the night before
Phil	Quarter grades end the next day
Sally	She has written it in her planner

Using the above information, mark a H if a homework is turned in on time and an N if it will not.

_____ Shirley has a soccer game the night before
_____ Tyler went to bed early
_____ Sally has written her homework down in her planner.
_____ Lori's dog ate her homework.
_____ Paula loses her planner.
_____ Phil knows that the quarter ends tomorrow
_____ Joe knows that the quarter ends tomorrow
_____ Margaret went to bed early
_____ Sally has not written her homework down in her planner.
_____ Jake finds his planner
_____ Brenda loses her planner

List all of the student**s** that will have their homework turned in on time, assuming they ALL have a soccer game the night before. ____

III. You will go through this same process to find out if an ion will dissolve in water. If something is able to dissolve, it is called ________________. If something will NOT dissolve it is called ______________________. When something is dissolved in water, it is known as an ____________________ solution. If an insoluble compound is mixed with water it is seen as a precipitate. You can see it either floating on the top of the water, or sunk at the bottom of the container.

This is 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

How is this table similar to the homework table?

How is it different?

Using the table, determine if each compound is soluble or insoluble. If it is insoluble, it will form a precipitate. Mark a S if it is soluble, and an I if it is insoluble in water.

_____ NaCl
_____ $CaCrO_4$
_____ NaOH
_____ $PbBr_2$
_____ $MgSO_4$
_____ Li_2S
_____ H_2CO_3
_____ K_2CO_3
_____ $Fe(OH)_2$
_____ $Mn(ClO_3)_4$
_____ Ag_2SO_4

Write out 3 compounds (different from the list above) that would be ***soluble*** in water:
(note that you must have a positive ion and a negative ion in your compound and it must be made neutral)

__________ __________ __________

Write out 3 compounds (different from the list above) that would be ***insoluble*** in water:
(note that you must have a positive ion and a negative ion in your compound and it must be made neutral)

__________ __________ __________

<u>Practice Regents Questions for Unit 7 - Solutions: Show all work where necessary</u>

1. Based on Table *F*, identify ***one* ion** that reacts with Br^- ions in an aqueous solution to form an insoluble compound. [1] ___________________________

2. What is the mass of NH4Cl that must dissolve in 200. grams of water at 50.°C to make a saturated solution?
   a. 26 g b. 84 g c. 42 g d. 104 g

3. A 1.0-gram strip of zinc is reacted with hydrochloric acid in a test tube. The unbalanced equation below represents the reaction.

$$Zn(s) + HCl(aq) \rightarrow H_2(g) + ZnCl_2(aq)$$

   Explain, using information from Reference Table *F*, why the symbol (aq) is used to describe the product ZnCl2. [1]

   ____

   ____

4. Based on Table *G*, determine the total mass of NH3 that must be dissolved in 200. grams of water to produce a saturated solution at 20.°C. ________________

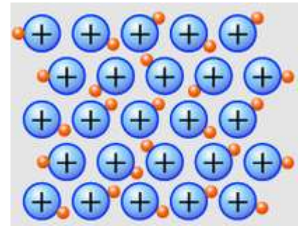
5. Which compound is *least* soluble in water at 60.°C?
   a. KClO3 b. NaCl c. KNO3 d. NH4Cl

Checkpoint!

Topic 7.6

Electrolytes: What properties of a substance change when it is dissolved?

A. A solution is formed when a ________________________ and _______________________ combine to form a mixture that is ______________________. When working with water, we know that there is a partial positive (+) (_____) and partial negative (-) (___) end. When two substances dissolve in each other, a solution is made. This process is a _________________________________ change.

