TEMPERATURE EFFECTS ON DISSOLVED OXYGEN IN WATER

LAB DO 4.CALC

INTRODUCTION
Although water is composed of oxygen and hydrogen atoms, biological life in water depends upon another form of oxygen—molecular oxygen. Oxygen is used by organisms in aerobic respiration, where energy is released by the combustion of sugar in the mitochondria. This form of oxygen can fit into the spaces between water molecules and is available to aquatic organisms.

Fish, invertebrates, and other aquatic animals depend upon the oxygen dissolved in water. Without this oxygen, they would suffocate. Some organisms, such as salmon, mayflies, and trout, require high concentrations of oxygen in their water. Other organisms, such as catfish, midge fly larvae, and carp can survive with much less oxygen. The ecological quality of the water depends largely upon the amount of oxygen the water can hold.

The following table indicates the normal tolerance of selected animals to temperature and oxygen levels. The quality of the water can be assessed with fair accuracy by observing the aquatic animal populations in a stream.

<table>
<thead>
<tr>
<th>Animal</th>
<th>Temperature Range (°C)</th>
<th>Minimum Dissolved Oxygen (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trout</td>
<td>5 – 20</td>
<td>6.5</td>
</tr>
<tr>
<td>Smallmouth bass</td>
<td>5 – 28</td>
<td>6.5</td>
</tr>
<tr>
<td>Caddisfly larvae</td>
<td>10 – 25</td>
<td>4.0</td>
</tr>
<tr>
<td>Mayfly larvae</td>
<td>10 – 25</td>
<td>4.0</td>
</tr>
<tr>
<td>Stonefly larvae</td>
<td>10 – 25</td>
<td>4.0</td>
</tr>
<tr>
<td>Catfish</td>
<td>20 – 25</td>
<td>2.5</td>
</tr>
<tr>
<td>Carp</td>
<td>10 – 25</td>
<td>2.0</td>
</tr>
<tr>
<td>Mosquito</td>
<td>10 – 25</td>
<td>1.0</td>
</tr>
<tr>
<td>Water boatmen</td>
<td>10 – 25</td>
<td>2.0</td>
</tr>
</tbody>
</table>
PURPOSE
The purpose of this experiment is to study the effect of temperature on the amount of dissolved oxygen in water and to predict the effect of water temperature on aquatic life.

MATERIALS/EQUIPMENT

- LabPro
- TI Graphing Calculator
- DataMate program
- Vernier Dissolved Oxygen Probe
- Temperature Probe
- D.O. calibration bottle and cap
- 3, 250-mL beakers
- hot and cold water
- 1-gallon plastic milk container
- ice
- Styrofoam cup

PRE-LAB PROCEDURE

Important: Prior to each use, the Dissolved Oxygen Probe must warm up for a period of 30 minutes as described below. If the probe is not warmed up properly, inaccurate readings will result. Perform the following steps to prepare the Dissolved Oxygen Probe.

1. Prepare the Dissolved Oxygen Probe for use (see Figure 1).
   a. Unscrew the membrane cap from the tip of the probe.
   b. Using a pipet, fill the membrane cap with 1 mL of DO Electrode Filling Solution.
   c. Carefully thread the membrane cap back onto the electrode.
   d. Place the probe into a 250-mL beaker containing distilled water.

2. Plug the Dissolved Oxygen Probe into Channel 2 of the LabPro. Use the link cable to connect the TI Graphing Calculator to the interface. Firmly press in the cable ends.

3. Turn on the calculator and start the DATAMATE program. Press [CLEAR] to reset the program.
4. The calculator screen should display DO (MG/L) in CH 2. If not, tell your instructor.

5. It is necessary to warm up the Dissolved Oxygen Probe for 10 minutes before taking readings. With the probe still in the distilled water beaker, wait 10 minutes while the probe warms up. The probe must stay connected at all times to keep it warmed up.

6. Prepare the calculator and interface for calibration.
   a. Select SETUP from the main screen.
   b. Press once to select CH2.
   c. Select CALIBRATE from the setup screen.

7. Calibrate the Dissolved Oxygen Probe.
   - If your instructor directs you to manually enter the calibration values, select MANUAL ENTRY from the CALIBRATION screen. Enter the slope and intercept values, select OK, then proceed to Step 1 of the procedure.
   - If your instructor directs you to perform a new calibration, select CALIBRATE NOW from the CALIBRATION screen and follow this procedure.

**Zero-Oxygen Calibration Point**

a. Remove the probe from the water bath and place the tip of the probe into the Sodium Sulfite Calibration Solution (see Figure 2).
   **Important:** No air bubbles can be trapped below the tip of the probe or the probe will sense an inaccurate dissolved oxygen level. If the voltage does not rapidly decrease, tap the side of the bottle with the probe to dislodge the bubble. The readings should be in the 0.2- to 0.5-V range.

b. When the voltage stabilizes (~1 min), press.

c. Enter “0” as the known value in mg/L.
**Saturated DO Calibration Point**

a. Rinse the probe with distilled water.

b. Unscrew the lid of the calibration bottle provided with the probe. Slide the lid and the grommet about 1/2 inch onto the probe body.

c. Add water to the bottle to a depth of about 1/4 inch and screw the bottle into the cap, as shown. **Important:** Do not touch the membrane or get it wet during this step (see Figure 3).

d. Keep the probe in this position for about a minute. The readings should be in the 2.0- to 3.3-V range. When the voltage stabilizes, press **ENTER**.

e. Enter the correct saturated dissolved-oxygen value (in mg/L) from Table 3 (for example, “8.66”) using the current barometric pressure and air temperature values. If you do not have the current air pressure, use Table 4 to estimate the air pressure at your altitude.

f. Select OK to return to the setup screen.

g. Select OK to return to the main screen.

h. Return the Dissolved Oxygen Probe to the distilled water beaker.

