SOLUTIONS & SOLUBILITY

What is a solution??? A homogenous liquid mixture where a solute is evenly distributed in a solvent.

Properties of a Solution

100 mL Make ~~200 mL~~ solutions using the substances available. Record your observations of these solutions in the chart below.

Substance dissolved →	Food Coloring (3 Drops)	5g NaCl (s)	$CuSO_4(aq)$ (Already made)
Can you read the writing on the card when you hold it behind the solution?	Yes - The Soln. is CLEAR	Yes	Yes
When you pour some of the solution through filter paper, does the filter paper collect the substance dissolved?	No - Soln. PASSES through UNCHANGED	No	No
Does the solution have a color?	Yes - 'Color' & 'Clarity' are not the same	No	YES
Have any of the dissolved particles become undissolved during this activity?	No	No	NO

Solute: The substance dissolved

Solvent: The substance A solute is dissolved in

What was/were the solutes in the activity? Food coloring, NaCl(s), $CuSO_4(s)$

What was/were the solvents in the activity? Water (universal

FACTORS THAT AFFECT SOLUBILITY

1) Temperature: Does temperature affect the solubility of a solid or gas?

Solids – Using a ~~teaspoon~~ Spatula, Add 1 scoop at a time, add and mix sugar into hot and cold water to observe which water temperature can dissolve more.

Approximate # of ~~teaspoons~~ scoops dissolved in hot water: _____

Approximate # of ~~teaspoons~~ scoops dissolved in cold water: _____

**It can be concluded that As temp. increases, the solubility of A solid increases.

Gas – Pour soda into ~~a~~ two test tubes and place ~~this test tube~~ one in a hot water bath and one in a cold water bath. The bubbles observed are carbon dioxide molecules that are no longer soluble in the soda.

Which temperature water resulted in more bubbles being released from the soda? High temp.

**It can be concluded that As temp. increases, the solubility of A gas decreases.

2) Polarity: Does the polarity of a molecule affect solubility?

Using water as the solvent (water is a polar molecule, hint hint), set up paper chromatography using permanent & washable markers. If the ink moves with the water on the paper, it is soluble in water.

Results in water:

Permanent marker – Soluble or insoluble Insoluble (Nonpolar)

Washable marker – Soluble or insoluble Soluble (Polar)

**It can be concluded that The permanent marker is insoluble which shows us that Nonpolar

3) Pressure: Does pressure make a substance more or less soluble?

Watch the video 'Why don't whales get the bends, when divers can?' and answer the following questions.

*As a diver descends, what happens to the amount of pressure on the diver's body? It increases

*Since higher pressure air is inhaled, how does that change the amount of gas in the blood stream? More is dissolved

*What happens to the solubility of nitrogen in the blood as the pressure on the body increases? It increases

*When a diver comes to the surface the nitrogen in the blood becomes Less soluble. The lungs cannot rid the body of this nitrogen fast enough. As a result, bubbles of nitrogen exist in the blood.

***It can be concluded that As pressure increases, the solubility of A gas increases.

Other Factors...

* Stirring - Increases solubility of A solid
  Decreases solubility of A gas

* Surface Area - Increased surface area will increase solubility.
  (Smaller particle size = Higher surface area)

TABLE F: Solubility Guidelines of Aqueous Solutions

Name or write the formula for the following polyatomic ions.

Ammonium NH_4^+ NO_3^- nitrate

SO_4^{2-} Sulfate acetate $C_2H_3O_2^-$

Phosphate PO_4^{3-} OH hydroxide

Carbonate CO_3^{2-} Chlorate ClO_3^-

1st Table	
These ions will form soluble compounds when bonded to something else...	Except when they're bonded to these ions.

2nd Table	
These ions will form insoluble compounds when bonded to something else...	Except when they're bonded to these ions.

Using Table F

1. At least one of the ions in your given compound will be on Table F. Find the ion.

2. Determine if it forms 'soluble' or 'insoluble' compounds.

3. Check to see if that ion is combined with an exception to the rule.

Using Table F, determine if the following compounds are *soluble* or *insoluble*.

1) NH_4Cl Soluble 2) $CaCO_3$ Insoluble

3) NaCl Soluble 4) $PbCl_2$ Insoluble

5) $Ca(OH)_2$ Soluble 6) $Mg_3(PO_4)_2$ Insoluble

7) CuS Insoluble 8) $NaCH_3COO$ Soluble

Solutions & Solubility

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. Under which conditions of temperature and pressure is a gas most soluble in water?

   A) high temperature and low pressure

   B) high temperature and high pressure

   C) low temperature and low pressure

   D) low temperature and high pressure

3. Which formula represents a mixture?

   A) $C_6H_{12}O_6(\ell)$ B) $C_6H_{12}O_6(s)$

   C) LiCl(aq) D) LiCl(s)

4. 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

5. An aqueous solution of sodium chloride is best classified as a

   A) homogeneous compound

   B) homogeneous mixture

   C) heterogeneous compound

   D) heterogeneous mixture

6. Which must be a mixture of substances?

   A) solid B) liquid

   C) gas D) solution

7. The solubility of a salt in a given volume of water depends primarily on the

   A) surface area of the salt crystals

   B) temperature of the water

   C) rate at which the salt and water are stirred

   D) pressure on the surface of the water

8. A change in pressure would have the greatest effect on the solubility of a

   A) solid in a liquid B) gas in a liquid

   C) liquid in a liquid D) liquid in a solid

9. At room temperature, the solubility of which solute in water would be most affected by a change in pressure?

   A) methanol B) sugar

   C) carbon dioxide D) sodium nitrate

10. Carbon dioxide gas is most soluble in water under conditions of

    A) high pressure and low temperature

    B) high pressure and high temperature

    C) low pressure and low temperature

    D) low pressure and high temperature

TABLE G - SOLUBILITY CURVE

Identify the following components of Table G:

X axis: Temperature (°C)

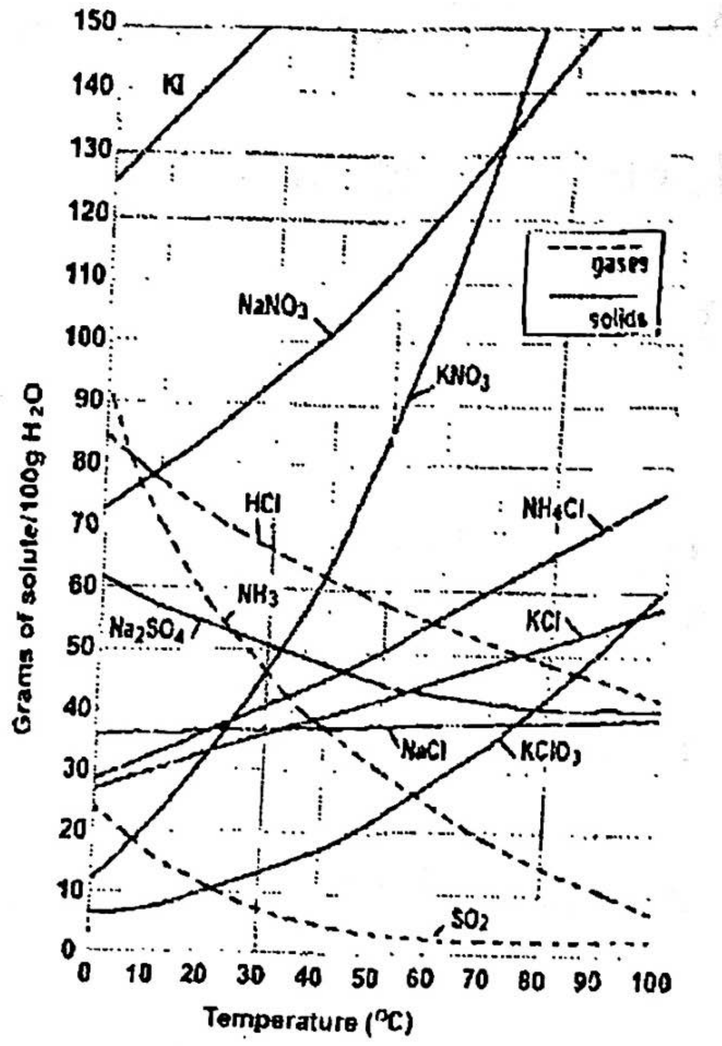
Y axis: g solute / 100 g H_2O → Solubility

How many grams of water are used

in each solution? 100g = 100 mL

Do all lines on Table G have the same relationship

between temperature and solubility? No



Using Table G in your reference tables, identify the mass of each solute that is soluble in 100g of water for the temperatures given.

1) KCl at 70 C 47-48g

2) NH_3 at 10 C 70g

3) KI at 20 C 145g

4) KNO_3 at 50 C 84-85g

5) NaCl at 100 C 40g

6) SO_2 at 80 C 3-4g

7) $NaNO_3$ at 70 C 135-136g

8) HCl at 30 C 67g

Saturated solution: The maximum amount of solute than can be dissolved in a volume of water at a given temperature.

Supersaturated solution: A solution with more solute dissolved than normally can be dissolved @ a given temp.

Unsaturated solution: A solution that is able to dissolve more solute at a given temp.

Are the following solution *saturated, unsaturated or supersaturated?*

1. 60 g KCl at 70 °C Supersaturated
2. 10 g $KClO_3$ at 60 °C Unsaturated
3. 80 g $NaNO_3$ at 10 °C Saturated
4. 70 g NaCl at 20 °C Supersaturated

Tell how many grams of each solute must be added to 100 g of water to form a saturated solution at the given temperature.

1. $NaNO_3$ at 10 °C 80g
2. NaCl at 30 °C 37-38 g
3. NH_3 at 50 °C 27-28 g
4. SO_2 at 50 °C 4-5 g

When comparing solubility: The solute with more grams dissdued at a given temp. is MORE SOLUBLE.

SOLUBILITY RATIOS

If the amount of water or solute changes and you are still making a saturated solution, you can set up a ratio to calculate the amounts of water & solute needed.

Temperature NEVER goes into the proportion

Example:
How much solute is needed to make a saturated solution of KNO_3 with 275g of water at 50 degrees Celsius.?

$$\frac{g\ solute}{g\ solvent} \rightarrow KNO_3\ @\ 50°C \rightarrow \frac{84g\ KNO_3}{100g\ H_2O} \not\propto \frac{X\ g}{425g\ H_2O}$$

$$100X = (84)(425)$$

$$X = \boxed{231g\ KNO_3}$$

Saturated and Unsaturated Solutions

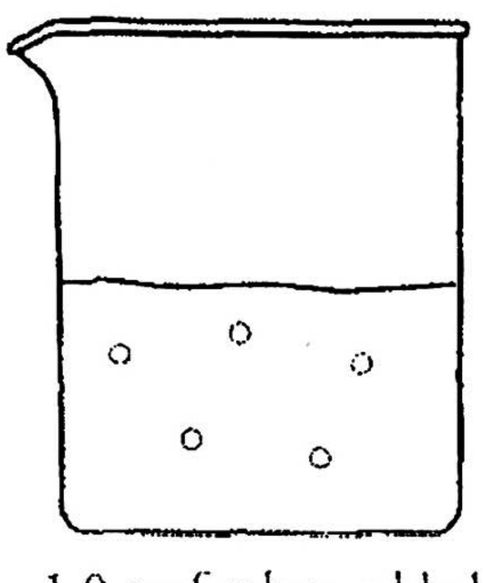
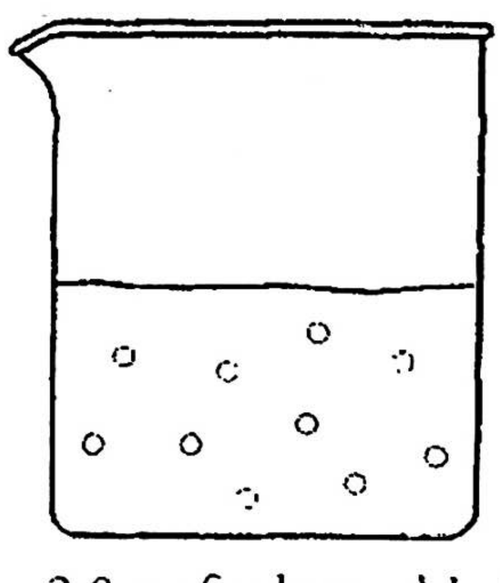
Is there a limit to the amount of solute that will dissolve in a solvent?

