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

<table>
<thead>
<tr>
<th></th>
<th>Unsaturated Solutions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Beaker A</td>
<td>Beaker B</td>
</tr>
<tr>
<td>1.0 g of solute added</td>
<td>2.0 g of solute added</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Number of dissolved particles</th>
<th>Number of solid particles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
<td>0</td>
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</table>

Saturated Solutions

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td></td>
<td>Beaker C</td>
<td>Beaker D</td>
</tr>
<tr>
<td>3.6 g of solute added</td>
<td>7.0 g of solute added</td>
<td>9.0 g of solute added</td>
</tr>
</tbody>
</table>

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>17</td>
</tr>
<tr>
<td>18</td>
</tr>
</tbody>
</table>

1. Which illustration below represents
   a. solute particles in a solid state in water?
   b. solute particles in an aqueous state?

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

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?
   b. Which beakers represent saturated solutions?

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

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.

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?

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.

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.

Saturated and Unsaturated Solutions

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**Solubility**

How is the quantity of solute in a saturated solution determined?

**Why?**

When we add salt to a pot of boiling water or sugar to a pitcher of iced tea, we expect that the added solute will completely dissolve. It requires a large quantity of these solutes to saturate a solution. On the other hand, water has flowed over rock riverbeds for centuries and only dissolved enough material in some cases to provide a trace of certain minerals in the water. Different solutes, such as salt, sugar, or minerals, dissolve to very different extents in water (and other solvents). In this activity you will learn how to quantify the amount of solute that is dissolved in a saturated solution.

**Model 1 – Three Solutions**

The following data refer to three experiments in which solute is added to water in a beaker at 20 °C. The mixtures are stirred and then allowed to sit for three hours before measuring the amount of solid that dissolves. Ten separate trials are conducted for each experiment. The same solute is used in all three experiments.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Experiment 1 In 10.0 g water</th>
<th>Experiment 2 In 20.0 g water</th>
<th>Experiment 3 In 50.0 g water</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.0</td>
<td>1.0</td>
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<tr>
<td>2</td>
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<td>9.0</td>
<td>3.6</td>
<td>9.0</td>
</tr>
<tr>
<td>10</td>
<td>10.0</td>
<td>3.6</td>
<td>10.0</td>
</tr>
</tbody>
</table>

1. Identify the variable(s) that were controlled among all three experiments in Model 1.

2. What variable(s) were changed purposefully among the three experiments in Model 1?
3. What experimental question can be answered by analyzing the data in the three experiments in Model 1? Use the words "solvent" and "solute" in your question.

4. In each of the three experiments in Model 1, determine the point in the experiment that the beakers became saturated. Draw a box around the entire section of data in each experiment that represents saturated solutions.

5. Consider the data in Model 1.
   a. Which experiment shows the largest mass of dissolved solute in the saturated solutions?
   b. Propose an explanation for why the mass of dissolved solute changed among the three experiments.

Read This!
Solubility is a measure of the maximum amount of solute that can dissolve in a given amount of solvent at a specific temperature. In other words, it is the ratio of solute to solvent in a saturated solution at a specific temperature. Solubility is typically reported as grams of solute per 100 g H₂O. For example, if a maximum of 20.4 g of table sugar (sucrose) will dissolve in 10.0 g of water at 20 °C, then the solubility of sucrose would be 204 g sucrose/100 g H₂O.

6. Would it be acceptable for a student to use Trial 2 from Experiment 1 to determine the solubility of the solute in Model 1? Explain your group's answer in a complete sentence.

7. In Model 1 none of the experiments used 100 g of water. Use complete sentences to explain how the ratio "grams of solute per 100 g H₂O" can be calculated from the data given in Model 1.

8. Use the data in Model 1 to calculate the solubility of the solute (at 20 °C) for all three experiments. Show your work.
   Experiment 1:  
   Experiment 2:  
   Experiment 3:  

Extension Questions
Model 2 – Solubility Curves

10. A student claims, "In Experiment 3, Trial 9, 18.0 grams of solute dissolved, whereas in Experiment 1, Trial 9, only 3.6 grams of solute dissolved. Obviously, the solubility is greater in Experiment 3." With your group, devise a well-constructed response.

11. Calculate the mass of the solute used in Model 1 that is needed to make a saturated solution in 140.0 g of water without leaving any solid solute at the bottom. Show your work.

