Cellular Respiration Lab

Reading:

Enzymes Science Literacy

Key Questions:

How does exercise affect carbon dioxide levels?

What factors can affect CO_2 production?

SAFETY:

Protective eyewear is required due to working with 0.1 N Sodium Hydroxide.
Wear appropriate safety gear (goggles, gloves, apron, etc.).
Use caution when working with chemicals.

MATERIALS AND EQUIPMENT: (Designed for group of 2 students)

For the classroom:

distilled water	1.5 mL pipettes
0.1 N NaOH	0.1% aqueous bromothymol blue (BTB) solution
straws	plastic wrap

8 oz water bottle (should be rinsed with bottled or distilled water between each use – Do not use TAP water)

For each group:

distilled water	1 - 10 ml graduated cylinders	2 straws
5 ml of bromothymol blue	2 - plastic water bottles with lid (250 ml)	1 – 1.5mL pipette
10 ml NaOH solution	2in X 2in plastic wrap	

HYPOTHESIS:

In this activity, you will explore how exercise affects CO_2 production. Make a hypothesis about the effect of exercise on CO_2 production, heart, and breathing rates. Explain your reasoning.

PROCEDURE:
Read all directions before beginning the experiment.

Each student group will be exercising for a different amount of time and calculating the amount of CO_2 that is produced. Each group will be assigned a specific amount of time to exercise. If you have 4 people in your group, you will be divided into 2 groups and each group will conduct the experiment. Therefore, you will have two data points that will need to be averaged together. The class data will then be combined to create a curve to show the CO_2 production rate over time. Each student is responsible for one role throughout the experiment.

Roles:

- **Research Technician:** Will be responsible for making the BTB solution and will also be the test subject. Please be sure you are healthy enough to exercise for 1 minute. You will fill the pipette with NaOH and be responsible for slowly adding the drops of NaOH .
- **Data Specialist:** Will be responsible for counting the number of drops added and swirling the flask to ensure an even mixture of solutes. You will record data in data table and calculate the CO_2 production

You will be assigned one of the follow exercise groups by your teacher:

- Group 1 = resting – no exercise
- Group 2 = 30 sec
- Group 3 = 60 sec
- Group 4 = 90 sec or 1 min and 30 sec
- Group 5 = 120 sec or 2 min
- Group 6 = 150 sec or 2 min and 30 sec
- Group 7 = 180 sec or 3 min
- Group 8 = 210 sec or 3 min and 30 sec

How to conduct the experiment?

1. Use a graduated cylinder to measure 20 mL of distilled/bottled water and pour it into an 8oz water bottle (~236 ml).
2. Add 1 ml bromothymol blue to the flask to make a BTB solution.
3. Cover the opening with plastic wrap. Leave space for straw to be inserted.
4. Exercise for your assigned amount of time.
5. Using a straw, **EXHALE** into the BTB solution for 20 seconds. **(CAUTION: Do not inhale the solution!)**
6. Observe the color change from blue to green to yellow.
7. Fill the pipet provided with 0.1 N sodium hydroxide (NaOH).
8. Slowly add one drop of NaOH into the BTB solution.
9. Aggressively swirl the flask between each drop.
10. Continue to add drops and swirl until the solution maintains the blue color again.
11. Record the total number of drops added in Table 1.
12. Rinse out bottle between measurements.

NOTE: The teacher will demonstrate how to blow into the water bottle and aggressively swirl the bottle.

DATA ANALYSIS:

TABLE 1: Rate of Carbon Dioxide Production					
Student Group A Leader	**Time Exercised**	**# of NaOH drops**	**[1]mL of NaOH**	**[2]Total mL solution**	**[3]Amount of CO_2 in Solution**
	Resting				
	30 sec				
	60 sec				
	90 sec				
	120 sec				
	180 sec				
	240 sec				

[1]0.04 ml/drop times the number of drops is used to calculate the **ml of NaOH.** For example, if there were 21 drops of NaOH: 0.04ml/drop x *(21 drops)* = 0.84 mL NaOH

[2]The **total ml** of solution is calculated by adding the solute + solvent (bromothymol (1 ml) + water (20 ml)).

[3]To calculate the **amounts of CO_2** present use the formula below:

$$CO_2 \text{ mg/L} = \left(\frac{\text{ml of NaOH x ml 0.1 N NaOH}}{\text{ml of solution}}\right) \quad X \quad 1000$$

$$CO_2 \text{ mg/L} = \left(\frac{0.84 \text{ x } 0.1 \text{ N NaOH}}{21 \text{ mL}}\right) \text{ x } 1000 = 4 \text{ mg/L of } CO_2$$

1. Create a graph showing the amount of CO_2 in solution from table 1 of the experiment. Add a title to the graph and label the x-axis and y-axis. Include units for each axis. Label the data for each trial. Include a legend for the graph.

CONCLUSIONS:

1. How did exercise affect the amount of NaOH required to turn the yellow solution to blue?

2. What can you conclude about the effect of exercise on the amount of carbon dioxide that is present in your exhaled breath?

3. Why do your heart and breathing rates increase when you increase activity level? Why are your heart and lungs working harder?

4. Every experiment has the potential for error. List three things from this experiment that could have biased your data.

CRITICAL THINKING

1. Did your findings support your hypothesis? Why or why not?

2. How do you think your results would differ if you ran the full experiment with all males and again with all females? Which gender would have greater CO_2 production?

3. Based on the findings of this experiment, what would be a logical next question for the scientists to study?