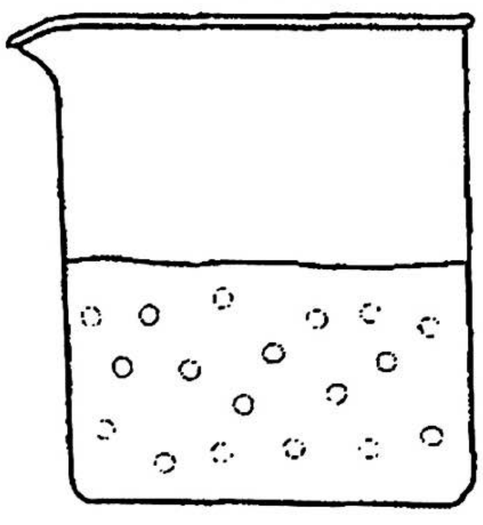
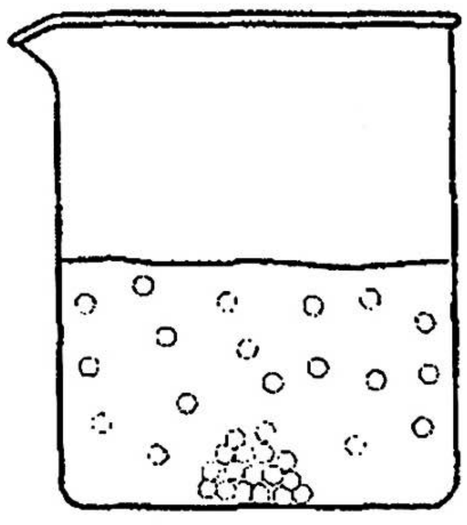
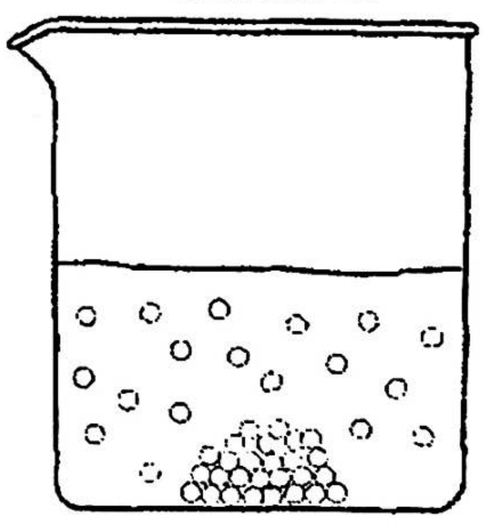
Why?

We use solutions every day. People who wear contact lenses use "lens solution" to rinse their contacts and keep them wet. Athletes who consume sports drinks after exercising benefit from the electrolytes in those solutions. This activity will explore whether or not there is a limit to how much of one substance can dissolve in another.

Model 1 – Saturated and Unsaturated Solutions

- All beakers contain 10.0 g of water.
- All beakers are kept at 20 °C.
- All solutions are stirred for 2 hours.
- Solute is the same substance in all beakers.

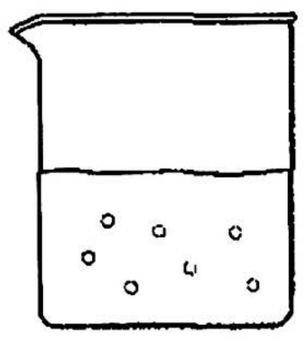
Unsaturated Solutions		
	Beaker A	Beaker B
		
	1.0 g of solute added	2.0 g of solute added
Number of dissolved particles	5	10
Number of solid particles	∅	0

Saturated Solutions		
	Beaker C	Beaker D	Beaker E
			
	3.6 g of solute added	7.0 g of solute added	9.0 g of solute added
	18	18	18
	∅	17	27

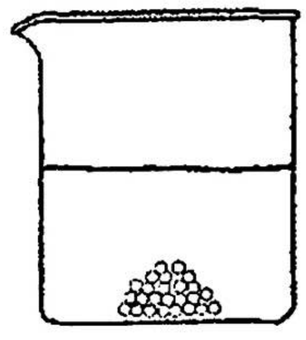
1. Which illustration below represents

   a. solute particles in a solid state in water?

   b. solute particles in an aqueous state?



B



A

2. What variables are controlled in all five beakers of Model 1?

- Temp.
- Amount of water
- Type of solute
- Stirring for 2 hours

3. Count the particles present in each beaker of Model 1. Fill in the table to show the number of dissolved solute particles and the number of solid solute particles.

4. Consider the beakers in Model 1.

   a. Which beakers represent **unsaturated** solutions?

   A, B

   b. Which beakers represent **saturated** solutions?

   C, D, E,

5. Beakers A–E in Model 1 are depicted as representing five different or separate solutions. They could also be considered as five "snapshots" of the same beaker over time. In other words, if additional measured quantities of solute were stirred into beaker A in small increments over time, then beakers B–E would result.

   a. When a small amount of additional solute is added to an unsaturated solution, what happens to the number of dissolved particles? Provide specific evidence from Model 1 to support your answer.

   It would dissolve.

   b. When a small amount of additional solute is added to a saturated solution, what happens to the number of dissolved particles? Provide specific evidence from Model 1 to support your answer.

   It would not dissolve

   c. Predict what would happen if a small amount of additional solute were stirred into beaker E in Model 1.

   It would remain undissolved / solid.

STOP

(10)

6. Have each person in your group provide an example of the word "saturated" as it is used in an everyday context. Summarize the meaning of the word in the space below.

- Maximum amount of sdute dissolved in a given amount of solvent
- Can't increase the amount of dissolved particles.

7. Use a grammatically correct sentence to explain why beakers D and E in Model 1 are labeled as "saturated." Be sure to incorporate the words "solute" and "solvent" in your explanation, and reach a consensus within your group.

The maximum amount of solute is dissolved in the given amount of solvent.

8. What feature in the beakers in Model 1 would typically enable a student to distinguish a saturated solution from an unsaturated one simply by looking at the beaker?

The solid particles at the bottom (undissolved)

9. Beaker C in Model 1 is shown as "saturated." Explain why this is the correct category for beaker C even though the typical feature listed in Question 8 is not present.

The maximum # of particles are dissolved (18)

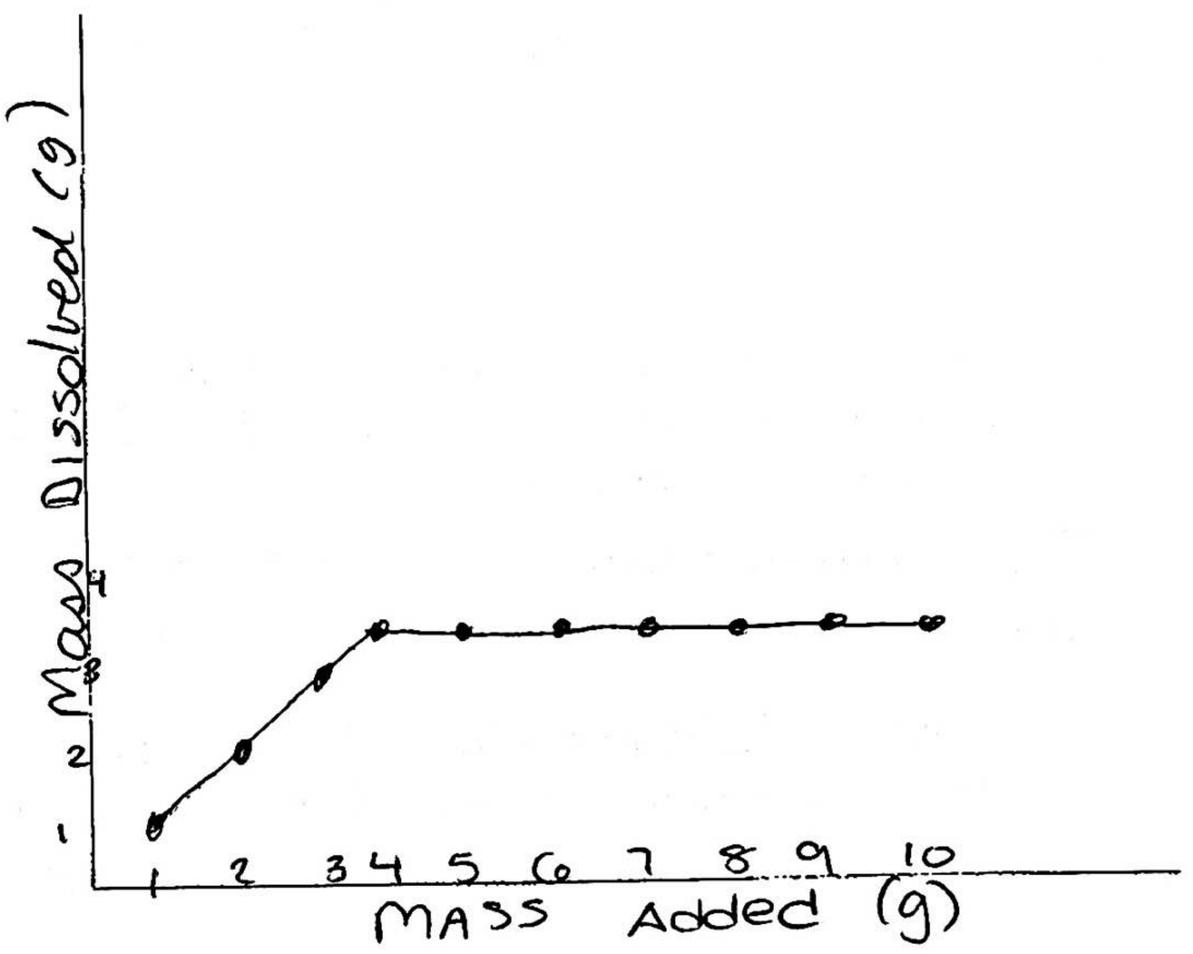
10. If you were handed a beaker containing a clear solution (with no solid solute at the bottom), and asked to identify it as "saturated" or "unsaturated," what simple test could you perform to determine the answer.

Add more solute & see if it dissolves.

Model 2 – Solute Dissolved vs. Solute Added

The following data refer to an experiment in which a measured mass of solid is added to 10.0 g of 20 °C water. The mixture is stirred and allowed to sit for 3 hours. Ten separate trials are conducted for the experiment.

Trial Number	Mass of solute added (grams)	Mass of solute dissolved (grams)
1	1.0	1.0
2	2.0	2.0
3	3.0	3.0
4	4.0	3.6
5	5.0	3.6
6	6.0	3.6
7	7.0	3.6
8	8.0	3.6
9	9.0	3.6
10	10.0	3.6



11. Four of the trials in Model 2 correspond to beakers A, B, D, and E from Model 1. Write the letters for those beakers next to the corresponding trial numbers in Model 2.

12. Identify the following variables in the experiment in Model 2.

Dependent variable Independent variable Controlled variable(s)

13. Sketch a graph of the data for the experiment in Model 2. A space has been provided next to the data table. Be sure to consider which variable belongs on each axis.

14. Consider the data in Model 2.

a. Which trials represent solutions that are unsaturated?

1, 2, 3

b. Which trial numbers represent solutions that are saturated?

4 – 10

c. Describe the feature in the graph that can help you identify the saturated solutions. Explain.

Flat line / constant dissolved mass

Chemistry: Form WS8.1.2A

Name _____

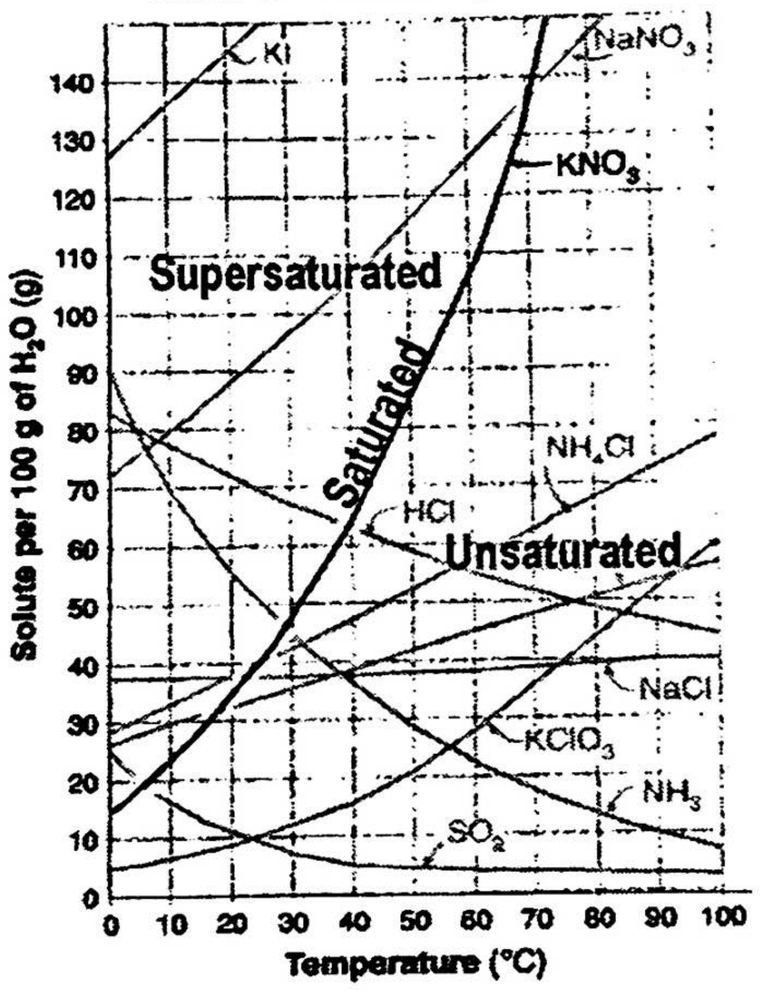
SOLUTIONS

Date _____ Period _____

Solubility Curves

The solubility of solid solutes generally increases as temperature increases, while the solubility of gaseous solutes generally decreases as temperature increases. A solution that holds as much solute as can dissolve at a given temperature is saturated. A solution that can dissolve more solute at a given temperature is unsaturated. A solution that holds more solute than can dissolve at a given temperature is supersaturated. The amount of solute that is needed to form a saturated solution at various temperatures can be graphed. This is what is shown in *Table G*. The values in *Table G* are based on solute dissolved in 100 g of water. Since water has a density of 1 g/mL, the graph can be considered to be based on 100 mL of water. A 200 mL sample of water would be able to dissolve twice as much at each temperature.

