Name **Date**

HANDS-ON LAB

Temperature and Solubility

In this experiment, you will study the effect of changing temperature on the amount of solute that will dissolve in a given amount of water. Water solubility is an important physical property in chemistry and is often expressed as the mass of solute that dissolves in 100 g of water at a certain temperature. In this experiment, you will completely dissolve different quantities of potassium nitrate, KNO_3, in the same volume of water at a high temperature. As each solution cools, you will monitor the temperature using a thermometer and observe the precise instant that solid crystals start to form. At this moment, the solution is saturated and contains the maximum amount of solute at that temperature. Thus each data pair consists of a *solubility* value (g of solute per 100 g H_2O) and a corresponding *temperature*. You will then plot a graph of the temperature-solubility data, known as a solubility curve.

RESEARCH QUESTION How does temperature affect solubility?

MAKE A CLAIM

What effect do you think temperature has on the solubility of different amounts of KNO_3 in water?

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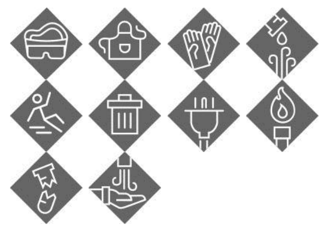
MATERIALS

- indirectly vented chemical splash goggles, nonlatex apron, nitrile gloves
- beaker, 250 mL
- beaker, 400 mL
- distilled water (20 mL)
- graduated cylinder, 10 mL
- hot plate
- potassium nitrate, KNO_3 (20 g)
- ring stand
- stirring rod
- test tube rack
- test tubes, 20 × 150 mm (4)
- thermometer
- thermometer clamp
- utility clamps (1)



SAFETY INFORMATION

- Wear indirectly vented chemical splash goggles, a nonlatex apron, and nitrile gloves during the setup, hands-on, and takedown segments of the activity.
- Potassium nitrate is a strong oxidant, so it is a fire and explosion risk when heated or in contact with organic material. Do not heat potassium nitrate directly in this lab.
- Potassium nitrate is a skin irritant and highly toxic. If you get a potassium nitrate on your skin, wash with plenty of water. If you get potassium nitrate in your eye, use an eyewash station immediately. If swallowed, rinse mouth with water.
- Immediately clean up any liquid spilled on the floor so it does not become a slip/fall hazard.
- Never pour chemicals, either used or unused, back into their original container. Dispose of chemicals according to your teacher's instructions.
- Never taste any substance or chemical in the lab.
- Use only GFI protected circuits when using electrical equipment, and keep away from water sources to prevent shock.
- Use caution when working with hot plates, which can cause skin burns or electric shock.
- Use caution when working with glassware, which can shatter if dropped and cut skin.
- Wash your hands with soap and water immediately after handling chemicals.

CARRY OUT THE INVESTIGATION

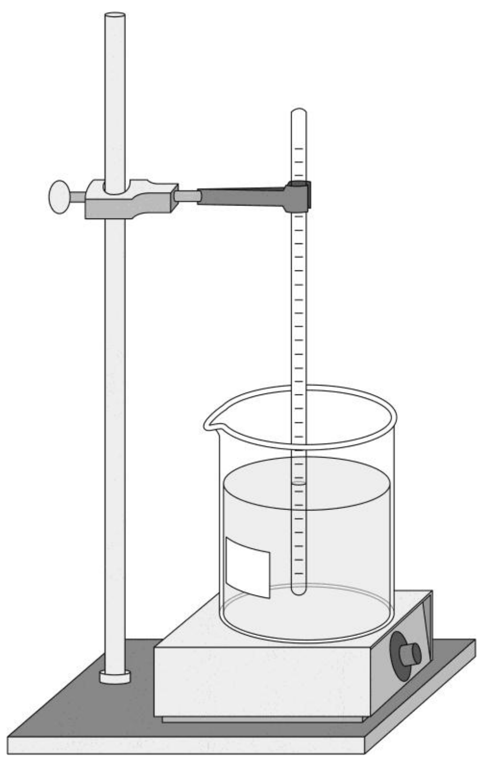
1. Label four test tubes 1–4. Into each of these test tubes, measure out the amounts of solid shown in the second column of the table below (amount per 5 mL). **Note:** The fourth column (amount per 100 g of H_2O) is proportional to your measured quantity and is the amount you will use on the solubility graph.

