Diffusion Intrusion

Student Instruction Sheet

Challenge

Explore the movement of molecules via diffusion and determine how heat affects the rate of diffusion.

Equipment and Materials

• computer with USB port	• hot plate
• PASPORT USB interfaces, 2	• wash bottle & waste container
• PASPORT pH Sensor	• pipet with bulb
• PASPORT Temperature Sensor	• kimwipes or paper towels
• DataStudio software	• water, distilled, 1.0 L
• Buret Clamps, 2	• water, 450.0 mL
• Small Tripod Base & Rod, 2	• ammonia, 5.0 mL
• Three-finger Clamp	• protective gear
• test tube, medium	• *Student Instruction Sheet*
• beaker, 500-mL	• *Student Response Sheet*

Safety Precautions

Wear safety glasses and follow standard laboratory safety procedures.

Keep water away from electrical outlets, the computer, the keyboard, and the PASPORT equipment!

Follow the teacher's directions for the clean up and disposal of all chemicals.

Background

Diffusion is the spontaneous distribution of molecules from one area to another. The rate of diffusion is influenced by a number of factors including the type of molecules and environmental conditions.

In this lab you will use a PASPORT pH Sensor and a PASPORT Temperature Sensor to observe the diffusion of hydronium molecules while varying an environmental factor.

Predict

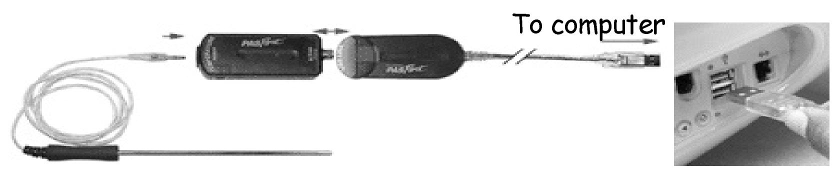
Before beginning the eLab, complete the prediction and vocabulary portions of the *Student Response Sheet*.

Explore

Computer Setup

1. Plug the USB interfaces into the computer's USB port or USB hub.
2. Plug the pH Sensor into one of the USB interfaces.

3. Plug the Temperature Sensor to the other USB interface.



4. Choose the appropriate DataStudio configuration file entitled

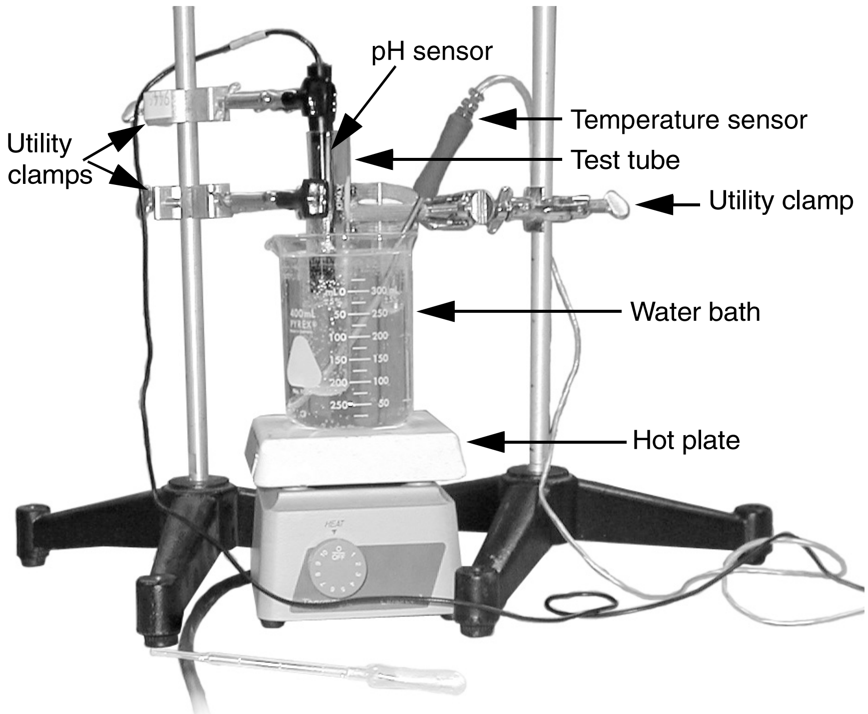
07 Diffusion CF.ds

and proceed with the following instructions.

> **Note**: Configuration files automatically launch the appropriate display(s), sampling rate(s), etc.