Table G Solubility Curves



Answer the questions below by referring to *Table G*.

1. The compound which is the most soluble at 20°C is KI.
2. The compound which is the least soluble at 10°C is KClO3.
3. The compound which is the least soluble at 80°C is SO2.
4. The number of grams of potassium nitrate (KNO3) needed to saturate 100 mL of water at 70°C is 134-135 g.
5. The formulas of the compounds which vary inversely with the temperature are SO2, NH3 and HCl.

   g ↓ / T
6. One hundred mL of a sodium nitrate (NaNO3) solution is saturated at 10°C. How many additional grams are needed to saturate the solution at 50°C? 10°C = 80g 50°C = 116g **36g**
7. One hundred mL of a saturate KCl solution at 80°C will precipitate 10 grams of salt when cooled to what temperature? 80°C = 52g → 42g @ **49-50°C**
8. The two salts that have the same degree of solubility at 70°C are KNO3 and NaNO3.
9. The salt with a solubility is least affected by a change in temperature is NaCl.
10. The salt that has the greatest increase in solubility in the temperature range between 30°C and 50°C is KNO3.
11. The number of grams of sodium nitrate (NaNO3) that must be added to 50 mL of water to produce a saturated solution at 50°C is $\frac{116}{100} = \frac{x}{50}$ **58g**.
12. A saturated solution of potassium chlorate (KClO3) is made at 10°C by dissolving the correct mass of salt in 100 mL of water. When the solution is heated to 90°C, how many grams must be added to saturate the solution? **45g**

    $KClO_3$ @ 10°C = 7g

    @ 90°C = 52g

Continue ☞

13. At what temperature do saturated solutions of sodium chloride (NaCl) and potassium chloride (KCl) contain the same mass of solute per 100 mL of water? 37°C

14. A saturated solution of potassium nitrate (KNO3) is prepared at 60°C using 200 mL of water. If the solution is cooled to 30°C, how many grams will precipitate out of the solution? $\frac{106}{100} = \frac{X}{200}$ 212g @30°C = 45 x 2 = 96 **116g**

15. How many more grams of ammonia can be dissolved in 100 mL of water at 10°C than at 90°C? 70g − 10g = 60g

16. A saturated solution of sodium nitrate in 100 mL of water at 40°C is heated to 50°C. The rate of increase in solubility grams per degree is 105g → 115g 10g / 10°C 1g per degree.

17. Thirty grams of KCl is dissolved in 100 mL of water at 45°C. The number of additional grams of KCl that would be needed to make the solution saturated at 80°C is 22g.

30g → 52g

1. Which compound becomes *less* soluble in water as the temperature of the solution is increased?

A) HCl B) KCl

C) NaCl D) NH_4Cl

2. An unsaturated aqueous solution of NH_3 is at 90°C in 100. grams of water. According to Reference Table G, how many grams of NH_3 could this unsaturated solution contain? *Less than 10g

A) 5 g B) 10. g C) 15 g D) 20. g

3. The solubility of $KClO_3(s)$ in water increases as the

A) temperature of the solution increases

B) temperature of the solution decreases

C) pressure on the solution increases

D) pressure on the solution decreases

4. According to Reference Table G, which of these substances is most soluble at 60°C?

A) NaCl – 38g B) KCl – 45g

C) $KClO_3$ – 28g D) NH_4Cl – 57g

5. According to Reference Table G, what is the approximate difference between the amounts of $KClO_3$ and KNO_3 soluble in 100 grams of water at 40°C? → 16g → 64g 64-16 = 48g

A) 17 g B) 22 g C) 47 g D) 64 g

6. 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? KNO_3 @ 40°C → 64g

64
-35
29

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

7. According to Reference Table G, which solution is saturated at 30°C?

A) 12 grams of $KClO_3$ in 100 grams of water

B) 12 grams of $KClO_3$ in 200 grams of water 6g/100 g H_2O

C) 30 grams of NaCl in 100 grams of water

D) 30 grams of NaCl in 200 grams of water 15g/100 g H_2O

8. A solution is formed by dissolving 45 grams of NH_4Cl in 100 grams of H_2O at 70°C. Which statement correctly describes this solution? NH_4Cl @ 70°C → 62g

A) NH_4Cl is the solute, and the solution is saturated.

B) NH_4Cl is the solute, and the solution is unsaturated.

C) NH_4Cl is the solvent, and the solution is saturated.

D) NH_4Cl is the solvent, and the solution is unsaturated.

9. According to Reference Table G, approximately how many grams of $KClO_3$ are needed to saturate 100 grams of H_2O at 40°C?

A) 6 B) 16 C) 38 D) 47

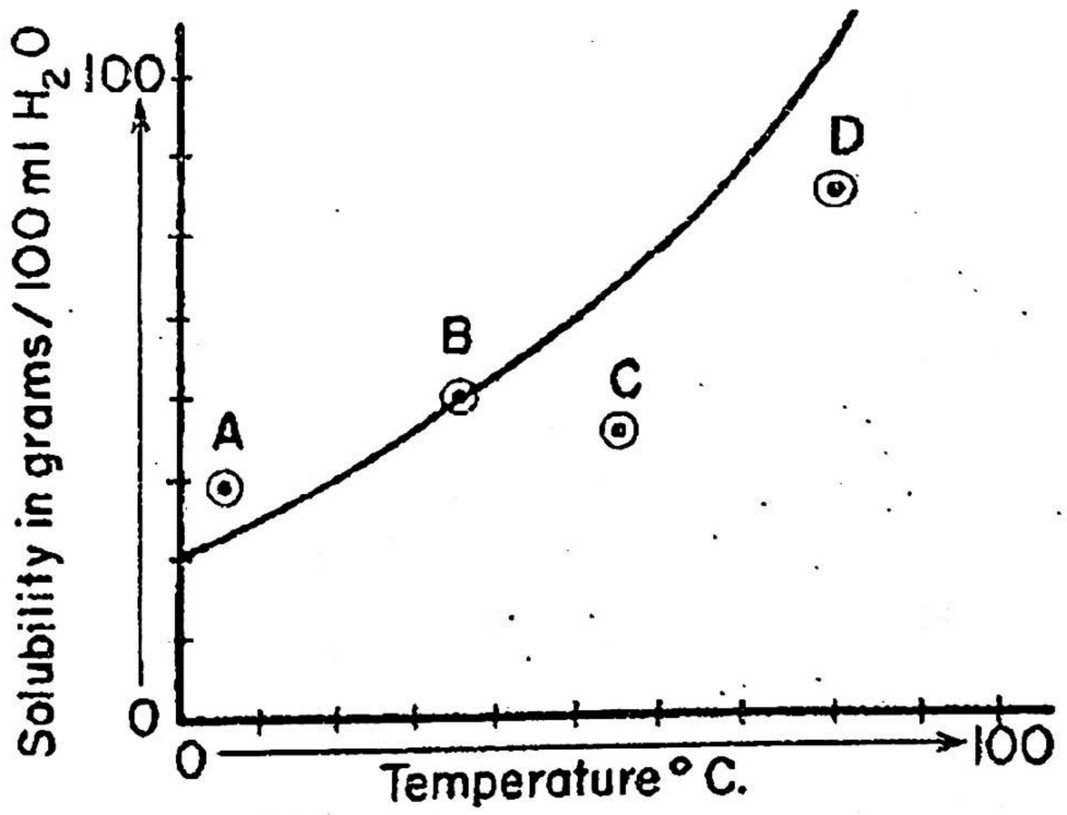
10. According to Reference Table G, how many grams of NH_4Cl must be dissolved in 100 grams of H_2O at 70°C to reach solution equilibrium?

A) 52 g B) 56 g C) 62 g D) 86 g

11. A solution contains 70 grams of $NaNO_3$ in 100 grams of water at 10°C. How many additional grams of $NaNO_3$ are required to saturate this solution?

A) 10 B) 20 C) 60 D) 70

12. Base your answer to the following question on the diagram below which represents the solubility curve of salt *X*. The four points on the diagram represent four solutions of salt *X*.



Which point represents a supersaturated solution of salt *X*?

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

13. How many grams of $NaNO_3$ would have to be added to 100. grams of water at 45°C to make a saturated solution of this salt?

A) 100 B) 110. C) 120. D) 130.

14. A solution contains 90 grams of a salt dissolved in 100 grams of water at 40°C. The solution could be an unsaturated solution of

A) KCl B) KNO_3

C) NaCl D) $NaNO_3$

CONCENTRATION

Refers to the number of particles dissolved in A given volume of solution

Table T:

Molarity (M):

$$M = \frac{\text{moles solute}}{\text{Liters solution}}$$

* g → moles (Table T)
* mL → L (÷ 1000)

Parts Per Million (ppm):

$$ppm = \frac{\text{grams solute}}{\text{grams solution}} \times 1{,}000{,}000$$

solute + solvent

Examples...

1) What is the concentration of a 2 L solution that contains 5.5 moles of NaCl?

$$M = \frac{\text{moles}}{L} \qquad M = \frac{5.5 \text{ moles}}{2 L}$$

2) What is the concentration of a 0.5L solution that contains 174g of NaCl (molar mass = 58 g/mol)

grams → moles

$$X \text{ moles} = \frac{174 \text{ g}}{58 \text{ g/mol}}$$

3 moles

$$M = \frac{\text{moles}}{L}$$

$$M = \frac{3 \text{ moles}}{0.5 L}$$

6 M Soln.

3) 0.0043 g of oxygen is dissolved in 100 mL of H_2O @ 20C. What is the concentration in ppm?

$$ppm = \frac{\text{g solute}}{\text{g solution}} \times 1{,}000{,}000$$

solute + water

$$ppm = \frac{0.0043 \text{ g}}{100.0043 \text{ g}} \times 1{,}000{,}000$$

Name

Molarity Intro.

(1 Step Problems)

1. The molarity of an aqueous solution of NaCl is defined as the

   A) grams of NaCl per liter of water
   B) grams of NaCl per liter of solution
   C) moles of NaCl per liter of water
   D) moles of NaCl per liter of solution

2. Which unit can be used to express solution concentration?

   A) J/mol
   B) L/mol
   C) mol/L
   D) mol/s

3. A 3.0 M HCl(aq) solution contains a total of

   A) 3.0 grams of HCl per liter of water
   B) 3.0 grams of HCl per mole of solution
   C) 3.0 moles of HCl per liter of solution
   D) 3.0 moles of HCl per mole of water