Test tube number	Amount of KNO_3 used per 5 mL H_2O (weigh in Step 1)	Temperature at which crystals first appear	Amount of KNO_3 used per 100 g H_2O (use in Step 9)
1	2.0		40
2	4.0		80
3	6.0		120
4	8.0		160

2. Add exactly 5.0 mL of distilled water to each test tube.

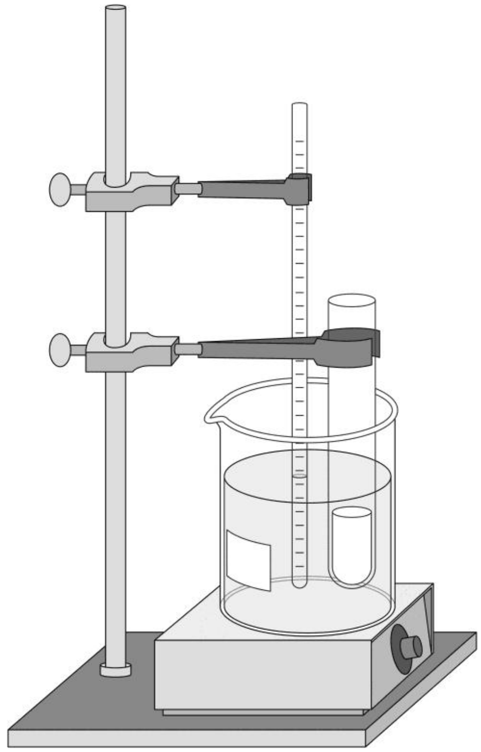
3. Fill a 400 mL beaker three-fourths full of tap water. Place it on a hot plate situated on (or next to) the base of a ring stand. You will use a thermometer to monitor the temperature. Use a thermometer clamp on the ring stand to suspend the thermometer within the beaker of water as shown in Figure 1. Do not let the thermometer touch the bottom or sides of the beaker. Heat the water bath to about 90 °C and adjust the heat to maintain the water at this temperature.

Figure 1



4. Use a utility clamp to fasten one of the four test tubes to the ring stand. Lower the test tube into the water. **Note:** In order to dissolve all of the KNO_3, Test Tubes 3 and 4 need to be heated to a higher temperature than Test Tubes 1 and 2. Use your stirring rod to stir the mixture until the KNO_3 is *completely* dissolved. Do not leave the test tube in the water bath any longer than is necessary to dissolve the solid.

Figure 2



5. When the KNO_3 is completely dissolved, remove the thermometer from the water bath, wipe it dry, and place it into the solution in the test tube. Do not let the thermometer touch the bottom or sides of the test tube. Unfasten the utility clamp and test tube from the ring stand. Use the clamp to hold the test tube up to the light to look for the first sign of crystal formation. At the same time, stir the solution with a slight up and down motion of the thermometer. At the moment crystallization starts to occur, note the temperature in the third column of your data table.

6. Repeat Steps 4 and 5 for each of the other three test tubes. Here are some suggestions to save time:
   - One lab partner can be stirring the next KNO_3-water mixture until it dissolves while the other partner watches for crystallization and enters data into the table.
   - Test Tubes 1 and 2 may be cooled to lower temperatures using cool tap water in the 250-mL beaker. This drops the temperature much faster than air. If the crystals form too quickly, *briefly* warm the test tube in the hot-water bath and again dissolve the solid. Then, repeat the cooling, and collect the data.

7. When you have finished collecting data, discard the four solutions as directed by your teacher, and clean up the rest of your lab equipment.

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CALCULATE

1. **Use Mathematics** In the space provided, plot the data you collected on a graph with solubility on the *y*-axis and temperature on the *x*-axis. For solubility, use the g/100 g H_2O values from your data table. Determine an appropriate scale so your graph uses as much space as possible.

2. **Use Mathematics** Draw a best-fit curve for your data points on your graph. A best-fit curve passes through as many points as possible, and shows trends in the data better than if the points were connected by straight lines.

ANALYZE

1. According to your data, how is the solubility of KNO_3 affected by an increase in temperature of the solvent?

2. Using your graph, tell if each of the following solutions would be saturated or unsaturated. Explain your answer using evidence from your graph.
   a. 110 g of KNO_3 in 100 g of water at 40 °C
   b. 60 g of KNO_3 in 100 g of water at 70 °C
   c. 140 g of KNO_3 in 200 g of water at 60 °C

3. According to your graph, will 50 g of KNO_3 completely dissolve in 100 g of water at 50 °C? Explain.

4. According to your graph, will 120 g of KNO_3 completely dissolve in 100 g of water at 40 °C? Explain.

5. According to your graph, about how many grams of KNO_3 will dissolve in 100 g of water at 30 °C?

CONSTRUCT AN EXPLANATION

1. How does a change in temperature affect how much solute can be dissolved in the solvent?

2. When a solution is saturated at a certain temperature, why can no more solute dissolve?

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DRAW CONCLUSIONS

Write a conclusion that addresses each of the points below.

Claim What effect does temperature have on the solubility of different amounts of KNO_3 in water?

Evidence Give specific examples from your data to support your claim.

Reasoning Explain how the evidence you gave supports your claim. Describe, in detail, the connections between the evidence you cited and the argument you are making.