12. According to the graph in Model 2, what is the solubility of Substance A at 30 °C?

13. Describe the trend in solubility for Substances A and B in Model 2 as temperature increases.

14. If a saturated solution of Substance A in 100.0 g of water is cooled from 30 °C to 10 °C, what mass of solid solute would crystallize out? Show your work.

15. If a saturated solution of Substance B in 50.0 g of water at 30 °C is warmed to 50 °C, what mass of solute would need to be added to make the solution saturated again?
1. Describe hydration. What properties of water enable its molecules to interact with ions in solution?

2. Sodium sulfate (Na₂SO₄) is a strong electrolyte. What species are present in Na₂SO₄(aq)?

3. Which of the following diagrams best represents the hydration of NaCl when dissolved in water, and why? The Cl⁻ ion is larger in size than the Na⁺ ion.

(a)  

(b)  

(c)  

4. Identify each of the following substances as a strong electrolyte (S), weak electrolyte (W), or nonelectrolyte (N):
   a. C₆H₆  f. Ba(NO₃)₂
   b. KCl  g. Ne
   c. HNO₃  h. NH₃
   d. CH₃COOH  i. NaOH
   e. C₆H₅O₁

5. Explain why a solution of HCl in benzene (C₆H₆) does not conduct electricity but in water it does?

6. You are given two colorless, aqueous solutions, one containing NaCl and the other sucrose (C₁₂H₂₂O₁₁). Suggest a chemical (reaction) and a physical test that would allow you to distinguish between these two solutions.
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 dosage, 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*

Lemonade Solution 1

Lemonade Solution 2

*Both pitchers were filled with enough water (solvent) to provide 2 liters of solution.

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

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 as 2. How do you know?

3. Lemonade Solution 2 is considered to be concentrated, and lemonade Solution 1 is considered to be dilute. Examine the two pictures in Model 1. List two ways to differentiate a concentrated solution from a dilute solution.

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

5. 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: Consider both amount of solute and amount of solvent.

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

Molarity

POGIL™ Activities for High School Chemistry
Model 2 – Chemical Solutions

Dilute

1 M CaCl₂ Solution
0.06 mole CaCl₂ in 0.06 L solution

3 M CaCl₂ Solution
0.18 mole CaCl₂ in 0.06 L solution

Concentrated

1 M Glucose Solution
0.06 mole glucose in 0.06 L solution

3 M Glucose Solution
0.18 mole glucose in 0.06 L solution

M = Molarity
“3 M” is read as “three molar”

3 M Glucose Solution
0.06 mole glucose in 0.02 L solution

6. List the beaker numbers for the solutions in Model 2 that are considered to be “concentrated.”

7. What does the letter “M” stand for in Model 2?

8. Use the data in Model 2 to answer the questions below.
   a. Calculate the ratio of the moles of solute to liters of solution for each solution.
      
      moles of solute
      liters of solution
   b. How does the ratio compare to the molarity of each solution?

9. Write a mathematical equation to show how the molarity of a solution is calculated.

10. Which type of solution (dilute or concentrated) will have a larger molarity value?

11. Consider beakers 3–5 in Model 2. Circle the answer below for the quantity that is the same in all of the beakers that contain 3 M solutions.
    Number of moles of solute
    Volume of solution
    Ratio of moles of solute to liters of solution

12. Explain how beaker 5, with fewer moles of glucose, can have the same molarity as beaker 4.

13. Can molarity be determined by knowing either the number of moles alone or the volume of solution alone? Explain why or why not.
14. Calculate the molarity of a solution containing 1.5 moles of NaCl in 0.50 liters of solution. Show your work.

15. Calculate the molarity of a solution containing 0.40 moles of acetic acid in 0.250 liters of solution. Show your work.

16. A 0.5 M KCl solution contains 74.55 g of KCl (molar mass 74.55 g/mol) in 2000 mL of solution.
   a. Does the ratio 74.55 g KCl/2000 mL provide the correct molarity for this solution?
   b. What units do the amount of solute and the volume of solution need to be in to obtain the molarity of 0.5 M? Show the calculation.

17. Calculate the molarity of a solution containing 2.5 g of CuCl₂ in 1 L of solution. Show your work, including units.

18. Consider the 3 M solutions in Model 2. What would a 3 M HCl picture look like if the beaker contained 100 mL? In the circle below, visually show the number of solute particles that would be present in any very small volume of the overall solution. (See Model 2 for examples.)