4. What is the molarity of a solution of NaOH if 2 liters of the solution contains 4 moles of NaOH?

   $X\ M = \frac{4\ moles}{2\ L}$

   A) 0.5 M
   B) 2 M
   C) 8 M
   D) 80 M

5. What is the molarity of a solution that contains 0.50 mole of NaOH in 0.50 liter of solution?

   $X\ M = \frac{0.50\ moles}{0.50\ L}$

   A) 1.0 M
   B) 2.0 M
   C) 0.25 M
   D) 0.50 M

6. What is the total number of moles of solute in 2.0 liters of 3.0 M NaOH?

   $3\ M = \frac{X\ moles}{2\ L}$

   A) 1.0 mole
   B) 2.0 moles
   C) 3.0 moles
   D) 6.0 moles

7. What is the concentration of a solution of 10. moles of copper (II) nitrate in 5.0 liters of solution?

   $X\ M = \frac{10\ moles}{5\ L}$

   A) 0.50 M
   B) 2.0 M
   C) 5.0 M
   D) 10. M

8. What is the molarity of an H_2SO_4 solution if 0.25 liter of the solution contains 0.75 mole of H_2SO_4?

   $X\ M = \frac{0.75\ moles}{0.25\ L}$

   A) 0.33 M
   B) 0.75 M
   C) 3.0 M
   D) 6.0 M

9. How many liters of a 0.5 M sodium hydroxide solution would contain 2 moles of solute?

A) 1 L B) 2 L C) 3 L (D) 4 L

$0.5\ M = \frac{2\ mol}{X}$

10. Which solution is most concentrated?

A) 0.1 mole of solute dissolved in 400 ml of solvent

B) 0.2 mole of solute dissolved in 300 ml of solvent

C) 0.3 mole of solute dissolved in 200 ml of solvent

(D) 0.4 mole of solute dissolved in 100 ml of solvent

$\frac{2}{.5} = \frac{.5X}{.5}$

11. What is the total number of moles of solute contained in 0.50 liter of 3.0 M HCl?

A) 1.0 (B) 1.5 C) 3.0 D) 3.5

$3\ M = \frac{X\ mol}{.5}$

12. How many total moles of KNO_3 must be dissolved in water to make 1.5 liters of a 2.0 M solution?

A) 0.50 mol B) 2.0 mol

(C) 3.0 mol D) 1.3 mol

$2\ M = \frac{X\ mol}{1.5\ L}$

13. How many moles of solute are contained in 200 milliliters of a 1 M solution? * mL→L

A) 1 B) 0.2 C) 0.8 D) 200

$1\ M = \frac{X\ mol}{.2\ L}$

14. What is the total number of moles of H_2SO_4 needed to prepare 5.0 liters of a 2.0 M solution of H_2SO_4?

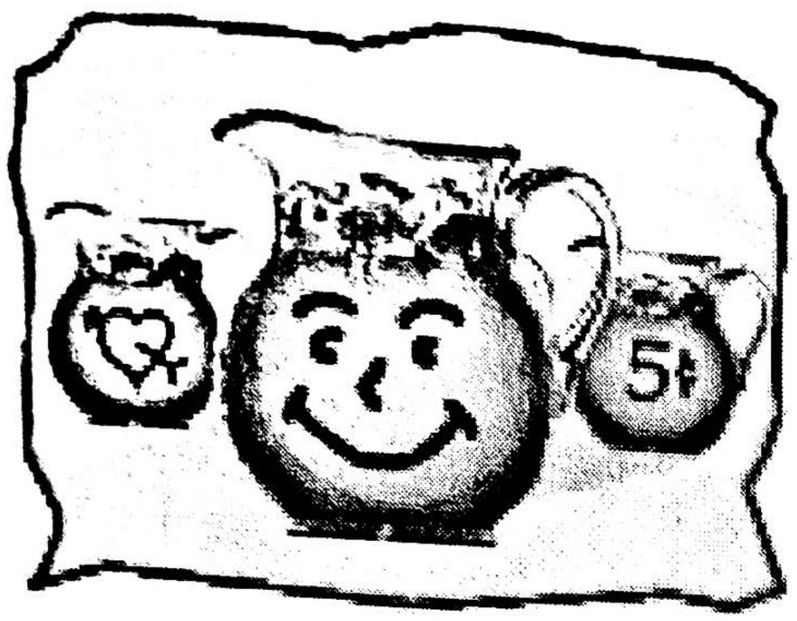
A) 2.5 B) 5.0 (C) 10. D) 20.

$2\ M = \frac{X}{5\ L}$

15. How many moles of KNO_3 are required to make 0.50 liter of a 2.0 M solution of KNO_3?

(A) 1.0 B) 2.0 C) 0.50 D) 4.0

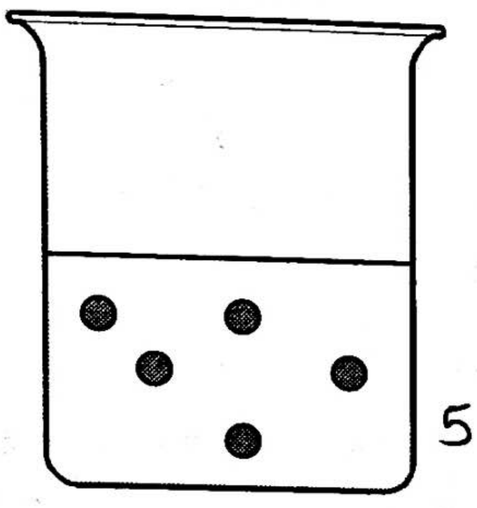
$2\ M = \frac{X\ mol}{.5\ L}$



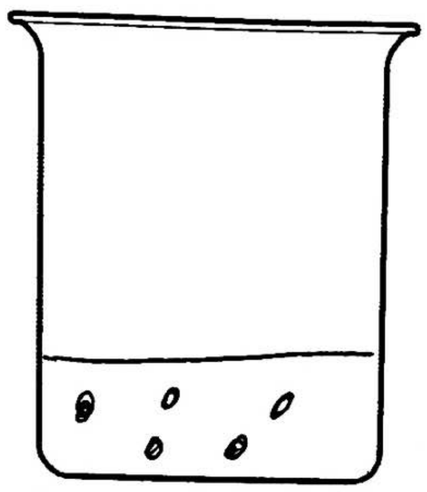
MOLARITY IS KOOL...

Chemists often work with aqueous solutions. In most cases a solid (the solute) is dissolved in water (the solvent) to make a solution. As more solid is added, the solution gets more concentrated. In the picture below, a solute has been added to some water in a beaker. Draw two other pictures that show different ways to make a solution that is MORE CONCENTRATED than the solution shown:

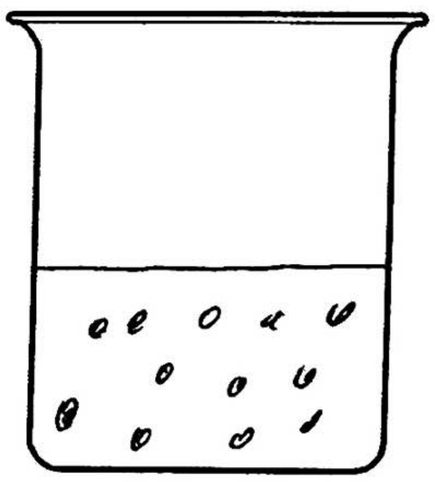
Solution 1



Solution 2



Solution 3



Explain how you made Solution 1 more concentrated:

Solution 2: Decreased the volume of water

Solution 3: Increased the Amount of solute

In chemistry we use some fancy words to describe a solution. The concentration is referred to as the MOLARITY of the solution. Molarity is a numerical value. We can calculate the MOLARITY by comparing the moles of solute to the volume of the solution. The volume is always measured in liters.

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

Your teacher will now make three salt water solutions by dissolving a specific amount of NaCl into water to make a specific volume of solution. Calculate the molarity of each NaCl solution.

Solution 1

Dissolve 2.00 grams of NaCl in water to make 50.00 mL of solution

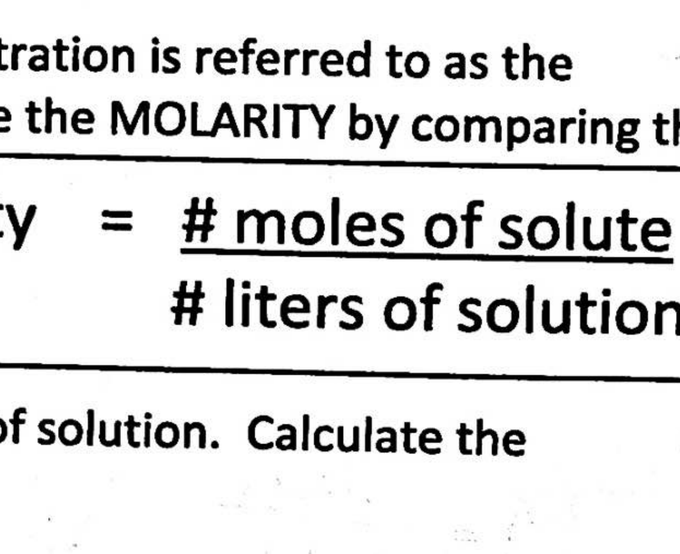
* Gram Form Mass = 58 g

.050 L

$M = \frac{\text{mole}}{L}$

$\text{moles} = \frac{2\text{ g}}{58}$

$M = \frac{.034}{.05\text{ L}}$ ← .034 moles



Molarity of Solution 1 = .68 **M NaCl**

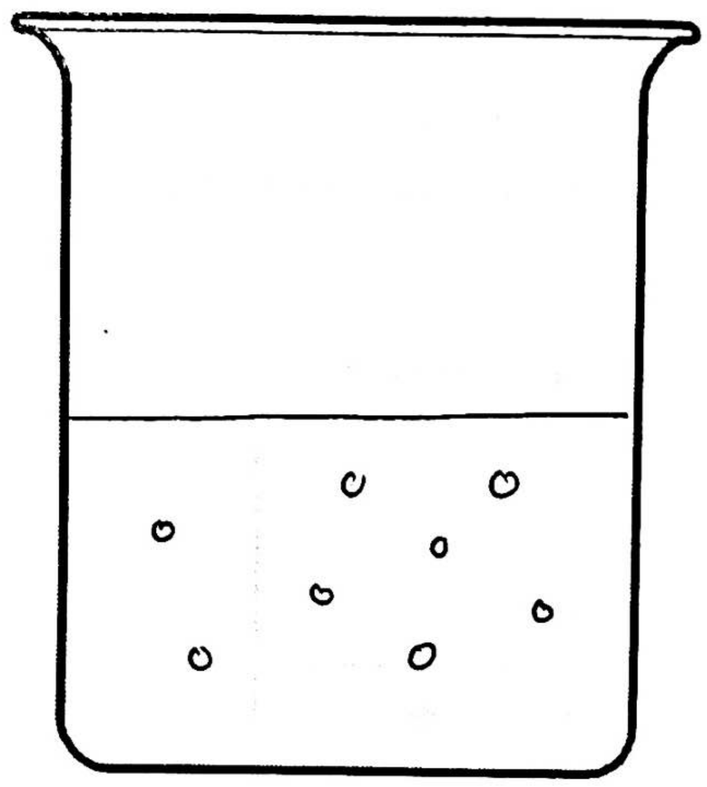
Solution 2

Dissolve 4.00 grams of NaCl in water to make 50.00 mL of solution

$M = \frac{mol}{L}$ .050 L

$M = \frac{.069}{.050\,L}$ ← $moles = \frac{4g}{58}$

.069



Draw a picture that shows how the concentration of Solution 2 is different from Solution 1.

Molarity of Solution 2 = 1.38 **M NaCl**

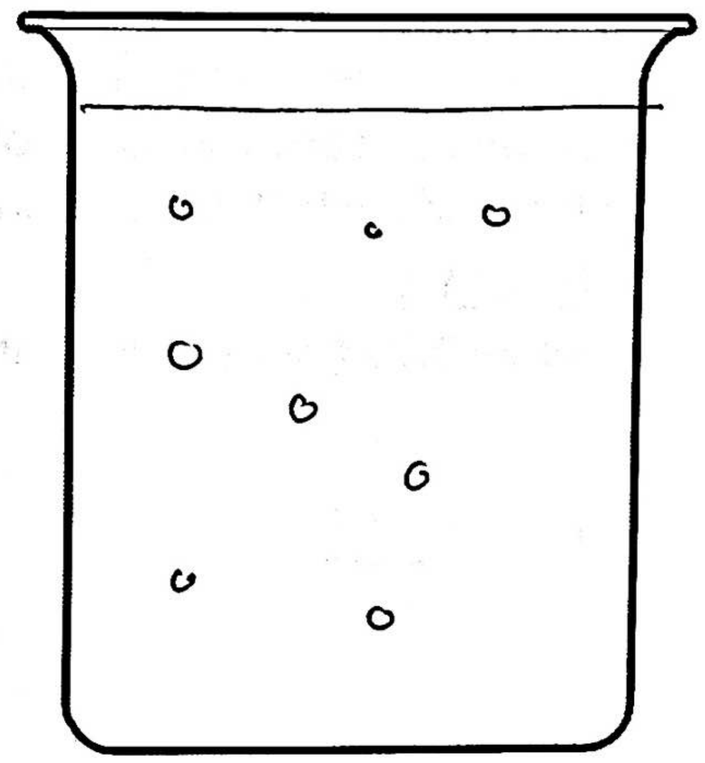
Solution 3

Dissolve 4.00 grams of NaCl in water to make 100.00 mL of solution

$M = \frac{mol}{L}$ .1 L

$M = \frac{.069}{.1\,L}$ ← $moles = \frac{4g}{58\ g/mol}$

.069



Draw a picture that explains the concentration of Solution 3.

Molarity of Solution 3 = .69 **M NaCl**

In this activity you will make three Kool-Aid solutions with different molarities. Follow the instructions carefully and complete the data table as you go.

Procedure:

1. Gather three large cups labeled A, B, and C.

2. Fill one of the cups to the top with tap water. Using a graduated cylinder, determine the volume of the cup. NOTE: Water should be poured from the cup INTO the cylinder. Do not do this incorrectly!!! You will be drinking these solutions and you do not want to contaminate the solutions with chemicals.

Record the volume of the cup. V = 180 milliliters

Convert the volume to liters. V = .180 liters

3. Using the data table as a guide, add the correct amount of solute to cup A, B, and C. In this activity we are making a huge assumption that the Kool-Aid is entirely sugar, $C_{12}H_{22}O_{11}$.

Determine the molar mass of $C_{12}H_{22}O_{11}$ 342 **g/mole**

$12 \cdot 12 = 144$
$1 \cdot 22 = 22$
$16 \cdot 11 = 176$
$+$
342

4. Now add tap water to the top of each cup. Use a popsicle stick to stir each solution.

5. Each student should get one Dixie cup. Analyze solution A by pouring some of the liquid into each Dixie cup. Drink the solution and make observations. Repeat this procedure for solution B and solution C. Record your observations in the data table.

