Connected Chemistry

Solutions Unit

Lesson 7: Saturation

Student's Lesson at a Glance

Lesson Summary

This two-day lesson includes a lab. Students are introduced to the concept of saturation through use of real-world applications and computer simulations. Students identify saturated and unsaturated solutions using both simulations and a solubility curve for a known ionic compound. Students will also discover the limitations of accurately identifying supersaturated solutions using computer simulations. Students begin to use a solubility curve to extrapolate information to solve solubility problems. Students perform a solubility lab in which they create solubility curves from the provided data.

SWBAT (Students Will Be Able To)

- Define unsaturated solutions as those solutions that are capable of dissolving additional solute
- Define saturated solutions as those solutions that cannot dissolve additional solute at a constant temperature
- Define supersaturated solutions as those solutions that have dissolved excess solute than normally possible, usually under specific conditions.
- Identify and explain how unsaturated, saturated and supersaturated solutions are formed at the submicroscopic level
- Generate solubility curves and identify how the solution looks at the different locations on the graph

Essential Vocabulary

Keep a list of all important words from this lesson. This list, in addition to the lists from other lessons, will make studying easier and improve scientific communication skills. The essential vocabulary from the unit is in bold. Additional words that will expand your scientific vocabulary are in italics.

Connected Chemistry Reminder

- Students and teachers from many different schools helped designed Connected Chemistry so that the lessons are more helpful and meaningful for all classroom participants.
- Many questions will ask you "what you think" or "to make predictions." The only answer that is wrong is the answer that is left blank.
- Prefixes and suffixes on words can help you discover the meaning of a word.
- Use the vocabulary section and note section to take good notes so that studying for tests and quizzes will be easier.
- Supporting claims with evidence is not only a skill that scientists use, but a skill that will help you in other classes and everyday life.
- Draw a key when you are sketching. Symbolic keys can help you and others decode your sketches at a later time.

Notes

Homework

Upcoming Quizzes/ Tests

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Activity 1: Connecting

1. What do you think it means for a solution to become saturated? *Be sure to explain what you think it would look like on the macroscopic level and on the submicroscopic level. Support your claim with evidence.*

Recall that Kool-Aid® is a solution. When making Kool-Aid®, sugar is added according to the directions on the packet. However, some people may like it sweeter, so they might add more sugar and see it dissolve. More sugar can be added because the solution is **unsaturated**, which means the solvent is able to dissolve more solute. In the case of making Kool-Aid® with extra sugar, the solution can dissolve more sugar without it settling to the bottom.

If too much sugar is added to the solution, some of the sugar will eventually settle at the bottom of the pitcher and no more sugar will dissolve no matter how much the solution is stirred. The Kool-Aid® has now become **saturated**. A saturated solution is a solution that has reached a point where no more solute can be dissolved in the solvent. A saturated solution is as concentrated as possible at a given temperature.

Besides humans, many animals can create solutions. Bees create honey, which is a *solution* composed of fructose, glucose, water, oil, flower pollen, and special enzymes produced by bees. Honey not only supplies bees with food in the summer and winter months, it is also used by humans as a natural sweetener that is easy for the body to digest. When buying honey at the store, various labels might indicate their product is pure honey.

2. Do you think you can tell the difference between a saturated solution and an unsaturated solution at the macroscopic level? *Explain your answer.*

3. Do you think you can tell the difference between a saturated solution and an unsaturated solution at the submicroscopic level? *Explain your answer.*

Activity 2: Simulations of Saturation

Part 1: *Use Simulation 4, Set 1*

Sketch each of the three simulations that your teacher shows to you. Make sure you record the simulation temperature. The simulation is for a solution of KCl and water.

Submicroscopic sketch of Simulation 1 at 0 °C	Submicroscopic sketch of Simulation 2 at 25°C	Submicroscopic sketch of Simulation 3 at 99 °C
Observations	**Observations**	**Observations**
Key		