**PROCEDURE**

1. Plug a Temperature Probe into Channel 1 of the LabPro.

2. Set up the calculator and interface for the Temperature Probe.
   a. Select SETUP from the main screen.
   b. If the calculator displays the correct Temperature Probe in CH 1, proceed directly to Step 3. If it does not, continue with this step to set up your sensor manually.
   c. Press **ENTER** to select CH 1.
   d. Select TEMPERATURE from the SELECT SENSOR menu.
   e. Select the correct Temperature Probe (in °C) from the Temperature menu.

3. Set up the data-collection mode.
   a. Press 1 (Selects SETUP)
   b. To select MODE, press **▲** once and press **ENTER**.
   c. Select SELECTED EVENTS from the SELECT MODE menu.
   d. Select OK to return to the main screen.

4. Select 2: START on the main screen to prepare for data collection. Be sure the blue cap is removed from the D.O. Probe.

5. Obtain two 250-mL beakers. Fill one beaker with ice and water. Fill the second beaker with warm water about 40 – 50°C.
6. Place approximately 100 mL of cold water and a couple small pieces of ice, from the beaker filled with ice, into a clean plastic one-gallon milk container. Seal the container and vigorously shake the water for a period of 2 minutes. This will allow the air inside the container to dissolve into the water sample. Pour the water into a clean Styrofoam cup.

7. Place the Temperature Probe in the Styrofoam cup as shown in Figure 4. Place the shaft of the Dissolved Oxygen Probe into the water and gently stir. Avoid hitting the edge of the cup with the probe.

8. Monitor the dissolved oxygen readings displayed on the calculator screen. Give the dissolved oxygen readings ample time to stabilize (90 – 120 seconds). At colder temperatures the probe will require a greater amount of time to output stable readings. When the readings have stabilized, press [ENTER]. Note: Do not press [STO] at this time.

9. Place the Dissolved Oxygen Probe back into the distilled water beaker. Pour the water from the Styrofoam cup back into the milk container. Seal the container and shake the water vigorously for 1 minute. Pour the water back into the Styrofoam cup.

10. Repeat Steps 7 – 10 until the water sample reaches room temperature.

11. When room temperature has been reached, begin adding about 25 mL of very warm water (40°C – 50°C) prior to shaking the water sample. This will allow you to take warmer water readings. Repeat Steps 7 – 10 until the water sample reaches 35°C.

12. When all samples have been taken, press [STO] to stop data collection.

13. Select CH 2 VS. CH 1 from the graph screen to display a graph of dissolved oxygen concentration vs. temperature. As you move the cursor right or left, the dissolved oxygen (Y) and temperature (X) values of each data point are displayed below the graph. Record the data values in Table 2.

14. Use the graph of dissolved oxygen concentration vs. temperature to help you answer the questions below. When finished, press [ENTER] and select MAIN SCREEN from the graph screen.

15. Press 6 to exit program if instructed to do so.
TEMPERATURE EFFECTS ON DISSOLVED OXYGEN IN WATER

DATA TABLE

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Dissolved Oxygen (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

QUESTIONS

1. At what temperature was the dissolved oxygen concentration the highest? Lowest?

2. Does your data indicate how the amount of dissolved oxygen in the water is affected by the temperature of water? Explain.
3. If you analyzed the invertebrates in a stream and found an abundant supply of caddisflies, mayflies, dragonfly larvae, and trout, what minimum concentration of dissolved oxygen would be present in the stream? What maximum temperature would you expect the stream to sustain?

4. Mosquito larvae can tolerate extremely low dissolved oxygen concentrations, yet cannot survive at temperatures above approximately 25°C. How might you account for dissolved oxygen concentrations of such a low value at a temperature of 25°C? Explain.

5. Why might trout be found in pools of water shaded by trees and shrubs more commonly than in water where the trees have been cleared?
Temperature Effects on Dissolved Oxygen in Water

### Table 3: 100% Dissolved Oxygen Capacity (mg/L)

<table>
<thead>
<tr>
<th>Elevation (feet)</th>
<th>Pressure (mm Hg)</th>
<th>Elevation (feet)</th>
<th>Pressure (mm Hg)</th>
<th>Elevation (feet)</th>
<th>Pressure (mm Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>770 mm</td>
<td>14.76</td>
<td>760 mm</td>
<td>14.57</td>
<td>750 mm</td>
<td>14.38</td>
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<tr>
<td>740 mm</td>
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<td>680 mm</td>
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<td>660 mm</td>
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<td>0°C</td>
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<td>12.49</td>
<td>4°C</td>
<td>12.65</td>
<td>5°C</td>
<td>12.70</td>
</tr>
<tr>
<td>6°C</td>
<td>12.97</td>
<td>7°C</td>
<td>13.31</td>
<td>8°C</td>
<td>13.51</td>
</tr>
<tr>
<td>9°C</td>
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<td>10°C</td>
<td>13.82</td>
<td>11°C</td>
<td>13.97</td>
</tr>
<tr>
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<tr>
<td>29°C</td>
<td>15.19</td>
<td>30°C</td>
<td>15.25</td>
<td>31°C</td>
<td>15.32</td>
</tr>
</tbody>
</table>

### Table 4: Approximate Barometric Pressure at Different Elevations

<table>
<thead>
<tr>
<th>Elevation (feet)</th>
<th>Pressure (mm Hg)</th>
<th>Elevation (feet)</th>
<th>Pressure (mm Hg)</th>
<th>Elevation (feet)</th>
<th>Pressure (mm Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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<td>746</td>
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<td>746</td>
<td>750</td>
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<td>727</td>
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<td>1250</td>
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</table>

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