6. CLEAN UP: Rinse out cups A, B, and C carefully with tap water. All Dixie cups should be thrown away.

DATA TABLE: SHOW ALL WORK FOR CALCULATIONS.

Trial	Mass of $C_{12}H_{22}O_{11}$ (grams)	Calculate the MOLES of $C_{12}H_{22}O_{11}$	Calculate the Molarity of $C_{12}H_{22}O_{11}$ solution (moles/liters)	Observations
A	5.0	$\frac{5g}{342} = .0146$ mol	$\frac{.0146 \text{ mol}}{.180 \text{ L}} = \boxed{.081 \text{ M}}$	
B	10g → 10.0 ↘	$\frac{10}{342} = .0292$ mol $\frac{15}{342} = .0439$ mol	$\frac{.0292}{.180} = \boxed{.162 \text{ M}}$ $\frac{.0439}{.180} = \boxed{.244 \text{ M}}$	
C	30.0	$\frac{30}{342} = .0877$ mol	$\frac{.0877}{.180} = \boxed{.487 \text{ M}}$	

Post-lab Questions

1. Define the following vocabulary words:

mixture	Physical combination of 2 or more substances
solution	Homogenous mixture containing a solute & solvent
solvent	Medium solute is dissolved into
solute	Substance being dissolved
dilute	A low concentration; Less solute per volume of solution.
concentrated	A high concentration; More solute per volume of solution.

2. In this lab you made solutions of different concentrations of Kool-Aid.

a. What was the **solute** in this lab? Kool-Aid / Iced tea

b. What was the **solvent** in this lab? Water

3. Mathematically compare the concentrations of Solution A and Solution C. You must show your work. (Think: How do you compare two numbers? We've done this several times!)

Solution C is _____ times more concentrated than Solution A.

4a. Let's pretend that you make a fourth Kool-Aid solution by dissolving 45.0 grams of $C_{12}H_{22}O_{11}$ in water to make 600 mL of solution. We will call this Solution D. Calculate the molarity of Solution D.

$M = \frac{.132 \text{ mol}}{.600 \text{ L}}$

600 mL = .600 L

moles = $\frac{45 \text{ g}}{342 \text{ g/mol}}$

.132 moles

.22 M

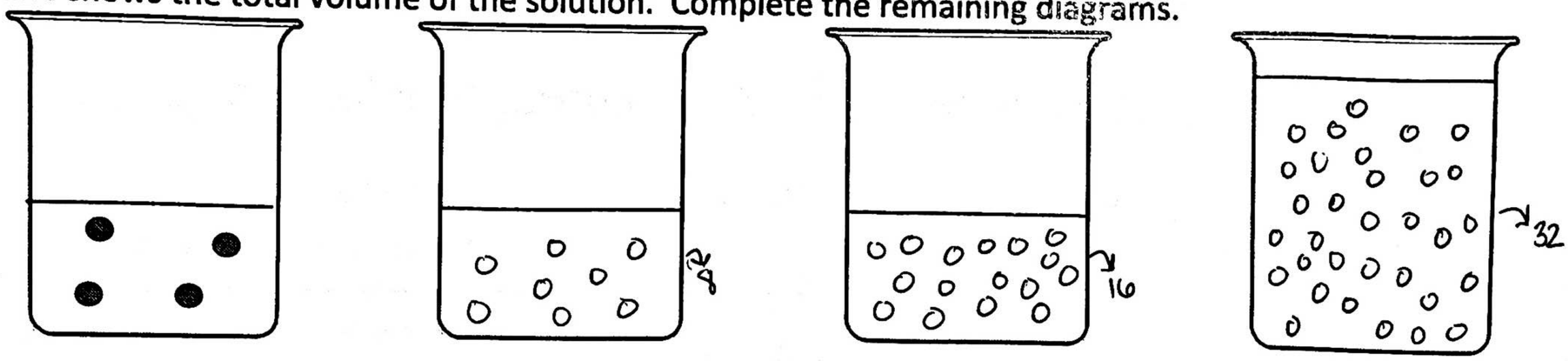
b. Look at the calculated molarity value of Solution D. How does Solution D's molarity value compare to the molarities of solutions A, B, and C that you made in the lab? Compare the solutions:

Solution D would be MORE concentrated than solution(s): (circle) **(A) (B) C**

Solution D would be LESS concentrated than solution(s): (circle) **A B (C)**

*with 30g. or 15g.

5. A diagram of a 1.0 M solution is shown. The dots represent the amount of solute dissolved. The line shows the total volume of the solution. Complete the remaining diagrams.



1.0 M **2.0 M** **4.0 M** **4.0 M**

6a. A lab requires you to make 500.0 mL of a 3.00 M solution of NaCl. You start with solid NaCl. Explain the steps that you would take to make this solution.

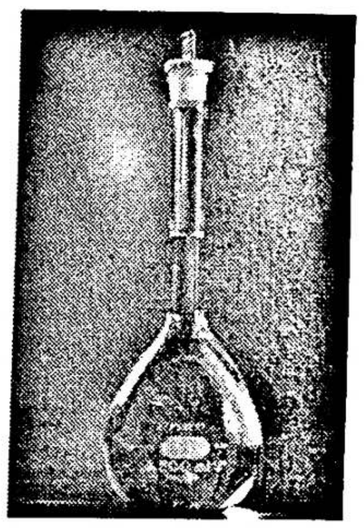
$3\ M = \frac{X\ moles}{.5\ L}$

1.5 moles NaCl

$1.5\ moles = \frac{X\ g}{58\ g/mol}$

87 g NaCl

- Put 87 g NaCl in a graduated container.
- Add water to reach the .5 L line.
- Stir to dissolve salt



6b. If you took the 500.0 mL of 3.00 M NaCl solution off the shelf and wanted to increase the molarity to 6.00 M NaCl, what steps would you have to take to accomplish this task?

$6\ M = \frac{X\ mol}{.5\ L}$

3 moles

↓

174 g NaCl

- ~~Boil off~~
- Add an additional 87 g of NaCl
- Boil of H_2O until volume is .5 L again.

TRUE or FALSE?

b. If you add more solid NaCl to the solution in 6a, the molarity will increase. TRUE

c. If you pour some of the solution that you made in 6a into a 100 mL beaker, the molarity will increase. False

d. If you pour all of the solution that you made in 6a into a 1000 mL beaker, the molarity will decrease. False

e. If you pour all of the solution that you made in 6a into a 1000.0 mL flask and add water to the line, the molarity will decrease. True

f. If you take the solution you made in 6a and pour some of it down the drain, the remaining solution will have a lower molarity. False

Parts Per Million

1. Which type of concentration is calculated when the grams of solute is divided by the grams of the solution, and the result is multiplied by 1,000,000?

A) molarity B) parts per million

C) percent by mass D) percent by volume

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

A) L/s B) J/g C) ppm D) kPa

3. A 2400.-gram sample of an aqueous solution contains 0.012 gram of NH_3. What is the concentration of NH_3 in the solution, expressed as parts per million?

$$\frac{.012\ g}{2400\ g} \times 1{,}000{,}000 =$$

A) 5.0 ppm B) 15 ppm

C) 20. ppm D) 50. ppm

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

$$5\ ppm = \frac{x\ g}{1000 g} \times 1{,}000{,}000$$

A) 0.005 g B) 0.05g

C) 0.5 g D) 5g

5. What is the concentration of $O_2(g)$, in parts per million, in a solution that contains 0.008 gram of $O_2(g)$ dissolved in 1000. grams of $H_2O(l)$?

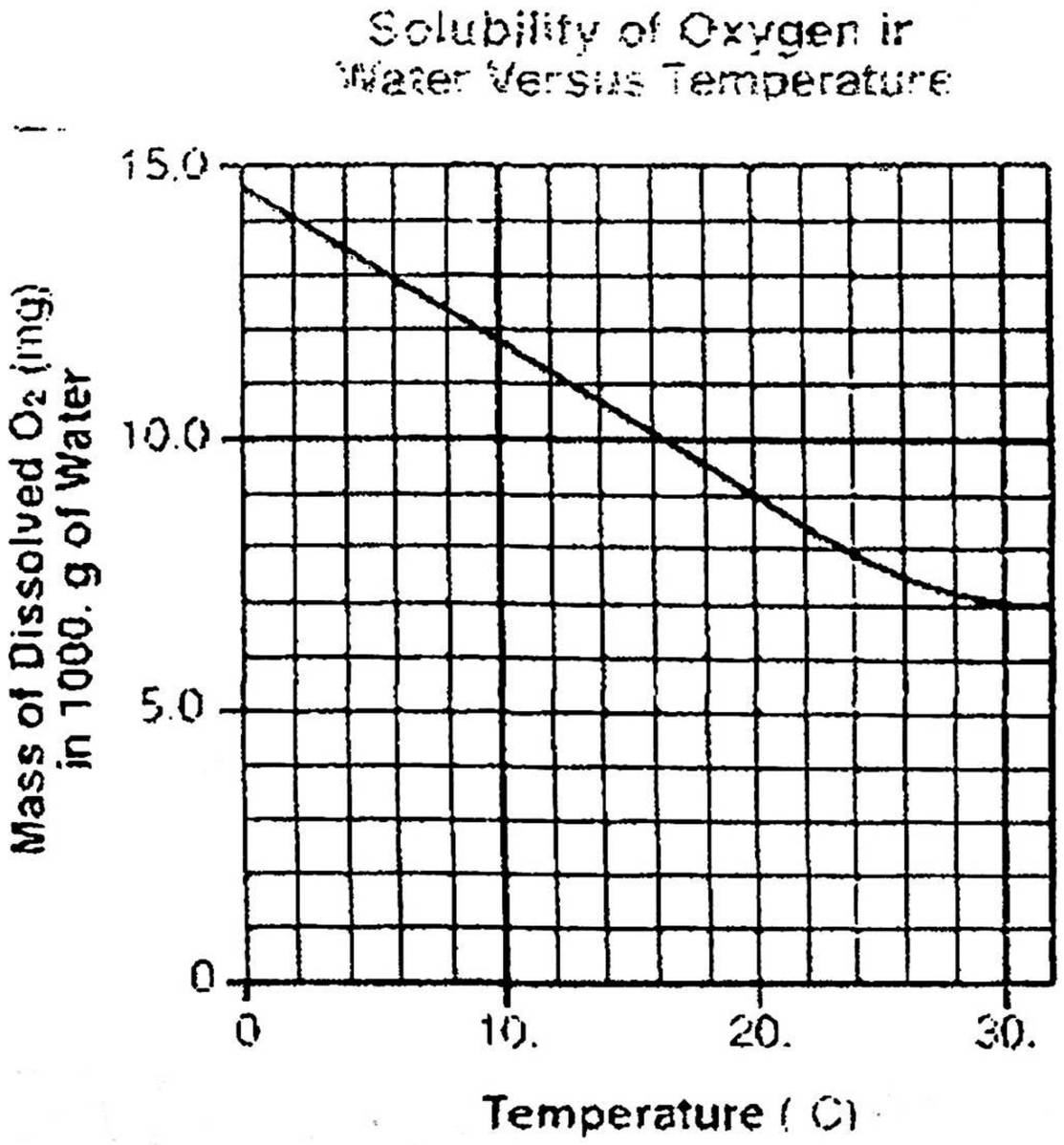
$$\frac{.008\ g}{1000.008\ g} \times 1{,}000{,}000 = \boxed{7.9}$$

A) 0.8 ppm B) 8 ppm

C) 80 ppm D) 800 ppm

6. Base your answer to the following question on the information below

Scientists who study aquatic ecosystems are often interested in the concentration of dissolved oxygen in water. Oxygen, O2, has a very low solubility in water, and therefore its solubility is usually expressed in units of milligrams per 1000. grams of water at 1.0 atmosphere. The graph below shows a solubility curve of oxygen in water.



$X\ ppm = \frac{.0070}{1000.007} \times 1{,}000{,}000$

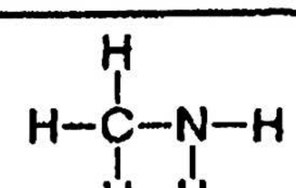
6.9 ppm

An aqueous solution has 0.0070 gram of oxygen dissolved in 1000. grams of water. Calculate the dissolved oxygen concentration of this solution in parts per million. Your response must include *both* a correct numerical setup and the calculated result.

7. Base your answer to the following question on the information below.

Bond energy is the amount of energy required to break a chemical bond. The table below gives a formula and the carbon-nitrogen bond energy for selected nitrogen compounds.

Selected Nitrogen Compounds

Compound	Formula	Carbon-Nitrogen Bond Energy (kJ/mol)
hydrogen cyanide	H–C≡N	890.
isocyanic acid	H–N=C=O	615
methanamine		293

$X_{ppm} = \frac{.00074\ g}{3.2\ g} \times 1{,}000{,}000$

231.2

A 3.2-gram sample of air contains 0.000 74 gram of hydrogen cyanide. Determine the concentration, in parts per million, of the hydrogen cyanide in this sample.