**Extension Questions**

19. A student thinks that she can determine the concentration of a solution based on the darkness or color intensity of the solution alone. Based on the pictures in Model 2 describe why this student's method will not always work.

20. Calculate the molarity of a KCl solution if 37.3 g of KCl are dissolved in water to give a final solution volume of 500 mL. Show your work.

21. A student correctly determines that 17.1 grams of sucrose are needed to make 50 mL of a 1 M sucrose solution. When making this solution in lab, the student measured 50 mL of water and mixed 17.1 grams of sucrose. The student then mixed the two together into a new beaker. The student’s resulting solution was not 1 M sucrose as intended. After the student mixed sucrose and water, the resulting solution was poured into a graduated cylinder and it read 62 mL.
   a. What part of the molarity equation did the student overlook when mixing the solution?
   b. What steps should the student take in lab to correctly prepare the 1 M solution?
Case Study – Background & Introduction

Have you ever seen the bags of fluids that hang by a patient in the hospital? These bags are not just full of water, but instead they are full of specific solutions that can be used to treat a patient.

IV means intravenous, because a hollow needle is placed inside the vein by a trained nurse or phlebotomist. A number of substances may be administered in an IV by various means.

A syringe full of a medication can be used to directly add that medication into the vein. A medication injected into the vein takes action nearly immediately. Some medications cannot be taken orally because they are not well absorbed by the body in the stomach or intestines, or they are metabolized too quickly, so they can only be given by IV. Many IV medications are for emergency situations and are able to work much more quickly because of IV administration.

When a substance needs to be given over a longer period of time, or when it is a large volume of liquid, the solution is instead added to an IV bag. A small tube connects the bag of fluids to the IV in the patient, and is hung up above the bed. Gravity allows the fluid to drip down the small tube and into the patient, and a bedside machine controls how many drops per minute are allowed into the vein.

A very important consideration for IV fluids is what they will do to a cell. It is important that the solutions given are similar in the concentration of solute as compared to the body. A solute is the minor compound that is dissolved to make a solution. Since the fluids in our body are mostly water, the solvent used for IV fluids is very pure water. The medical staff then needs to add just the right amount of salts, sugars or medications in order to match the body’s normal solute concentrations.

A solution that has a matching concentration to the body is called “isotonic.” This means it has the same “tonicity” as the body’s fluids. If the solution has a lower concentration it’s called hypotonic, and this will cause water to enter cells it comes across and the cells will expand. If the solution has a higher concentration it’s called hypertonic, and this will cause water to leave the cells and shrink.

If you’ve ever gotten water up your nose or felt stinging eyes while swimming, you’ve experienced the effect of a hypotonic solution. Your cell walls allow water to cross through because the water is attracted to all of the solutes within the cell. As the water enters your cells they expand and are damaged and can burst, which is why it’s pretty painful to get water up your nose or even in your eyes. Instead, if you use a normal saline solution – which is a concentration of salt water just like you have in your cells, you will not feel pain. Eye drops or nasal irrigation devices (like a neti pot) both use normal saline so that you can rinse your eyes or sinuses without the pain.

In order to create isotonic solutions, it is essential that all concentrations are carefully calculated so that the amount of solute is just right to create a solution, which is why it is very important that nurses, pharmacists and other medical personnel have strong math skills. A very small error in calculation can have severe health consequences for the patient.

Scenario: Making Solutions

Nurses, pharmacists and other medical professionals need to prepare the IV solution for each patient. Although some medications or solutions come from a factory pre-mixed, there are also times that the solution must be mixed at the hospital. To make an IV solution, you first calculate the amount of solute you need using the equation below. Once you measure out the solute, add it to a graduated cylinder or volumetric flask. Add very pure water until you reach the desired volume and mix well until all of the solute has dissolved.

Calculations

Your goal is to calculate how to create all of the solutions to fill the given IV bags. When creating solutions the solute is the substance you are adding (often a powder or crystals) and the solvent is the larger amount (in this case water.)