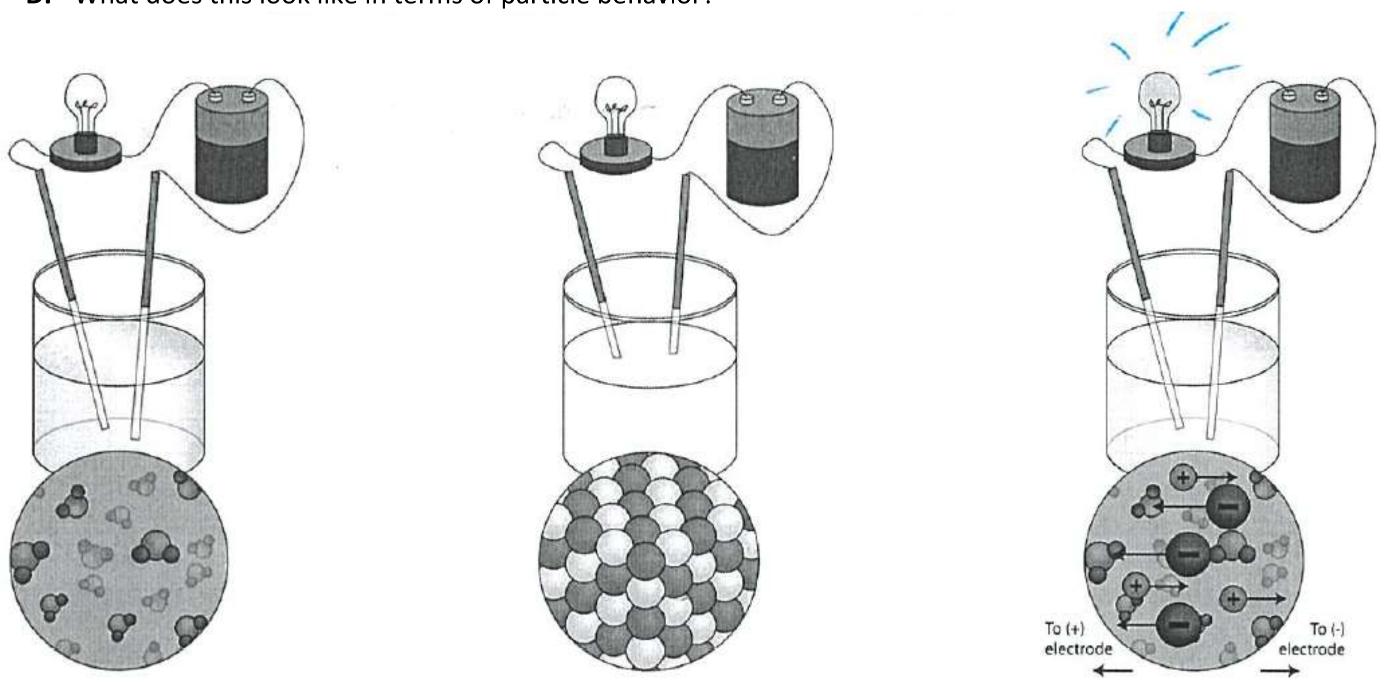


B. What substances that we know of can conduct electricity?

- **a.** ____________________ conduct electricity well because of their structure (***__________________________________)
    - **i.** These ____ create a functional "path" for electricity to "flow" through.
- **b.** ____________________________ conduct electricity only when we can get __________________________. So when is this possible?
    - **i.** _____________________ the ionic substance
    - **ii.** _____________________ the ionic substance

C. Let's talk about the word "electrolyte." It means:

D. What does this look like in terms of particle behavior?



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.

Will a substance that is ionic always conduct? _____ it must be _______________ on table F for it to be an electrolyte.

Which of the following are electrolytes?

H_2O LiBr $SrCO_3$ K_2CO_3 HCl C_2H_5OH

Assignment 7.4

____ 1. Which compound is insoluble in water?

A) potassium bromide
B) sodium bromide
C) silver bromide
D) calcium bromide

____ 2. Which barium salt is *insoluble* in water?

A) $BaCO_3$ B) $Ba(NO_3)_2$
C) $Ba(ClO_4)_2$ D) $BaCl_2$

____ 3. According to Table *F*, which substance is most soluble in water?

A) $CaCO_3$ B) Na_2CO_3
C) AgCl D) $SrSO_4$

____ 4. Solubility data for four different salts in water at 60°C are shown in the table below.

Salt	Solubility in Water at 60°C
A	10 grams / 50 grams H_2O
B	20 grams / 60 grams H_2O
C	30 grams / 120 grams H_2O
D	40 grams / 80 grams H_2O

Which salt is most soluble at 60°C?