Colligative Properties

1. Which sample, when dissolved in 1.0 liter of water, produces a solution with the highest boiling point?

   A) 0.1 mole KI
   B) 0.2 mole KI
   C) 0.1 mole $MgCl_2$
   D) 0.2 mole $MgCl_2$

2. 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 lower boiling point and a lower freezing point
   B) a lower boiling point and a higher freezing point
   C) a higher boiling point and a lower freezing point
   D) a higher boiling point and a higher freezing point

3. How do the boiling point and freezing point of a solution of water and calcium chloride at standard pressure compare to the boiling point and freezing point of water at standard pressure?

   A) Both the freezing point and boiling point of the solution are higher.
   B) Both the freezing point and boiling point of the solution are lower.
   C) The freezing point of the solution is higher and the boiling point of the solution is lower.
   D) The freezing point of the solution is lower and the boiling point of the solution is higher.

4. Compared to the freezing point and boiling point of water at 1 atmosphere, a solution of a salt and water at 1 atmosphere has a

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

5. 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

6. Which solution has the lowest freezing point?

   A) 10. g of KI dissolved in 100. g of water
   B) 20. g of KI dissolved in 200. g of water
   C) 30. g of KI dissolved in 100. g of water
   D) 40. g of KI dissolved in 200. g of water

7. 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) lower
   B) higher
   C) the same

8. When ethylene glycol (an antifreeze) is added to water, the boiling point of the water

   A) decreases, and the freezing point decreases
   B) decreases, and the freezing point increases
   C) increases, and the freezing point decreases
   D) increases, and the freezing point increases

Topic 7: Solutions

1. Solution: Recalling concept facts and definitions

1. Which must be a mixture of two or more substances?
   1) Solid 2) Liquid 3) Gas 4) Solution

2. All aqueous mixtures must contain
   1) Water 2) Sodium chloride 3) Oxygen 4) Sand

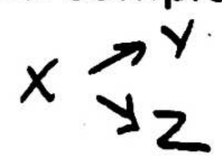
3. A small quantity of salt is stirred into a liter of water until it dissolves. The water in the mixture is
   1) The solute 2) Dispersed material 3) A precipitate 4) The solvent

4. The process of recovering a salt from a solution by evaporating the solvent is known as
   1) Decomposition 2) Crystallization 3) Reduction 4) Filtration

5. In a true solution, the dissolved particles
   1) Are visible to the eyes
   2) Will settle out on standing
   3) Are always solids
   4) Cannot be removed by filtration

6. Aqueous solutions are best described as a
   1) Homogenous compounds
   2) Homogeneous mixtures
   3) Heterogeneous compounds
   4) Heterogeneous mixtures

7. When sample X is passed through a filter paper and a white residue, Y, remains on the paper and a clear liquid, Z, passes through. When Z is vaporized, another white residue remains. Sample X is best classified as
   1) An element
   2) A compound
   3) A heterogeneous mixture
   4) A homogeneous mixture



8. An aqueous solution of copper sulfate is poured into a filter paper cone. What passes through the filter paper?
   1) Only the solvent
   2) Only the solute
   3) Both solvent and solute
   4) Neither the solvent nor solute

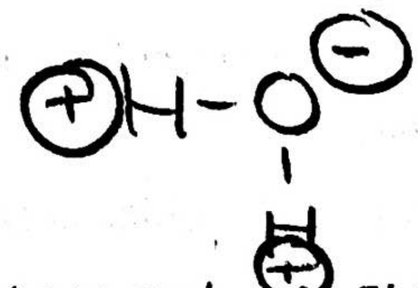
9. One similarity between all solutions and compounds is that both
   1) Are always heterogeneous
   2) Are always homogeneous
   3) Have definite ratio of composition
   4) Are composed of two or more substances

2. Solute and solvents: Determining solutes and solvent of a solution

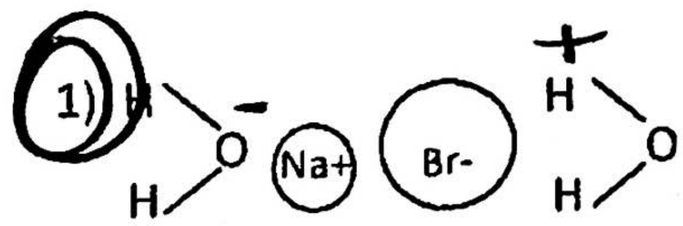
1. In an aqueous solution of potassium ~~fluoride~~ chloride, the solute is KCl
   1) K+ only 2) Cl- only 3) K+Cl- 4) H_2O

2. A small of $LiNO_3$ is dissolved in H_2O to make a solution. In this solution
   1) $LiNO_3$ is the solute
   2) $LiNO_3$ is the solvent
   3) H_2O is the solute
   4) H_2O is the precipitate

3. What happens when KI(s) is dissolved in water?
   1) I- ions are attracted to the oxygen atoms of water
   2) K+ ions are attracted to the oxygen atoms of water
   3) K+ ions are attracted to the hydrogen atoms of water
   4) No attractions are involved, the crystal just falls apart



4. Which diagram best illustrates the molecule-ions attractions that occur when NaF(s) is added to water?

1)


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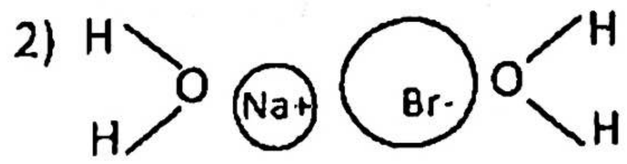

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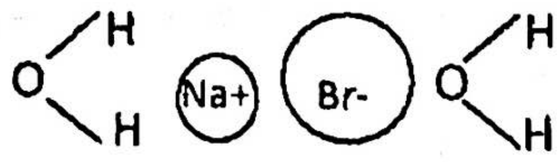

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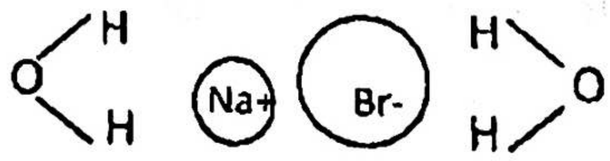


Need Help? Study book Pg 139 – 140 Set 1 – 4

Need Help? Study book Pg 140 Set 3

Solutions: Review

1. Base your answer to the following question on the information below.

Cold packs are used to treat minor injuries. Some cold packs contain $NH_4NO_3(s)$ and a small packet of water at room temperature before activation. To activate this type of cold pack, the small packet must be broken to mix the water and $NH_4NO_3(s)$. The temperature of this mixture decreases to approximately 2°C and remains at this temperature for 10 to 15 minutes.

Identify the type of mixture formed when the $NH_4NO_3(s)$ is completely dissolved in the water.

Homogenous or solution
mixture

Base your answers to questions **2** and **3** on the information below.

A 2.0-liter aqueous solution contains a total of 3.0 moles of dissolved NH_4Cl at 25°C and standard pressure.

2. Determine the molarity of the solution.

$M = \frac{moles}{L}$ $M = \frac{3}{2}$ 1.5 M

3. Identify the *two* ions present in the solute.

Solute: NH_4Cl

- NH_4^+ and Cl^-
- Ammonium and chloride

Base your answers to questions **4** through **6** on the information below.

In a laboratory, a student makes a solution by completely dissolving 80.0 grams of $KNO_3(s)$ in 100.0 grams of hot water. The resulting solution has a temperature of 60.°C. The room temperature in the laboratory is 22°C.

4. Describe a laboratory procedure that can be used to recover the solid solute from the aqueous solution.

- Heat solution to evaporate water
- Boil of water

5. Classify, in terms of saturation, the type of solution made by the student.

(saturated, unsaturated or supersaturated)

80g KNO_3 @ 60°C → Unsaturated

6. Compare the boiling point of the solution at standard pressure to the boiling point of water at standard pressure.

The boiling point of the solution is higher than the water.

Base your answers to questions **7** through **9** on the information below.

A soft-drink bottling plant makes a colorless, slightly acidic carbonated beverage called soda water. During production of the beverage, $CO_2(g)$ is dissolved in water at a pressure greater than 1 atmosphere. The bottle containing the solution is capped to maintain that pressure above the solution. As soon as the bottle is opened, fizzing occurs due to $CO_2(g)$ being released from the solution.

7. Explain why $CO_2(g)$ is released when a bottle of soda water is opened.

The pressure decreases so the solubility of $CO_2(g)$ decreases.

8. Write the chemical name of the acid in soda water.

Carbonic acid

9. State the relationship between, the solubility of $CO_2(g)$ in water and the temperature of the aqueous solution.

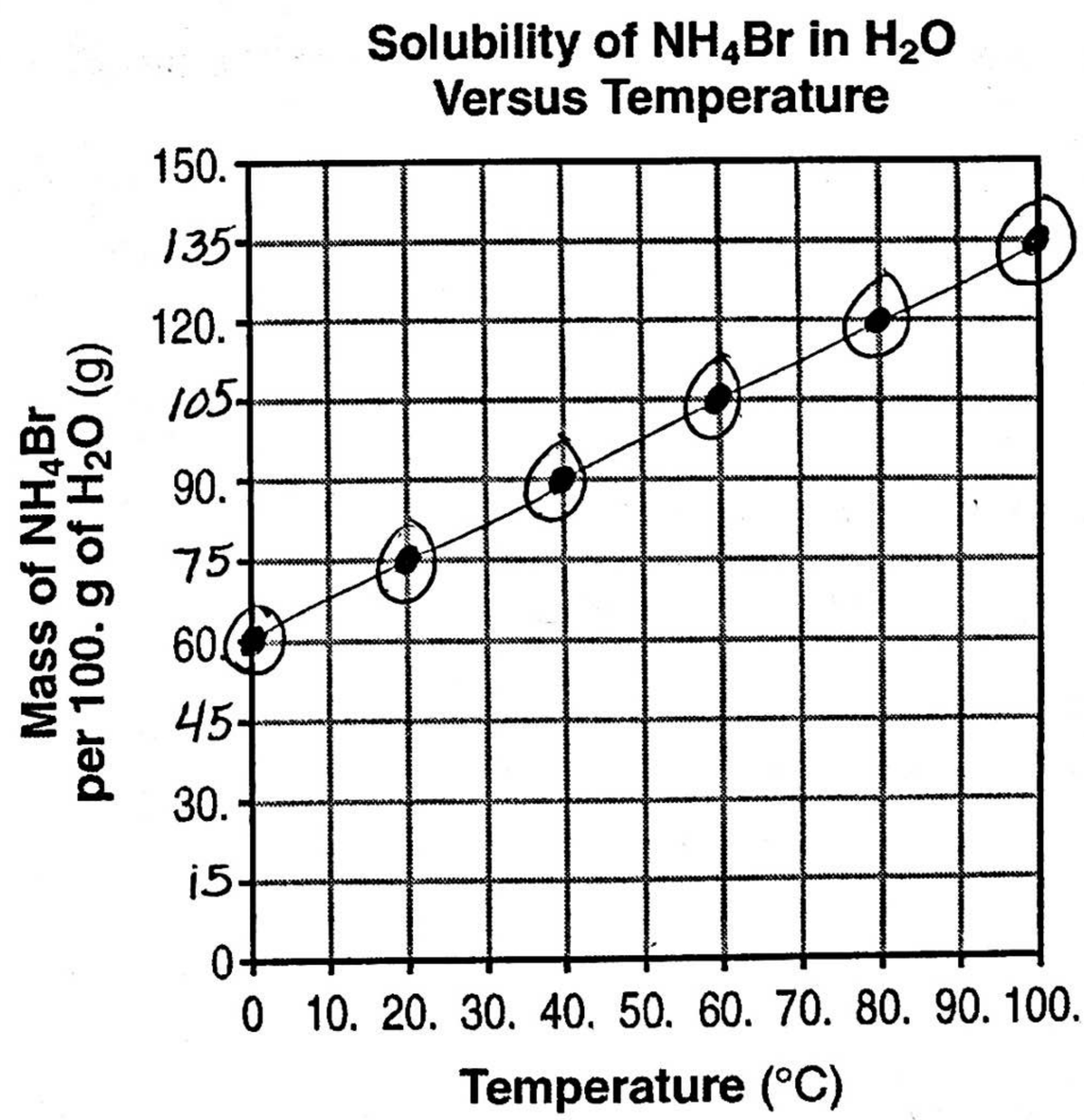
As the temp. decreases the solubility of a gas increases.

Base your answers to questions **10** through **12** on the information below.

The compounds $NH_4Br(s)$ and $NH_3(g)$ are soluble in water. Solubility data for $NH_4Br(s)$ in water are listed in the table below.