To find the percent weight per unit volume (%w/v) you can use the following equation:

\[
\text{%w/v} = \frac{\text{grams of solute}}{100 \text{ml solution}}
\]

You can use this to find the grams of solute required for any amount of solution by using proportions to find the grams of solute in any volume of solution.

\[
\frac{\text{grams of solute}}{100 \text{ml solution}} = \frac{\text{grams of solute}}{\text{any ml of solution}}
\]

Spotlight – Normal Saline

Normal Saline is a 0.9% weight by volume solution of sodium chloride, which you might know as table salt. This is the most used IV fluid, and it is ideal for patients who are dehydrated.

There are many illnesses that can cause dehydration. Diarrhea reduces your body’s ability to absorb water from the intestines, so any illness involving diarrhea can quickly cause dehydration. A patient who is unconscious or is going to have a surgery might be given IV fluids because it is unsafe for them to drink water.

Heat stroke, or merely spending a lot of time in the sun without drinking as much water as you are losing through sweat and urine, can also cause dehydration. Feeling thirsty is a sign that you are already dehydrated, so it’s always best to drink water before you get to the point that you feel thirsty.

It is recommended that you drink about 2 liters (or 1/4 gallon) per day. Although other beverages can be counted towards your water intake, many can actually increase the amount of water you lose so water is always best.

References

http://www.naturalhealthmag.com inward/dilution.htm
http://www.naturalhealthmag.com/drug-supplements/intravenous-therapy/description/app-20073377
http://www.drugs.com/persi/millium-bicarbonate.html
Practice Problems

Normal saline is also known as 0.9% sodium chloride. Depending on the patient and their situation, a different amount of normal saline might be required. Calculate how many grams of NaCl would be required for each of the IV bags.

<table>
<thead>
<tr>
<th>Solution 1: 500mL of 0.9% NaCl</th>
<th>Solution 2: 1000mL of 0.9% NaCl</th>
<th>Solution 3: 200mL of 0.9% NaCl</th>
<th>Solution 4: 250mL of 0.9% NaCl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set up equation to compare proportions</td>
<td>( \frac{0.9g}{100mL} = \frac{xg}{500mL} )</td>
<td>Solve for grams of solute needed</td>
<td>( x = 4.5g ) NaCl</td>
</tr>
<tr>
<td>Directions to make solution</td>
<td>Add 4.5g to a 500mL graduated cylinder. Add water until the solution is exactly 500mL, stir well.</td>
<td></td>
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</tr>
</tbody>
</table>

Spotlight – Sodium Bicarbonate

This IV fluid can come in a number of concentrations which can be chosen based on the level of need. Sodium bicarbonate is a slightly basic buffer, which can help bring the pH back to normal. In the body, the physiological pH is 7.35, which is just slightly more basic than water. Some diseases can cause metabolic acidosis, which means that the body pH has dropped and become slightly acidic. This can occur if a patient has renal disease, undergoes shock, has uncontrolled diabetes or has a heart attack. Additionally, some drugs or poisons can lower the blood pH and may require the use of Sodium Bicarbonate to bring the pH back to 7.35.

Practice Problems

Calculate how many grams of sodium bicarbonate are needed to make each solution, and then write directions to make each solution.

<table>
<thead>
<tr>
<th>Solution 5: 500mL of 4.2% Sodium Bicarbonate</th>
<th>Solution 6: 500mL of 5.0% Sodium Bicarbonate</th>
<th>Solution 7: 500mL of 7.5% Sodium Bicarbonate</th>
<th>Solution 8: 500mL of 4% Sodium Bicarbonate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set up equation to compare proportions</td>
<td>( 4.2g \times \frac{100mL}{500mL} = xg )</td>
<td>Solve for grams of solute needed</td>
<td>( x \times 21g ) sodium bicarbonate</td>
</tr>
<tr>
<td>Directions to make solution</td>
<td>Add 21grams to a 500mL graduated cylinder. Add water until the solution is exactly 500mL, stir well.</td>
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</table>

Spotlight – Dextrose Solution

Dextrose is a 5% weight by volume solution of a specific type of sugar known as Dextrose. The ending “ose” means that it is a type of sugar, for instance, “sucrose” is table sugar and “fructose” is a fruit sugar.

A dextrose solution is used to help give patients a quick form of nutrition as well as fluids. When a patient is not able to take in fluids or food by mouth, they can be given a dextrose solution as a form of temporary calories.

How would you make 200mL of a 5% Dextrose Solution?

Research: HetaStarch

Research HetaStarch to answer the following questions:

What is the medical use of HetaStarch?

How much HetaStarch is normally used for a patient?