A) *A* B) *B* C) *C* D) *D*

____ 5. At which temperature can water contain the most dissolved oxygen at a pressure of 1 atmosphere?

A) 10.°C B) 20.°C C) 30.°C D) 40.°C

____ 6. A student adds solid KCl to water in a flask. The flask is sealed with a stopper and thoroughly shaken until no more solid KCl dissolves. Some solid KCl is still visible in the flask. The solution in the flask is

A) saturated and is not at equilibrium with the solid KCl
B) saturated and is at equilibrium with the solid KCl
C) unsaturated and is not at equilibrium with the solid KCl
D) unsaturated and is at equilibrium with the solid KCl

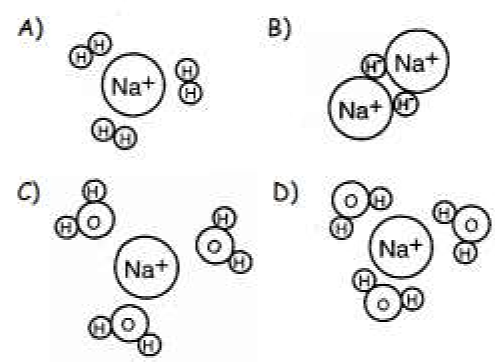
____ 7. A saturated solution of $NaNO_3$ is prepared at 60.°C using 100. grams of water. As this solution is cooled to 10.°C, $NaNO_3$ precipitates (settles) out of the solution. The resulting solution is saturated. Approximately how many grams of $NaNO_3$ settled out of the original solution?

A) 85 g B) 61 g C) 126 g D) 46 g

____ 8. According to Reference Table *G*, which solution at equilibrium contains 50 grams of solute per 100 grams of H_2O at 75°C?

A) a saturated solution of $KClO_3$
B) an unsaturated solution of $KClO_3$
C) an unsaturated solution of KCl
D) a saturated solution of KCl

____ 10. Which diagram best illustrates the hydration of sodium ions in an aqueous solution? [The diagrams are not drawn to scale.]



____ 9. Base your answer to the following question on the information below.

Ammonium chloride is dissolved in water to form a 0.10 M $NH_4Cl(aq)$ solution. This dissolving process is represented by the equation below.

$$NH_4Cl(s) + heat \xrightarrow{H_2O} NH_4^+(aq) + Cl^-(aq)$$

a. Explain, in terms of ions, why a 10.0-milliliter sample of 0.30 M $NH_4Cl(aq)$ is a better conductor of electricity than a 10.0-milliliter sample of the 0.10 M $NH_4Cl(aq)$.

9b. Is this reaction endo or exothermic?

Topic 7.7 **Concentration: Molarity** How can we use moles to compare concentration of solutions?

POGIL:

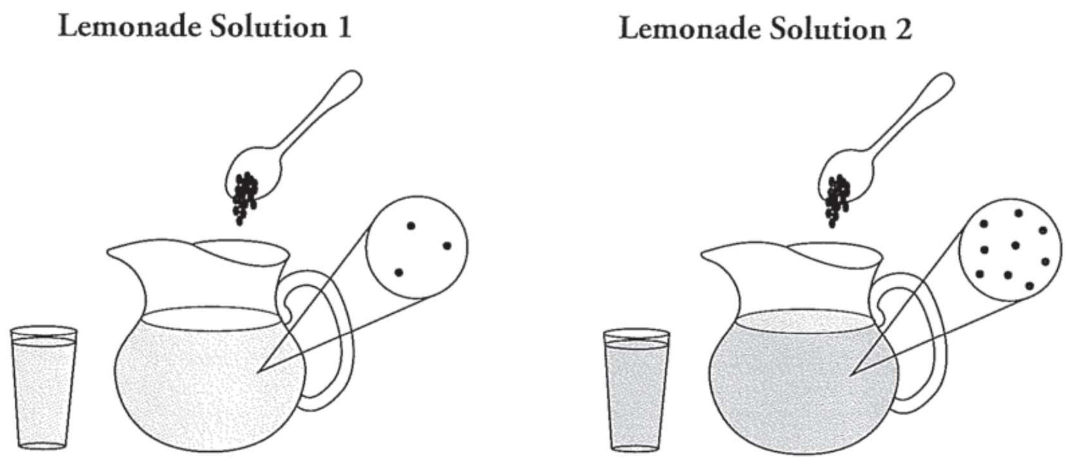
Molarity

How can the concentration of a solution be expressed quantitatively?