Solubility of NH_4Br in H_2O

Temperature (°C)	Mass of NH_4Br per 100. g of H_2O (g)
0	60.
20.	75
40.	90.
60.	105
80.	120.
100.	135



10. On the grid above, plot the data from the data table. Circle and connect the points.

11. Determine the total mass of $NH_4Br(s)$ that must be dissolved in 200. grams of H_2O at 60.°C to produce a saturated solution.

$$\frac{105\,g}{100\,g\ H_2O} = \frac{X}{200\,g\ H_2O}$$

$210\,g\ NH_4Br$

12. Compare the solubilities of $NH_4Br(s)$ and $NH_3(g)$, each in 100. grams of H_2O, as temperature increases at standard pressure. Your response must include *both* $NH_4Br(s)$ and $NH_3(g)$.

As temp. increases the solubility of $NH_4Br(s)$ increases and the solubility of $NH_3(g)$ decreases.

Base your answers to questions **13** and **14** on on the information below.

A solution is made by completely dissolving 90. grams of $KNO_3(s)$ in 100. grams of water in a beaker. The temperature of this solution is 65°C.

13. Describe the effect on the solubility of $KNO_3(s)$ in this solution when the pressure on the solution increases.

Pressure has no effect on the solubility of $KNO_3(s)$.

14. Determine the total mass of $KNO_3(s)$ that settles to the bottom of the beaker when the original solution is cooled to 15°C.

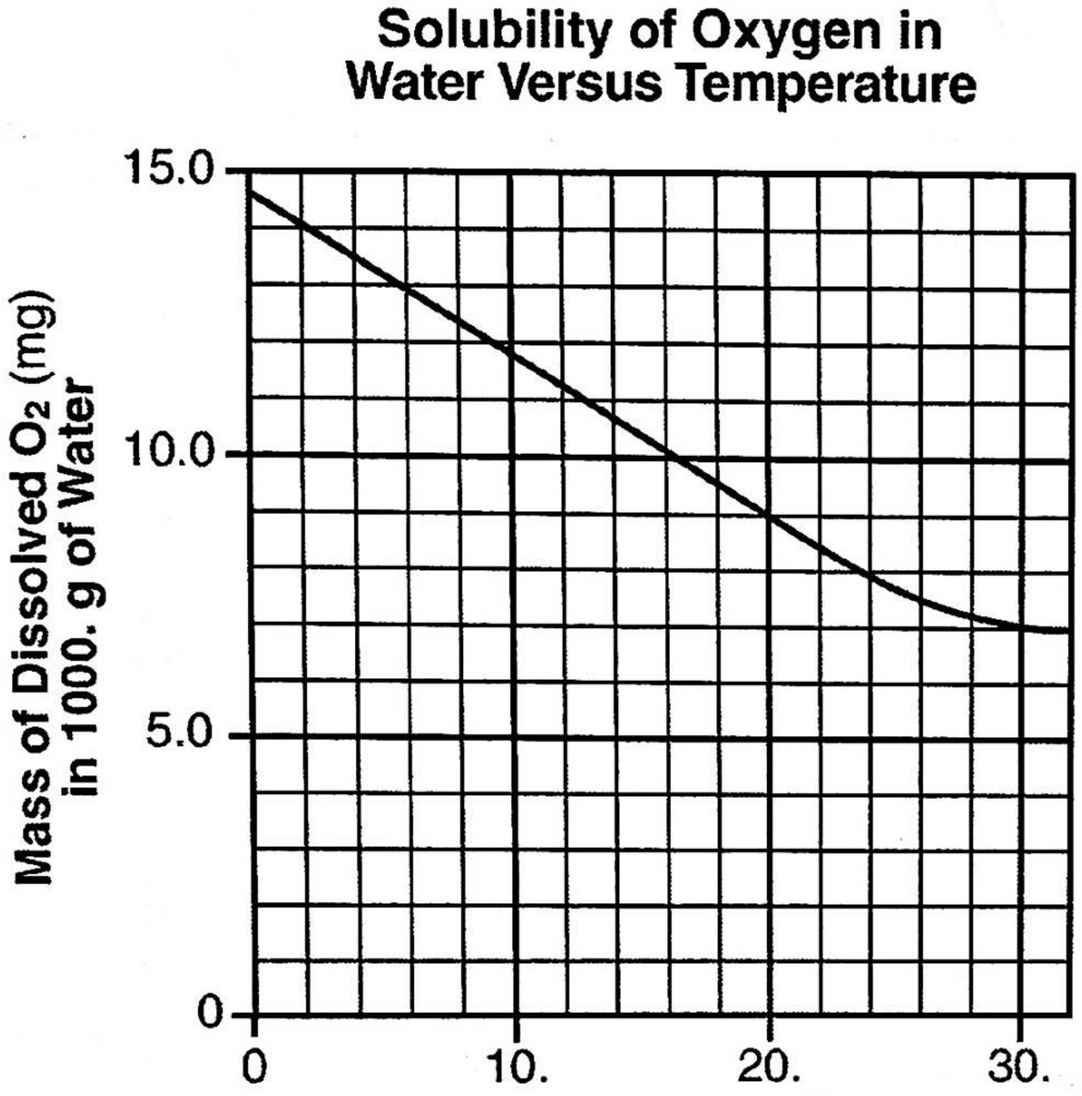
$65°C \rightarrow 15°C$

$90\,g \rightarrow 28\,g$

$62\,g$

15. Base your answer to the following question on the information below

Scientists who study aquatic ecosystems are often interested in the concentration of dissolved oxygen in water. Oxygen, O2, has a very low solubility in water, and therefore its solubility is usually expressed in units of milligrams per 1000. grams of water at 1.0 atmosphere. The graph below shows a solubility curve of oxygen in water.



An aqueous solution has 0.0070 gram of oxygen dissolved in 1000. grams of water. Calculate the dissolved oxygen concentration of this solution in parts per million. Your response must include *both* a correct numerical setup and the calculated result.

$$\text{ppm } O_2 = \frac{0.0070\text{ g}}{1000\text{ g } H_2O + 0.0070\text{ g } O_2} \times 1\,000\,000$$

6.9 ppm

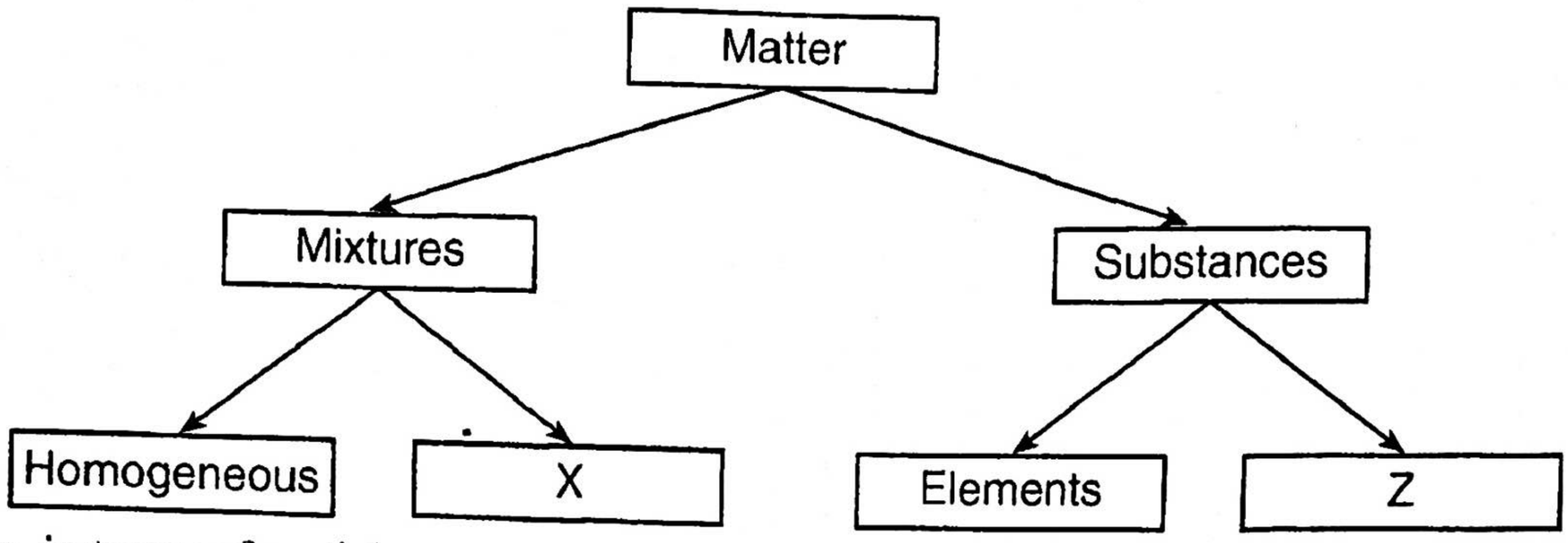
16. An aqueous solution contains 300. parts per million of KOH. Determine the number of grams of KOH present in 1000. grams of this solution.

$$300\text{ ppm} = \frac{X\text{ g KOH}}{1000\text{ g solution}} \times 1\,000\,000$$

.300 g KOH

Base your answers to questions **17** and **18** on the diagram below concerning the classification of matter.

Classification of Matter



17. Explain, in terms of particle arrangement, why NaCl(aq) is a homogeneous mixture.

Particles are mixed evenly throughout.

18. Given a mixture of sand and water, state *one* process that can be used to separate water from the sand.

- Filter the sand from the water
- Evaporate the water

19. Show a correct numerical setup for determining how many liters of a 1.2 M solution can be prepared with 0.50 mole of $C_6H_{12}O_6$.

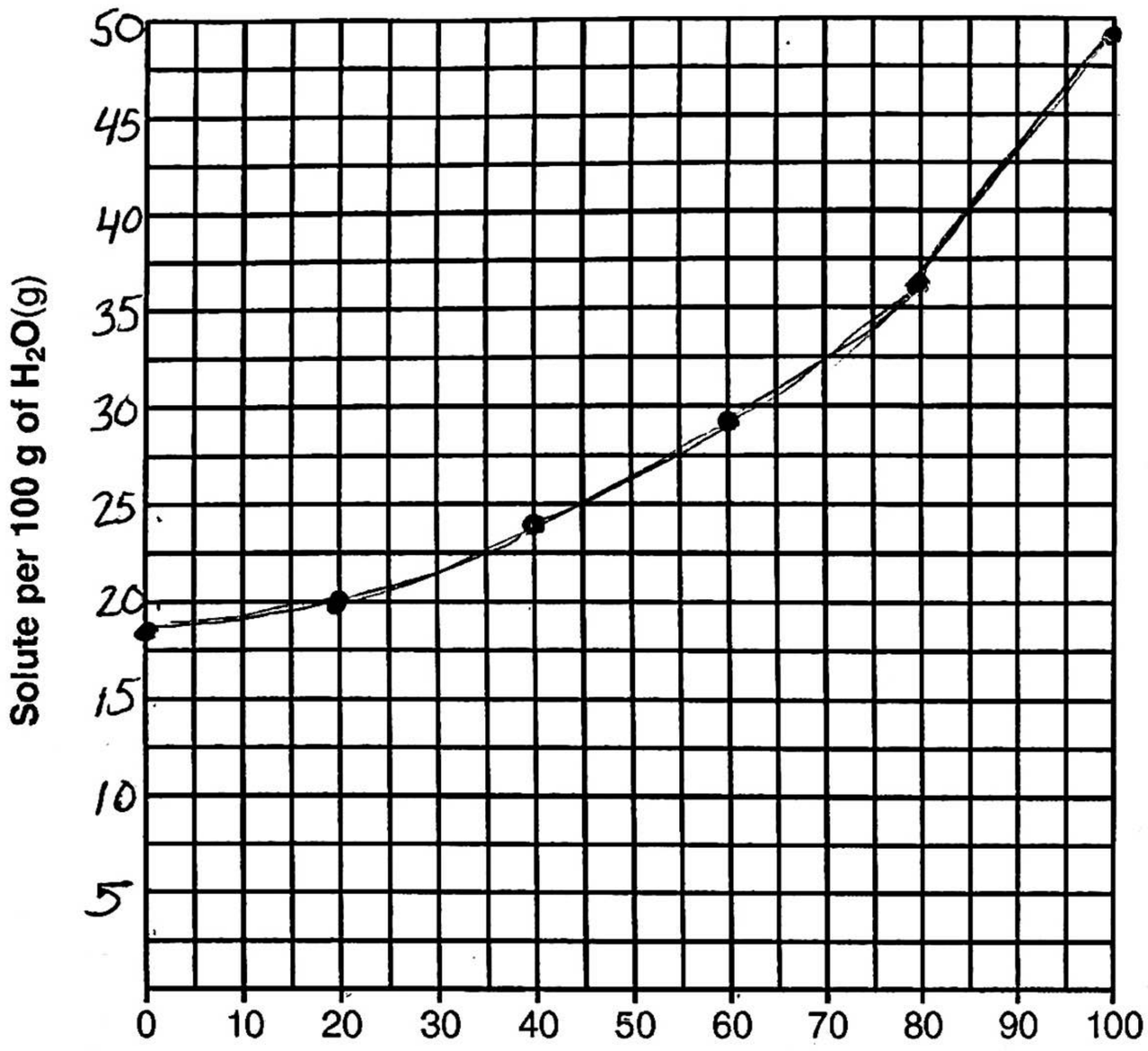
$$M = \frac{\text{moles}}{L}$$

$$1.2\ M = \frac{0.50\ \text{mole}}{X}$$

Solutions: Review

Base your answers to questions **20** through **22** on the data table below, which shows the solubility of a solid solute.