How would you make a 6% HetaStarch, 9.9% normal saline solution IV bag on the right?
Reading a Solubility Chart

1) The curve shows the # of grams of solute in a saturated solution containing 100 mL or 100 g of water at a certain temperature.

2) Any amount of solute below the line indicates the solution is unsaturated at a certain temperature.

3) Any amount of solute above the line in which all of the solute has dissolved shows the solution is supersaturated.

4) If the amount of solute is above the line but has not all dissolved, the solution is saturated and the # grams of solute settled on the bottom of the container = total # g in solution - # g of a saturated solution at that temperature. (according to the curve)

5) Solutes whose curves move upward w/ increased temperature are typically solids b/c the solubility of solids increases w/ increased temperature.

6) Solutes whose curves move downward w/ increased temperature are typically gases b/c the solubility of gases decreases with increased temperature.

Solubility Problems to solve

1. At 10°C, 80 g of NaNO₃ will dissolve in 100 mL (a saturated solution)

2. To find the # grams needed to saturate a solution when the volume is NOT 100 mL use the following strategy to find answer:

   Start w/ known vol. x Solubility/100mL at set temp. = amount of Solute needed to saturate

   Ex. 60 mL H₂O x 80 g NaNO₃/100 mL = 48 g NaNO₃ needed to saturate solution

   or if the chart is in units of 100 g of H₂O use the density of water conversion 1mL H₂O = 1 g H₂O

   Ex. 60 mL H₂O x 1 g H₂O x 80 g NaNO₃/100 g H₂O = 48 g NaNO₃
   1 mL H₂O 100 g H₂O
1. Which of the salts shown on the graph is the least soluble in water at 10°C?
2. Which of the salts shown on the graph has the greatest increase in solubility as the temperature increases from 30 degrees to 60 degrees?
3. Which of the salts has its solubility affected the least by a change in temperature?
4. At 20°C, a saturated solution of sodium nitrate contains 88 grams of solute in 100 ml of water. How many grams of sodium nitrate must be added to saturate the solution at 50°C?
5. At what temperature do saturated solutions of potassium nitrate and sodium nitrate contain the same weight of solute per 100 mL of water?
6. What two salts have the same degree of solubility at approximately 19°C?
7. How many grams of potassium chlorate must be added to 1 liter of water to produce a saturated solution at 50°C?
8. A saturated solution of potassium nitrate is prepared at 60°C using 100 mL of water. How many grams of solute will precipitate out of solution if the temperature is suddenly cooled to 30°C?
9. What is the average rate of increase for the solubility of KNO₃ in grams per 100 mL per degree Celsius in the temperature range of 60°C to 70°C?
10. If 50 mL of water that is saturated with KClO₃ at 25°C is slowly evaporated to dryness, how many grams of the dry salt would be recovered?
11. Thirty grams of KCl are dissolved in 100 mL of water at 45°C. How many additional grams of KCl are needed to make the solution saturated at 80°C?
12. What is the smallest volume of water, in mL, required to completely dissolve 39 grams of KNO₃ at 10°C?
13. What is the lowest temperature at which 30 grams of KCl can be dissolved in 100 mL of water?
14. Are the following solutions saturated, unsaturated or supersaturated (assume that all three could form supersaturated solutions)
   a. 40 g of KCl in 100 mL of water at 80°C
   b. 120 g of KNO₃ in 100 mL of water at 60°C
   c. 80 g of NaNO₃ in 100 mL of water at 10°C
15. Assume that a solubility curve for a gas such as ammonia, at one atmosphere of pressure, was plotted on the solubility curve graph. Reading from left to right, would this curve would ______
   a. slope upward       b. slope downward    c. go straight across

Answers: 1) KClO₃, 2) KNO₃, 3) NaCl 4) 14 g, 5) 72 ± 2°C, 6) KNO₃ and KCl, 7) 210 g, 8) 55 ± 2g, 9) 2.5 g/°C, 10) 5 g, 11) 20 g, 12) 170 mL, 13) 10°C, 14) a) unsat., b) supersat., c) sat. 15) b
Honors Chapter 15 Problems

1. Compare and contrast soluble and insoluble.
2. Compare and contrast immiscible and miscible.
3. What 4 factors affect the rate of solvation?