Why?

When you buy a bottle of a certain brand of lemonade you expect it to taste just as sweet as the last time you bought that kind of lemonade. Likewise, when doctors prescribe a certain ointment, they expect the concentration of medicine to be consistent. How do companies ensure their products taste or perform the same every time you purchase them? Many companies, including pharmaceutical companies, keep track of the concentration of a solution by measuring its **molarity**—a ratio of number of solute particles to the volume of solution. In this activity you will learn about molarity and how to represent concentration quantitatively.

Model 1 – Lemonade Mixtures*



*Both pitchers were filled with enough water (solvent) to provide 2 liters of solution.
Dissolved Lemonade Mix particle (solute) = •

1. Refer to Model 1:
   a. What is the solvent in this scenario?

   b. What is the solute in this scenario?

   c. What is a dissolved lemonade mix particle represented by?

2. Circle the word that best completes each sentence below and justify your answer based on the diagrams in model 1.
   a. Lemonade solution 1 has (more/ less/ the same) volume of solution 2. How do you know?

   b. Lemonade solution 1 has (more/ less/ the same) quantity of solute of solution 2. Describe how you know in terms of number of particles.

CHECKPOINT!

3. Lemonade solutions 2 is considered to be **concentrated** and lemonade solution 1 is considered to be **dilute.** Examine the two pictures from model 1. List two ways to differentiate a concentrated solution from a dilute solution.

4. A glass is filled with the concentrated lemonade from model 1.
   a. Is the solution in the glass the same concentration as the solution in the pitcher?

   b. Does the solution in the glass contain the same number of solute particles as the solution in the pitcher? If no, explain how your answer to part *a* can be true. *Hint:* Condsider both amount of solute and solvent.

5. Do the terms "concentrated" and "dilute" provide any specific information about the quantities of solute or solvent in a solution? Explain.

Checkpoint!

Let's define a few things:
Molarity:

Molarity (M) =	

***Note that the volume is the total volume of the solution, NOT the volume of the solvent alone.
Practice Problems:
1. A solution has a volume of 250 mL and contains .70 moles NaCl. What is its molarity

2. Household bleach is a dilute aqueous solution of sodium hypochlorite (NaClO). How many moles of solute are present in 1.5 L of a .70 M NaClO?

3. ?A solution has a volume of 2.0 L and contains 36.0 grams of glucose ($C_6H_{12}O_6$). If the molar mass of glucose is 180 grams/ mole, what is the molarity of the solution (2 steps required)?

4. How many moles of ammonium nitrate are in 335 mL of 0.425 M NH_4NO_3? (2 steps involved)

5. How many moles of solute are in 250 mL of 2.0 M $CaCl_2$? How many grams of $CaCl_2$ is this?

Topic 7.7 **Concentration: Parts per million:** How can we describe concentration in specialized contexts?

A. Molarity is GREAT, but sometimes quantities of solute are SO ______________________ that we use another calculation called *parts per million.*
   a. Many agencies use parts per million to describe limitations and environmental regulations.
   b. Parts per million is defined as:

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

B. Let's try a practice problem or 2
   a. A solution consists of 0.25 grams of solute dissolved in 1000 grams of solution. What is its concentration in ppm?

   b. A 100 gram sample of stream water is found to contain 0.0032 grams of MTBE (a gasoline additive) What is the concentration of MTBE, in ppm?

   c. The EPA finds the concentration of arsenic in a stream near a local factory is 5 ppm. If the volume of the sample was 1000g, how much arsenic was in the water?