Solubility Curve



The Solubility of the Solute at Various Temperatures

Temperature (°C)	Solute per 100 g of H_2O(g)
0	18
20	20
40	24
60	29
80	36
100	49

Plot points

20. On the grid provided, mark an appropriate scale on the axis labeled "Solute per 100 g of H_2O(g)." An appropriate scale is one that allows a trend to be seen.

21. According to Reference Table *G*, how many grams of $KClO_3$ must be dissolved in 100 grams of H_2O at 10°C to produce a saturated solution?

7g

22. Based on the data table, if 15 grams of solute is dissolved in 100 grams of water at 40°C, how many *more* grams of solute can be dissolved in this solution to make it saturated at 40°C?

40°C → 24g 24 − 15 = 9g

Molarity

Molarity is a way of calculating the *concentration* of a solution. Imagine you make two galsses of lemonade from a canister of powdered mix. If you add one scoop of mix to glass #1 and 3 scoops of mix into glass #2, you would describe glass #2 as being **stronger.** This means it has a higher concentration.

Concentration: The amount of particles dissolved in a given volume of solution.

Molarity uses <u>moles</u> as the quantity of particles and <u>liters</u> as the volume of solution.

Table T: $\text{Molarity (M)} = \frac{\text{moles}}{\text{Liters of solution (L)}}$

Find the molarity of the following solutions:

1) 0.50 moles of sodium chloride is dissolved to make 0.75 liters of solution.

M = moles/L → X M = 0.5 moles / 0.75 L

X = .67 M

2) 175 moles of sodium chloride is dissolved to make 0.075 liters of solution.

$$X\ M = \frac{175\ \text{moles}}{0.075\ L}$$

2,333 M

3) 2.5 moles of sodium chloride is dissolved to make 1.5 mL of solution.

$$X\ M = \frac{2.5\ \text{moles}}{.0015\ L}$$

1666.7M

Answer the questions below based on the reading and the sample problems on the previous page.

1. Determine the molarity of 500. mL of a solution with 0.35 mol of dissolved solute.

$M = \frac{.35\ mol}{.5\ L}$ .7 M

2. A 200. mL sample of a solution contains 4.0 g of NaOH. What is its molarity?

$X\ moles = \frac{4.0}{40}$ .1 moles

$X\ M = \frac{.1\ mol}{.2\ L}$ .5 M

3. How many grams of KNO_3 are needed to prepare 25 mL of a 2.0 M solution?

$2\ M = \frac{X}{.025}$ .05 mol

$.05 = \frac{X\ g}{101\ g}$ 5.05 g

4. How many moles of $MgSO_4$ are contained in 50. mL of a 3.0 M solution?

$3\ M = \frac{X\ mol}{.05\ L}$ .15 mol

5. How many grams of $CaCl_2$ are dissolved in 80.0 mL of a 0.75 M solution?

$.75\ M = \frac{X}{.080\ L}$ .06 moles

$.06\ moles = \frac{X\ g}{110\ g}$ 6.6 g

6. What is the molarity of 300 mL of a solution that contains 0.60 mol of dissolved ammonia?

$X\ M = \frac{.6\ mol}{.3\ L}$ 2 M

7. What is the molarity of 5.0 L of a solution containing 200. g of dissolved $CaCO_3$?

$X\ mol = \frac{200\ g}{100\ g}$ 2 mol

$X\ M = \frac{2\ mol}{5\ L}$ .4 M

8. How many grams of NaCl are needed to prepare 500. mL of a 0.400 M solution?

$.4\ M = \frac{X}{.5\ L}$ .2 moles

$.2\ mol = \frac{X}{58\ g}$ 11.6 g NaCl

9. How many moles of solute are contained in 3.0 L of a 1.5 M solution?

$1.5\ M = \frac{X}{3}$ 4.5 mol

10. What is the molarity of 750 mL of a solution that contains 40.0 g of dissolved $CuSO_4$?

$X\ mol = \frac{40\ g}{160\ g}$ .25 mol

$X\ M = \frac{.25\ mol}{.750\ L}$ .33 M

11. Degree of solubility – Using the Solubility Curve Table G: Determine which solute is most (or least) soluble, dilute, or concentrated

1. According to Table G, which of these substances is most soluble at 60°C?
   1) NaCl – 38g 2) KCl – 45 g 3) $KClO_3$ – 27 g 4) NH_4Cl – 56 g

2. A saturated solution of which compound will be the least concentrated solution in 100 g of water at 40°C?
   1) SO_2 2) NaCl 3) $KClO_3$ 4) NH_4Cl

3. Based on Reference Table G, which of these substances is least soluble at 50°C?
   1) $KClO_3$ 2) NH_3 3) NaCl 4) $NaNO_3$

4. Which of these saturated solution is the most dilute at 20°C?
   1) KI (aq) 2) KCl (aq) – 33 g 3) $NaNO_3$ (aq) 4) NaCl (aq)

5. Which saturated salt solution is most concentrated at 60°C?
   1) $NaNO_3$(aq) 2) $KClO_3$ (aq) 3) KNO_4 (aq) 4) KCl (aq)

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12. The solubility Curve Table G: Miscellaneous questions

1. According to Reference Table G, which solution at equilibrium contains 50 grams of solute per 100 grams of H_2O at 75°C?
   1) An unsaturated solution of KCl
   2) An unsaturated solution of $KClO_3$
   3) A saturated solution of KCl
   4) A saturated solution of $KClO_3$

2. Based on Reference Table G, which salt solution could contain 40 grams of solute per 100 grams of water at 40°C?
   1) A saturated solution of $KClO_3$
   2) A saturated solution of HCl
   3) An Unsaturated solution of NaCl
   4) An unsaturated solution of NH_4Cl

3. A solution contains 100 grams of a nitrate (NO_3) salt dissolved in 100 grams of water at 50°C. The solution could be a
   1) Supersaturated solution of $NaNO_3$
   2) Saturated solution of $NaNO_3$
   3) Supersaturated solution of KNO_3
   4) Saturated solution of KNO_3.

4. A solution is formed by dissolving 45 grams of NH_4Cl in 100 grams of H_2O at 70°C. Which statement correctly describes this solution?
   1) NH_4Cl is the solute, and the solution is saturated
   2) NH_4Cl is the solute, and the solution in unsaturated
   3) NH_4Cl is the solvent, and the solution is saturated
   4) NH_4Cl is the solvent, and the solution is unsaturated

5. According to Reference Table G, which is the best description of a system prepared by dissolving 30 grams of NH_3(g) in 100 grams of water at 20°C?
   1) A saturated solution of NH_4 with no excess NH_3(g)
   2) A saturated solution of NH_3 in contact with excess NH_3(g)
   3) An unsaturated solution of NH_3 with no excess NH_3(g)
   4) An unsaturated solution of NH_3 in contact with excess NH_3(g)

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 KCl is still visible in the flask. The solution in the flask is
   1) Saturated and is at equilibrium with the solid KCl
   2) Saturated and is not at equilibrium with the solid KCl
   3) Unsaturated and is at equilibrium with the solid KCl
   4) Unsaturated and is not at equilibrium with the solid KCl

Use Table G

8. Saturated solution – Using the solubility curves: Determining how much more salt is needed to form a saturated solution

1. A solution contains 14 grams of KCl in 100 grams of water at 40°C. What is the maximum amount of KCl that must be added to make this a saturated solution? 38 - 14 = ≈24
   1) 14 g
   2) 20 g
   3) 25 g
   4) 54 g

2. How many more grams of KNO_3 must be added to a solution containing 90 g of the solute in 100g of water at 60°C? 106 - 90 = ≈ 16
   1) 10 g
   2) 15 g
   3) 30 g
   4) 105 g

3. An unsaturated solution of $NaNO_3$ contains 70 grams of $NaNO_3$ dissolved in 100 g of water at 20°C. How many more grams of $NaNO_3$ are needed to make this a saturated solution? 87 - 70 = ≈17
   1) 70 g
   2) 95 g
   3) 30 g
   4) 18 g

4. A saturated solution of HCl is to be prepared. How many more grams of HCl are needed in a solution containing 100 grams of the solute in 200 grams of water at 20°C to make this a saturated solution? 100/200 = x/100, 50g; 72 - 50 = 22g ×2
   1) 44 g
   2) 72 g
   3) 144 g
   4) 100 g

5. What amount of potassium chloride must be added to a solution made by dissolving 80 g of the solute in 200 grams of H_2O at 60°C to produce a saturated solution? 80/200 = x/100, 40
   1) 45 g
   2) 160 g
   3) 100 g
   4) 120 g

6. A student dissolved only 40 grams of NaCl in 80 grams of water that is at 90°C. To make this a saturated solution, the student must add to the solution 40/80 = x/100, 50g
   1) 10 grams of NaCl
   2) 20 grams of NaCl
   3) 10 g of H_2O
   4) 20 g of H_2O

7. A student found a potassium iodide solution that was prepared by dissolving 120 grams of the salt in 100 g of water at 10°C. To make a saturated solution of this substance, the student must add
   1) 15 grams of potassium iodide
   2) 15 grams of water
   3) 20 g of potassium iodide
   4) 20 g of water

Need Help? Study book Pg 149 Set 15 and Table G

9. Saturated solution – Using the Solubility Curve Table: Determine the amount of solute that will precipitate (re-crystallized)

134 - 84 = 60

1. A saturated solution of KNO_3 is prepared with 100 grams of water at 70°C. According to Reference Table G, what amount of KNO_3 will precipitate if the solution is cooled to 50°C ?
   1) 215 g
   2) 55g (closest answers)
   3) 135 g
   4) 20 g

2. One hundred grams of water is saturated with NH_4Cl at 50°C. If the temperature of the solution is decreased to 10°C, what amount of the solute will precipitate? 53 - 34/33 =
   1) 5 g
   2) 17 g
   3) 30 g
   4) 50 g

3. When the temperature of a saturated solution of $KClO_3$ that is made with 100 g of H_2O is cooled from 25° C to 10°C, some salt crystals reformed at the bottom of the beaker. How many grams of the $KClO_3$ salt is at the bottom of the beaker? 10 - 5 =
   1) 5 g
   2) 10 g
   3) 15 g
   4) 20 g

4. A test tube contains a saturated solution of KNO_3 that was prepared with 100 grams of H_2O at 60°C. If the test tube is cooled to 30°C, what will be found at the bottom of the test tube? 106 - 47 = 59
   1) 30 grams of KNO_3
   2) 30 g of H_2O
   3) 57 g of KNO_3
   4) 57 g of H_2O

5. A test tube containing a saturated solution is cooled from 30°C to 10°C. If the test tube contains a saturated solution of sodium nitrate made with 100 g of water, what will be found at the bottom of the test tube? 96 - 80 = 16
   1) 15 grams of water
   2) 20 grams of water
   3) 15 grams of sodium nitrate
   4) 20 grams of sodium nitrate

Need Help? Study book Pg 149 Set 16 and Table G

Name _____

Date _____

Unit V.8 Worksheet
Topic: Table G Solubility Curves

Solubility Curves

Use the **Solubility Curves Table G** to answer questions 1-15.

For questions 1-4: Tell how many grams of each solute must be added to 100 grams of water to form a saturated solution.

1. $NaNO_3$ at 10^oC 80g
2. $KClO_3$ at 30^oC 12g
3. NH_4Cl at 60^oC 57g
4. KCl at 70^oC 48g

For questions 5-8: Use the term unsaturated, saturated or supersaturated to describe the solution

5. 130g KI at 10^oC UN.
6. 45g NaCl at 40^oC Super.
7. 10g NH_3 at 90^oC Sat.
8. 110g $NaNO_3$ at 50^oC UN.

9. The amount of solute needed to make a saturated solution of NaCl in 50g of water at 100^oC is 20g.

$$\frac{40}{100} = \frac{x}{50}$$

For questions 5-8: Fill in the blank

10. Which saturated solution is more concentrated at 70^oC, $KClO_3$ or NH_4Cl ? NH_4Cl (↗ Higher Solubility)
11. At 10^oC which salt would form the most dilute solution? $KClO_3$ (↗ least soluble)
12. What mass of SO_2 would be needed to form a saturated solution in 200g of water at 50^oC ? $\frac{5}{100} = \frac{x}{200}$ 10g
13. The temperature at which 110g KNO_3 will dissolve in 100g of water is 62°C.
14. If a saturated solution of NH_4Cl at 70^oC (62) is cooled to 50^oC (50) how much of the salt will crystallize out? 10g
15. Equal masses of three different solutes will dissolve equal masses of water at one particular temperature. What are the three solutes and what is the temperature?

NH_3, KCl, NaCl, 37-38C