

Solubility and Temperature

Answer Key

Vocabulary: concentration, dissolve, homogeneous mixture, solubility, solubility curve, solute, solution, solvent

Prior Knowledge Questions (Do these BEFORE using the Gizmo.)

[Note: The purpose of these questions is to activate prior knowledge and get students thinking. Students are not expected to know the answers to the Prior Knowledge Questions.]

1. What happens when you stir a spoonful of sugar into hot water?

The sugar dissolves into the water.

2. When sugar or another substance is **dissolved** in water, it disappears from view and forms a **homogeneous mixture** with the water, also called a **solution**.

If you can't see the sugar, how can you tell that it is there?

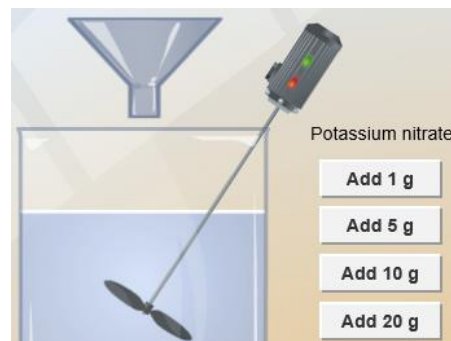
The water tastes sweet and may appear slightly cloudy. [You can boil or evaporate the water to see solid sugar again.]

3. Does sugar dissolve more easily in hot water or cold water? *Hot water*

Gizmo Warm-up

A solution generally consists of two parts, a **solute** that is dissolved and a **solvent** that the solute is dissolved into. For example, sugar is a solute that is dissolved into the solvent water. In the *Solubility and Temperature* Gizmo™, you will study how temperature affects how much solute will dissolve in a solution.

To begin, check that **Potassium nitrate** is selected and the **Temp.** of the water is 20 °C. Click **OK**.




1. In this solution, what is the solute? *Potassium nitrate* What is the solvent? *Water*

2. Click **Add 10 g** to mix 10 g of potassium nitrate into the water.

A. Did all of the potassium nitrate dissolve? *Yes*

B. How can you tell?

All of the potassium nitrate disappeared as it was stirred into the water.

Activity A: Solubility	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> • Click Reset. • Check that the Temp. is 20 °C and that Potassium nitrate is selected. 	
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Question: How do we find how much solute can be dissolved in a solvent?

1. **Observe:** Click **OK**. Click **Add 20 g**, and observe the potassium nitrate being mixed into the solution. On the right, select the **BAR CHART** tab and turn on **Show numerical value**. The bars show how much solute has been added and how much has piled up on the bottom.

Did all of the solute dissolve? *Yes*

2. **Calculate:** The **concentration** of a solution is equal to the mass of solute divided by the volume of solvent. Units of concentration are grams per 100 milliliters (g/100 mL, or g/dL).

What is the concentration of this solution? *20 g/100 mL (or 20 g/dL)*

3. **Experiment:** Click **Add 20 g** again.

A. Did all of the solute dissolve? Explain how you can tell.

No, some of the solute piled up on the bottom of the container.

B. Based on the amount of solute added and the amount piled up on the bottom, how many grams of solute dissolved in the water? *30.65 grams of solute have dissolved.*

C. The **solubility** of the solution is equal to the maximum concentration of the solute.

What is the solubility of potassium nitrate in 20 °C water? *30.65 g/100 mL*

4. **Experiment:** Click **Reset**, and select **Sodium chloride**. With the **Temp.** still set to 20 °C, click **OK**. Add sodium chloride to the beaker until it starts piling up at the bottom.

A. How much sodium chloride did you add? *Answers will vary.*

B. How much sodium chloride piled up at the bottom? *Answers will vary.*

C. How much sodium chloride dissolved in the water? *36.66 grams*

D. What is the solubility of sodium chloride in 20 °C water? *36.66 g/100 mL*

5. **Apply:** At 20 °C, how much sodium chloride could be dissolved into 2 L of water? *733.2 g*

How much potassium nitrate could be dissolved into the same amount of water? *613.0 g*

Activity B: Solubility and temperature	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> • Click Reset. • Set the Temp. to 10 °C. • Select Potassium nitrate, and click OK. 	12.22
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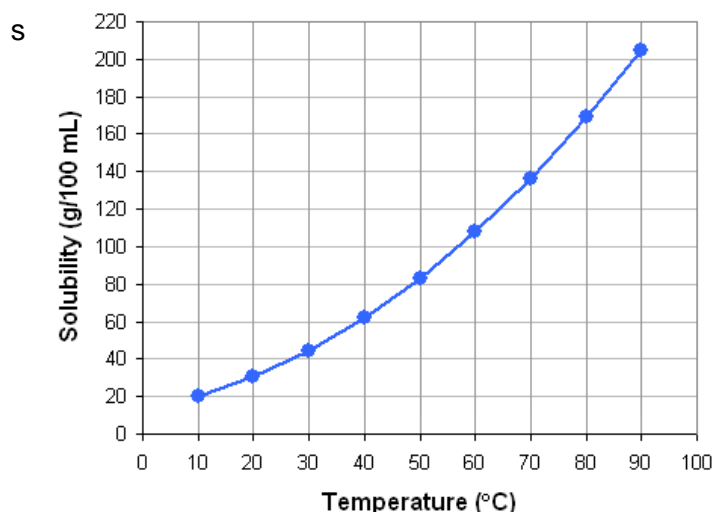
Question: How does temperature of the solvent affect solubility?