Let's combine our practice:

1. What is the molarity of 1.5 liters of an aqueous solution that contains 52 grams of lithium fluoride, LiF, (gram-formula mass =26 grams/mole)?

a. 1.3 M b. 3.0 M c. 2.0 M d. 0.75 M

Base your answers to question 2 on the information below.
The dissolving of solid lithium bromide in water is represented by the balanced equation below.

$$LiBr(s) \xrightarrow{H_2O} Li^+(aq) + Br^-(aq)$$

2. Calculate the total mass of LiBr(s) required to make 500.0 grams of an aqueous solution of LiBr that has a concentration of 388 parts per million. Your response must include *both* a correct numerical setup and the calculated result. [2]

3. What is the total mass of solute in 1000. grams of a solution having a concentration of 5 parts per million?

a. 0.005 g b. 0.5 g c. 0.05 g d. 5 g

Been Having problems concentrating lately?

Topic 7.8

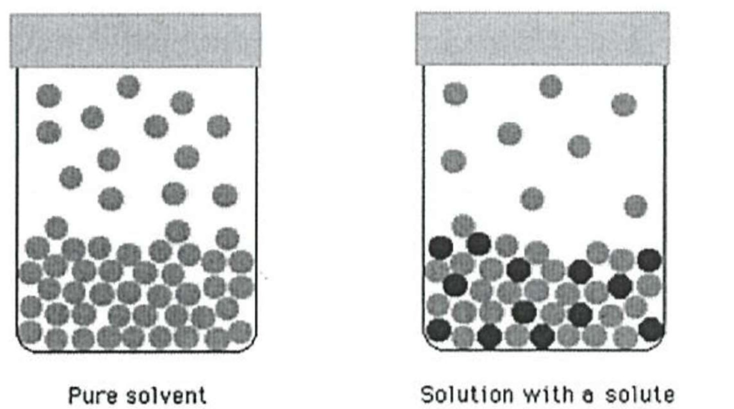
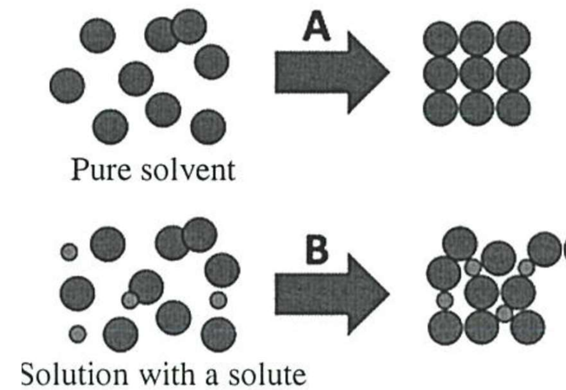
Colligitive Properties: What properties of the solvent change when a solute is dissolved?

A. When a solute dissolves in water, not only the properties of the solute change, but the properties of the solvent (usually ____________________ because we are dealing with aqueous solutions) change as well. You observed these changes in your investigation before break. Let's review and make sure we have a solid understanding of how this works.

B. ***Properties of a solution different from the pure solvent used to make that solution

***Differences in properties have to do with the ____ in the solution.

C. What are the changes that we have to know?

<table>
<tr><td>Boling point changes</td><td>Freezing point changes</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>Boiling point____.</td><td>Freezing point __________________________________.</td></tr>
<tr><td colspan="2">How does this work?</td></tr>
<tr><td>The solute and solvent are ________________________ to one another. This "blocks" the solvent from being able to escape. The amount of ____________________is ____________________ than normal so it takes __________ energy to get the liquid to boil.</td><td>The solute tries to insert itself into the solid crystal that is forming.
This means that the ________________________energy must decrease even more than normal to get the solid to form.</td></tr>
<tr><td colspan="2">How much will it change by?</td></tr>
<tr><td colspan="2">The actual values are NOT important, but the _______________________ solute particles (or ions) dissolved, the _________________________ the boiling point and the __________________________the freezing point.</td></tr>
</table>

D. Let's practice

____ 1. A solution consists of 0.50 mole of $CaCl_2$ dissolved in 100. grams of H_2O at 25°C. Compared to the boiling point and freezing point of 100. grams of H_2O at standard pressure, the solution at standard pressure has

A) a higher boiling point and a higher freezing point
B) a higher boiling point and a lower freezing point
C) a lower boiling point and a lower freezing point
D) a lower boiling point and a higher freezing point