4. Classify sketch 1 at 0 degres as saturated or unsaturated. *Support your claim with evidence.*

5. Classify sketch 2 at 25 degrees as saturated or unsaturated. *Support your claim with evidence.*

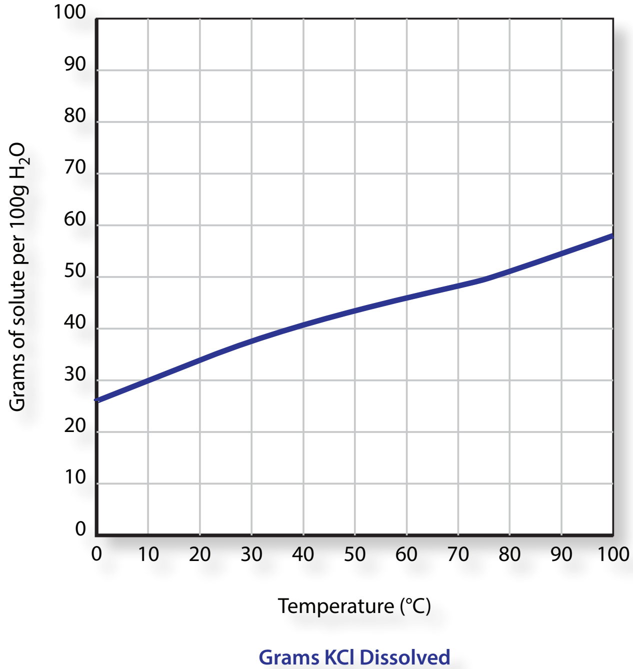
6. Classify sketch 3 at 99 degrees as saturated or unsaturated. *Support your claim with evidence.*

7. What is the limitation of just using the submicroscopic simulation to determine saturation?

Part 2

A student created a solubility graph for KCl. The teacher asked the student to label two points on the graph which represent a saturated and unsaturated solution for KCl. Recall the meaning of these two types of solutions.

Label the graph below with the letters to correctly identify the two types of solutions: A = Saturated, B = Unsaturated



8. Using the graph, locate a solution of 80 grams of dissolved KCl solute per 100 grams water at 90 °C. What type of solution is this? *Please explain.*

9. At 30 °C, how many grams of KCl is needed to saturate the solution?

10. What would happen to a saturated solution composed of 90 grams KCl dissolved in 100 grams water at 70 °C, if you added two more grams of KCl?

11. How much more KCl would you need to add to make a saturated solution if you already had added 10 g at 20 °C?

12. What would make a supersaturated solution of KCl begin to precipitate out?

13. When labels indicate "pure" honey, does this mean that honey is a pure substance in scientific terms? *Support your claim with evidence.*

Honey is a special type of solution because it is a naturally made **supersaturated solution**. A supersaturated solution is a case in which the solvent contains more solute than it can hold *theoretically* at a given temperature. Supersaturated solutions are formed by heating a solution to dissolve more solute, then cooling the solution down slowly. By cooling slowly, the honey is able to dissolve more sugar at a lower temperature than it can under normal circumstances.

14. What does the prefix *super-* mean?

15. In your own words, what do you think supersaturated means?

Honey **crystallizes**, meaning it forms a solid when sitting undisturbed for a long period of time. Supersaturated solutions are often unstable and easily crystalize. Honey and other supersaturated solutions are created by heating the solvent, which causes the solvent molecules to move farther apart from each other. This situation allows more solute particles to dissolve in between the solvent molecules than at lower temperatures. In nature, bees accomplish this by heating water (the solvent) and dissolving two different kinds of sugars, glucose and fructose (the solutes), to make a supersaturated solution. Where do the bees get the heat to create the supersaturated solution? Honey is made in the summer when the temperatures are warmer and flowers are in bloom. The summer heat causes the solvent to dissolve more sugar into the solution. Worker bees also help to regulate the temperature of the hive by vibrating their wings to generate heat. The bees then cool the solution down slowly so that the sugar still remains dissolved in the solvent.

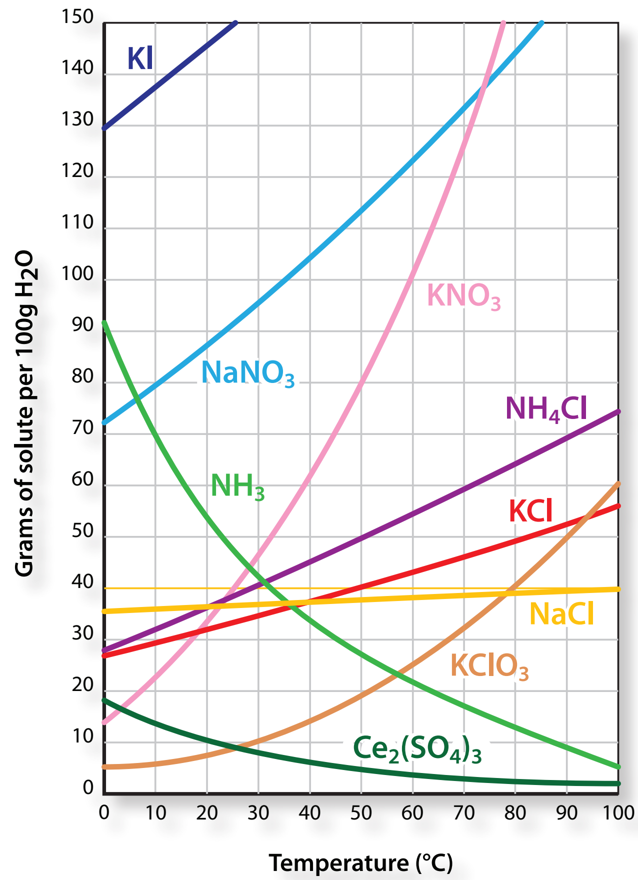
This temperature regulation ensures that honey remains a liquid in the cold winter months. Because honey is supersaturated, addition of any extra solid sugar crystals, agitation, cooling, or even small air bubbles could cause many of the sugar molecules to precipitate out of the solution. After precipitation occurs, the honey is no longer supersaturated.