Electrolytes
4. What does it mean to dissociate or ionize?
5. Which compounds dissociate or ionize in solution?
6. What is an electrolyte?
7. What is a nonelectrolyte?
8. Compare and contrast a strong electrolyte, weak electrolyte and a nonelectrolyte.
9. What kind of electrolyte is glucose?

Henry's Law and Solubility
10. If the solubility of KCl is 344 g/L at 20°C in water, what is the maximum mass of KCl that can be dissolved in 450 mL of water?
11. If the solubility of NaNO₃ at 25°C is 921 g/1.00 L of H₂O, what is the maximum mass of NaNO₃
that can be dissolved in 200.0 g of H₂O? (1.0 mL H₂O = 1.0 g H₂O and 1 L = 1000 mL)
12. If 0.55 g of a gas dissolves in 1.0L of water at 20.0kPa of pressure, how much will dissolve at
110.0kPa of pressure?
13. A gas has a solubility of 0.66 g/L at 10.0atm of pressure. What is the pressure on a 1.0L sample
that contains 1.5 g of gas?

Percent by Mass
14. What is the percent by mass (m/m) of NaHCO₃ in a solution containing 25 g NaHCO₃ dissolved in
65 mL H₂O? (Density of H₂O = 1.0 g/mL)
15. You have 1500.0 g of a bleach solution. The percent by mass (m/m) of the solute sodium
hypochlorite, NaOCl, is 36.2% (m/m). How many grams of NaOCl are in the solution?
16. In the last question, how many grams of solvent are in the solution?

Percent by Volume
17. What is the percent by volume (v/v) of a 335 mL solution with 150 mL of methanol?
18. What is the percent by volume of isopropyl alcohol in a solution that contains 200.0 mL of isopropyl
alcohol in 1.0L of water?

Parts Per Million
19. Methane is considered non-toxic at 10,000 ppm for mammals. What is this concentration in
grams/mL?
20. If a reading was taken at Aliso Canyon 0.0016 g/mL, is this safe for the residents to return to
their home?
21. If carbon monoxide should not exceed 30 ppm indoors, what is the concentration in mg/mL?
22. Helium gas, 3.0 x 10⁻⁴ g, is dissolved in 200 g of water. Express this concentration in parts per
million.
23. A sample of 300.0 g of drinking water is found to contain 38 mg Pb. What is this concentration in
parts per million?

Molarity
24. What is the molarity of bleach solution containing 9.50 g of NaOCl per 2.45 L of bleach?
25. How many grams of KNO₃ are in 1.34 L of a 0.355 M solution?
26. How many grams of CaCl₂ are in 235 mL of a 0.100 M solution?

Concentration, Molarity, % mass
27. Calculate the percent by mass of the solute in 31.0 g of KCl in 152 g of solution.
28. Find the % by mass of a 1.22 M sugar (C₁₂H₂₂O₁₁) solution (density of solution = 1.12 g/mL).
29. Calculate the molarity of a 37.0% by mass NaHCO₃ solution with a density of solution = 1.19 g/mL.
30. Given 30.0 g NH₃ (solute), 70.0 g H₂O (solvent) and a solution density of 0.982 g/mL.
   a. Find the % by mass
   b. Find the molarity of this solution.

Preparing Molar Solutions
31. A 2.50 L of 2.00 M NaOH solution contains how many grams of NaOH?
32. How many grams of CaCl₂ should be dissolved in 500.0mL of solution to make a 0.20 M solution of
CaCl₂?

Diluting Solutions
33. What volume in mL of a 3.00M KI stock solution would you use to make 0.300 L of a 1.25M KI
solution?
34. If 50.0 mL of a 4.50 M NaOH solution is used to make a dilute 2.00 L solution, what is the molarity
of the dilute solution?
35. What do colligative properties depend on?
36. What are the three colligative properties?

Honors Chemistry
Ch. 15 Solutions Study Guide

Vocabulary: Make sure you know definitions and examples for
immiscible, miscible, saturated, unsaturated, supersaturated, solubility, soluble, insoluble, solution,
solute, solvent, salution, electrolyte, strong electrolyte, weak electrolyte, nonelectrolyte

Know: like dissolves like, factors that affect solubility and factors that affect rate of solvation,
concentration calculations, how temperature and pressure affect solubility for gases and liquids,
colligative properties

Practice Questions:
Pg. 484 # 48-53, 60, 64, 67, 70, 71, 73, 76ab, 77bc, 78bc, 79ab, 80, 81, P. 487# 1, 9