Equipment Setup

1. Set up the equipment as shown on the following page and as follows:
2. Place 450.0 mL of water into a 500-mL beaker. The water should be at room temperature prior to use. This will be the water bath.
3. Place the beaker on the hot plate. Do not turn on the hot plate yet.
4. Use a clamp attached to the support rod to secure a test tube in the water bath as shown and not touching the bottom of the beaker.
5. Place distilled water into the test tube to a level about 1.0 cm below the water level of the beaker.



6. Rinse the pH Sensor thoroughly using the wash bottle containing distilled water. Use another clamp attached to the ring stand and lower the pH electrode into the water in the test tube, positioning it 2.0 cm below the surface.
7. Similarly use a clamp to position the Temperature Sensor in the water bath but not touching the bottom.

Record Data

1. In DataStudio, click on the **Digits Display** representing the Temperature Sensor. On the **Experiment** menu, click **Monitor Data**. Monitor the temperature of the water bath until it becomes stable. Record this data on the *Student Response Sheet*. Click the **Stop** (■ Stop) button.

2. Using a pipet or syringe, obtain a 1.0 mL sample of ammonia. Position the tip of the pipet at an angle, touching the inside of the test tube, near the water surface. Simultaneously click the **Start** (▶ Start) button while slowly adding one drop of ammonia to the water (best achieved when one student clicks **Start** upon command from the second student controlling the pipet).

3. Continue recording until the pH remains constant or begins to fall.

4. Click the **Stop** button.

5. Carefully unplug and remove the pH Sensor and test tube. Rinse thoroughly with distilled water. Discard the wastewater as per your teacher's instructions. Thoroughly clean the test tube and refill with distilled water to the same level as before. Replace the test tube and pH Sensor in the water bath. Try to maintain the exact same configuration.

6. Turn on the hot plate and monitor the temperature until the temperature of the water bath reaches approximately 40°C.

7. Repeat steps 1-5.

8. Heat the water bath to approximately 60°C.

9. Repeat steps 1-5.

10. Turn off the hot plate and remove the sensors from the solution. Rinse both thoroughly using distilled water and dry carefully. Return the pH Sensor to its storage container.

11. Dispose of the waste solution as instructed previously.

Analyze

1. Identify each data run in the Data area in the Summary window. Click once on the run name, then again to change (if preferred, rename each data run immediately after recording).

2. Click on the Graph to make it active. Next, click on the **Scale to Fit** ( ) button to rescale the graph to fit the data.

3. For each of the three runs, select the data and click the **Fit** (Fit) button.

   Select **Linear Fit** (Linear Fit). If the data is irregular, select the steepest portion of the line (click and drag to select a specific portion), and then select **Linear Fit**. The slope is the best fit line for the plot of pH versus Time, representing the rate of change in pH (which is the logarithmic representation of the ion concentration). Record the rate for each run on the *Student Response Sheet*.

4. Use the **Smart Tool** ( ) for each plot of data to identify at what point equilibrium occurred. Record the time on the *Student Response Sheet*.

5. Save your DataStudio file (on the **File** menu, click **Save Activity As**...) to the location specified by your teacher.

6. Answer the questions on the *Student Response Sheet*.

7. Follow your teacher's instructions regarding cleaning up your work space.

Student Response Sheet

Name: ______________________________

Date: ______________________________

Diffusion Intrusion

Vocabulary

Use available resources to find the definitions of the following terms:

acidic: ____

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basic: ____

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diffusion: ____

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dynamic equilibrium: ____

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entropy: ____

____

hydronium: ____

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ion: ____

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kinetic energy: ____

____

mass: ____

____

pH: ____

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static equilibrium: ____

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velocity:____

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viscosity:____

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Predict

1. Do you think the pH will increase or decrease as diffusion progresses?

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2. How quickly do you think this pH change will be detected (diffusion rate at room temperature)?

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3. What do you think will happen to the diffusion rate when the water temperature is raised? Why?

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4. How does increasing the temperature of the system influence the time it takes to reach equilibrium?

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Data

	Temperature	Diffusion Rate (Slope)	Time to Reach Equilibrium
Run #1			
Run #2			
Run #3			

Draw a sketch of your graph. Label the axes, each data run, any data points that are artifacts, and any other information that is notable.

Analyze

1. Did temperature affect the rate of diffusion? Explain.

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2. How do you explain a slope equal to zero? Which plot of data demonstrated a zero slope first?

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3. If a second pH Sensor were to be placed at the point of entry for the dispensed ammonia, hypothesize the results in relation to the first pH Sensor. Would the two sensors eventually demonstrate equivalency? Explain.

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Synthesize

How did your predictions compare with your results?

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