16. What does the phrase "precipitate out" mean?

17. At the submicroscopic level, what happens to the molecules of a solvent that is being heated such that it allows more solute to be dissolved into the solution?

Activity 3: Putting It All Together: Independent Practice

Use the graph to answer the following questions:



18. How many grams of solute are required to saturate 100 g of water in each of the following solutions?

KCl at 80 ºC	
$KClO_3$ at 90 ºC	
$NaNO_3$ at 10 ºC	
NH_3 at 20 ºC	

19. What is each of the solutions below: saturated or unsaturated? All of the solutes are mixed with 100 g of water.

40 g of NaCl at 80ºC	
30 g of NH_3 at 30ºC	
34 g of KCl at 20ºC	
80 g of KNO_3 at 60ºC	

20. How many grams of KNO_3 per 100 g of water would be crystallized from a saturated solution as the temperature drops from each of the following temperatures?

70ºC to 20ºC	
60ºC to 40ºC	
50ºC to 30ºC	
50ºC to 0ºC	

21. How many additional grams of $NaNO_3$ are required to keep each of the following $NaNO_3$ solutions saturated during the temperature changes indicated?

100 g of water, 10ºC changing to 30ºC	
200 g of water, 10ºC changing to 30ºC	
100 g of water, 40ºC changing to 90ºC	
1000g of water, 40ºC changing to 90ºC	

22. Which solute is the least affected by changes in temperature? *Support your claim with evidence.*

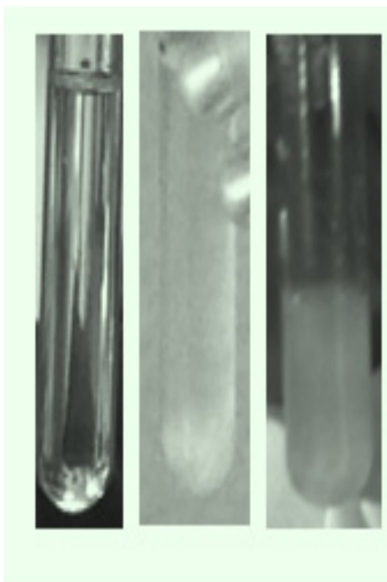
23. Which two solutes show a decrease in solubility with increasing temperature? *Support your claim with evidence.*

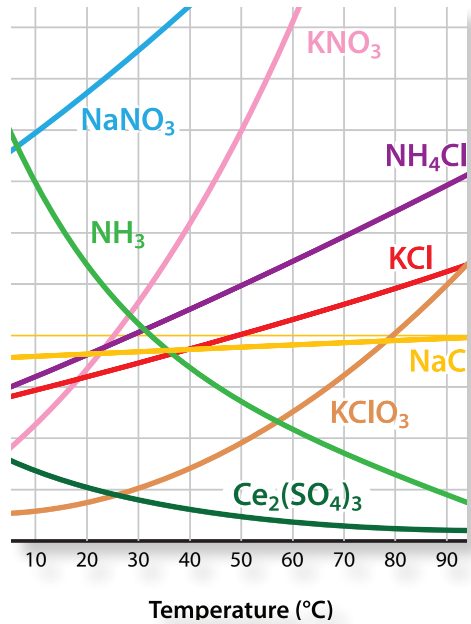
24. Can you use the graph to represent a supersaturated solution? *Support your claim with evidence.*

25. Which solute is more soluble: KCl or NaCl? *Provide evidence for your answer.*

Lesson Reflection Question

26. The image of the three test tubes shows a macroscopic image of various amount of KCl mixed with water. The solubility curve for KCl is shown next to the image. Do the macroscopic images show a saturated solution, unsaturated solution, or supersaturated solution? *Provide evidence for your answer.*





Activity 4: Solubility Lab: Creating a Solubility Curve

Part 1: Solubility Curve Lab

Part 2: Creating and Interpreting Solubility Curves