1. Predict: Based on your own experience, how do you expect temperature to affect solubility?

Predictions will vary. [Based on their experience putting sugar into hot and cold water, most students will predict that solubility increases as temperature increases.]

2. Gather data: Use the Gizmo to measure the solubility of potassium nitrate at each temperature given in the table below. Then, graph the resulting **solubility curve** at right.

Temperature	Solubility (g/100 mL)
10 °C	20.54 g/100 mL
20 °C	30.65 g/100 mL
30 °C	44.44 g/100 mL
40 °C	61.91 g/100 mL
50 °C	83.06 g/100 mL
60 °C	107.89 g/100 mL
70 °C	136.40 g/100 mL
80 °C	168.59 g/100 mL
90 °C	204.47 g/100 mL



3. Infer: Based on your graph, what would you predict is the solubility of potassium nitrate at a temperature of 5 °C? 95 °C? Check your 5 °C prediction with the Gizmo.

5 °C predicted solubility: *Predictions will vary.* 5 °C actual solubility: **16.86 g/100 mL**

95 °C predicted solubility: *Predictions will vary.* (Impossible to find actual solubility using Gizmo.)

4. Explain: Potassium nitrate absorbs a large amount of heat energy from the water as it dissolves. How does this explain the solubility curve you graphed for potassium nitrate?

The greater the water temperature, the greater the amount of heat energy is available to dissolve the potassium nitrate. Therefore, the solubility of potassium nitrate increases as the water temperature rises.

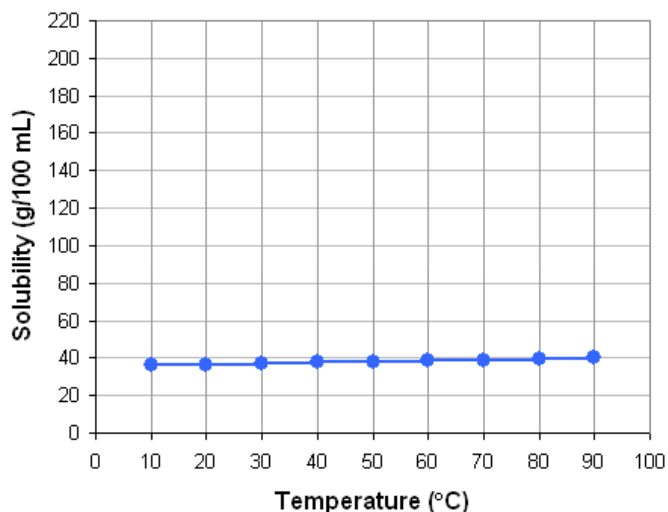
(Activity B continued on next page)



Activity B (continued from previous page)

5. **Gather data:** Now use the Gizmo to measure the solubility of sodium chloride at each temperature given in the table below. Then, graph the solubility curve of sodium chloride.

Temperature	Solubility (g/100 mL)
10 °C	36.18 g/100 mL
20 °C	36.66 g/100 mL
30 °C	37.13 g/100 mL
40 °C	37.61 g/100 mL
50 °C	38.09 g/100 mL
60 °C	38.57 g/100 mL
70 °C	39.05 g/100 mL
80 °C	39.52 g/100 mL
90 °C	40.00 g/100 mL



6. **Infer:** Based on your graph, what would you predict is the solubility of sodium chloride at a temperature of 5 °C? 95 °C? Check your predictions with the Gizmo.

5 °C predicted solubility: *Predictions will vary* 5 °C actual solubility: *35.94 g/100 mL*

95 °C predicted solubility: *Predictions will vary* 95 °C actual solubility: *40.24 g/100 mL*

7. **Compare:** How does the solubility curve for sodium chloride compare with the solubility curve for potassium nitrate?

The solubility curve of sodium chloride is very flat compared to the curve for potassium nitrate. Temperature has a very slight effect on the solubility of sodium chloride.

8. **Infer:** Potassium nitrate absorbs a lot of heat from water as it dissolves. Based on its solubility curve, what can you infer about how much heat sodium chloride absorbs?

Answers will vary. Sample answer: Raising the temperature does not increase the solubility of sodium chloride very much. Therefore, sodium chloride probably does not absorb as much heat as potassium nitrate does as it dissolves.

9. **Think and discuss:** What do you think the solubility curve would look like for sugar? Explain.

Sample answer: Sugar has a much greater solubility in hot water than cold water, so its solubility curve probably resembles the sloping solubility curve of potassium nitrate.

