Exhaling Acid

Background
Nearly every cell in your body contains mitochondria. The mitochondria are usually referred to as the “power houses” of the cell because they produce ATP, which is cellular energy. The equation for this process is shown below:

\[ \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 36\text{ATP} + 6\text{H}_2\text{O} + 6\text{CO}_2 \]

To produce this energy, cells must do cellular respiration. One product of cellular respiration is carbon dioxide (CO\(_2\)). As cells produce CO\(_2\), it is moved from the cells to the bloodstream. From there, it is transported to the lungs, where it gets exhaled.

We can measure how quickly your body is doing cellular respiration by measuring how quickly CO\(_2\) is produced and exhaled. Bromothymol blue is a chemical indicator that will be used to help us do this. Indicators are chemicals that change color as the pH of a solution changes. It is yellow in acidic solutions (pH:0-6) and blue in basic or neutral solutions (pH:7-14).

When carbon dioxide is dissolved in water, it combines with some of the water molecules to produce carbonic acid. This acid has a pH of ~5.7, which causes the solution to become more acidic as more CO\(_2\) is dissolved in the water. Today you will measure your cellular respiration rates both before and after exercise by exhaling into a test tube containing water and bromothymol blue!

Investigation Question
How does exercise affect a person’s rate of cellular respiration?

Hypothesis
Make a hypothesis statement below. Be sure to justify it with reasoning.

Pre-lab Questions
1. Write the equation for cellular respiration. Draw a circle around the reactants and a box around the products.

2. How will bromothymol blue be used in this experiment? What would happen if it were not used?

3. How is breathing related to cellular respiration?
Materials
- 1 large test-tube
- 1 - 10mL graduated cylinder
- 2 straws
- Bromothymol blue solution
- Water
- Timer
- Paper towels

Safety
- Safety goggles and lab aprons must be work when handling chemicals in the lab.
- Wash your hands thoroughly before leaving the lab.
- When working with acids and bases, if any solution gets on your skin immediately rinse the area with water.
- DO NOT DRINK THE SOLUTIONS TODAY
- Clean-Up
  - Solutions can be dumped down the drain.
  - Make sure you clean up any spills on your table and/or on the floor.
  - All straws and paper towels can be thrown in the trashcan.
  - Test-tubes must be rinsed out and put back in the test-tube rack.
  - Goggles and aprons must be returned as they were received.

Procedure
**Test-Tube Set Up**
1. Put on your safety equipment.
2. Obtain a clean test tube.
3. Using a graduated cylinder, measure 5mL of water. Then, pour the water into the test tube.
4. Add two drops of bromothymol blue to the test tube.

**Resting Cellular Respiration Rate**
1. Measure your resting heart rate.
   a. Have your partner set a timer for 15 seconds.
   b. Count the number of heart beats you feel for 15 seconds.
   c. Multiply that number by 4 to get your beats per minute.
   d. Record that value in Data Table 1 under “resting heart rate.”
2. Place a straw in the test tube.
3. Have your partner start the timer.
4. SLOWLY exhale through the straw, into the test tube. Take your mouth off of the straw to inhale between exhales so that you do not accidentally inhale the liquid. Continue to exhale until the color of the solution changes from blue to yellow (not green!)
5. Record the time it takes for the solution to change color in Data Table 2 under “resting cellular respiration rate.”
6. Rinse out your test-tube.
7. While you exercise for two minutes, your partner should set-up your test-tube again.

**Exercising Cellular Respiration Rate**
1. Measure your exercising heart rate
a. Have your partner set a timer for 15 seconds.
b. Count the number of heart beats you feel for 15 seconds.
c. Multiply that number by 4 to get your beats per minute.
d. Record that value in Data Table 1 under “exercising heart rate.”

2. Place a straw in the test tube.
3. Have your partner start the timer.
4. **SLOWLY** exhale through the straw, into the test tube. Continue to exhale until the color of the solution changes from blue to yellow (not green!)
5. Record the time it takes for the solution to change color in Data Table 2 under “exercising cellular respiration rate.”
6. Rinse out your test-tube.
7. Repeat the entire experiment, switching roles with your partner.

**Data**

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<thead>
<tr>
<th>Data Table 1: Heart Rates</th>
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<tr>
<td>Partner Name</td>
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<table>
<thead>
<tr>
<th>Data Table 2: Cellular Respiration Rates</th>
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<tbody>
<tr>
<td>Partner Name</td>
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**Analysis**

**Exercise and Heart Rate**

1. Create a bar graph that compares your heart rate before and after exercise.
2. Explain your graph. How did exercise affect your heart rate?

Exercise and Cellular Respiration
1. Create a bar graph that compares your cellular respiration rate before and after exercise.

2. Explain your graph. How did exercise affect your cellular respiration rate?
3. Does your data show that you produce more or less CO$_2$ with exercise?

**Conclusion**
1. Did your body need more oxygen or less oxygen to produce energy? How did your body compensate for this need?

2. What would happen if your cellular respiration rate increased but your heart rate did not? How might the pH of your blood be affected?

3. Why is it important to take deep breaths instead of shallow breaths while exercising?