____ 2. Which aqueous solution of KI freezes at the lowest temperature?

A) 1 mol of KI in 500. g of water
B) 2 mol of KI in 500. g of water
C) 1 mol of KI in 1000. g of water
D) 2 mol of KI in 1000. g of water

____ 3. Compared to the freezing point of 1.0 M $KCl(aq)$ at standard pressure, the freezing point of 1.0 M $CaCl_2(aq)$ at standard pressure is

A) higher B) the same
C) lower

Learning Target	I can	I need to review	I don't get it YET
1. Explain that a solution is a homogeneous mixture of a solute dissolved in a solvent. The solubility of a solute in a given amount of solvent depends on the temperature, pressure and the chemical nature of the solvents.			
2. Explain the differences in properties such as density, particle size, molecular polarity, boiling and freezing point and solubility permit physical separation of the components of a mixture.			
3. Define an electrolyte as a substance, which when dissolved in water, forms a solution capable of conducting an electric current. The ability of a solution to conduct an electric current depends on the concentration of ions.			
4. Describe the preparation of a solution, given the molarity.			
5. Apply the saying "like dissolves like" to real world situations, such as dry cleaning			
6. Interpret solution concentration data: a. Given an amount of solute and an amount of solvent, determine whether the solution is saturated, unsaturated, or supersaturated. b. Given data for the amounts of solute and solvent in each solution, determine which solution is more concentrated.			
7. Calculate solution concentrations in molarity (M), percent by mass, and parts per million (ppm).			
8. Interpret and construct solubility curves			
9. Use Solubility curves to distinguish among saturated, unsaturated and supersaturated solutions.			
10. Use table F to determine what ions and compounds are soluble or insoluble.			
11. Describe the effect adding a solute has on the boiling and freezing points of the solvent.			
12. Compare/ contrast the effect of a molecular solute with the effects of ionic solutes on the boiling and freezing points a solvent.			

Review for Solutions Unit test:

1.

At standard pressure, how do the boiling point and the freezing point of NaCl(aq) compare to the boiling point and the freezing point of H2O(ℓ)?

1. Both the boiling point and the freezing point of NaCl(aq) are lower.
2. Both the boiling point and the freezing point of NaCl(aq) are higher.
3. The boiling point of NaCl(aq) is lower, and the freezing point of NaCl(aq) is higher.
4. The boiling point of NaCl(aq) is higher, and the freezing point of NaCl(aq) is lower.

2.

The table below gives information about four aqueous solutions at standard pressure.

Four Aqueous Solutions

Aqueous Solution	Concentration (M)	Solute
A	2.0	$BaCl_2$
B	2.0	$NaNO_3$
C	1.0	$C_6H_{12}O_6$
D	1.0	K_2SO_3

Which list of solutions is arranged in order from highest boiling point to lowest boiling point?

1. *A, B, D, C*
2. *A, C, B, D*
3. *C, D, B, A*
4. *D, B, C, A*

3.

Which unit can be used to express the concentration of a solution?

1. L/s
2. J/g
3. ppm
4. kPa

4.

According to Table *F*, which compound is soluble in water?

1. barium phosphate
2. calcium sulfate
3. silver iodide
4. sodium perchlorate

5.

What is the concentration of a solution, in parts per million, if 0.02 gram of Na_3PO_4 is dissolved in 1000 grams of water?

1. 20 ppm
2. 2 ppm
3. 0.2 ppm
4. 0.02 ppm

6.

Base your answer to the question on the information below.

Two alcohols that are used in our everyday lives are rubbing alcohol and ethylene glycol. Rubbing alcohol is used as an antiseptic. Ethylene glycol is the main ingredient in antifreeze, which is used in automobile cooling systems.

Figure 1

Which of the following is a correct numerical setup for calculating the total number of moles of ethylene glycol needed to prepare 2.50 liters of a 10.0 M solution?

1. $10.0\ \text{M} = \dfrac{x\ \text{mol}}{2.50\ \text{L}}$
2. $x\ \text{mol} = \dfrac{10.0\text{M}}{2.50\ \text{L}}$
3. $10.0\ \text{L} = \dfrac{x\ \text{mol}}{2.50\text{M}}$
