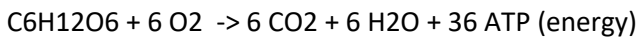


## **Exercise & Cellular Respiration/ Production of Carbon Dioxide**

LT: I can follow a procedure aimed to collect data on carbon dioxide production, breathing rate, and heart rate in order to determine the rate of cellular respiration. 4.5.1d

Background Information.

Cellular respiration is a chemical reaction that occurs in your cells to create energy; when you are exercising your muscle cells are creating ATP to contract. Cellular respiration requires oxygen (which is breathed in) and creates carbon dioxide (which is breathed out).



This lab will address how exercise (increased muscle activity) affects the rate of cellular respiration. You will measure 3 different indicators of cellular respiration: breathing rate, heart rate, and carbon dioxide production. You will measure these indicators at rest (with no exercise) and after 1 and 2 minutes of exercise. Breathing rate is measured in breaths per minute, heart rate in beats per minute, and carbon dioxide in the time it takes bromothymol blue to change color.

Carbon dioxide production can be measured by breathing through a straw into a solution of bromothymol blue (BTB). BTB is an acid indicator; when it reacts with acid it turns from blue to yellow. When carbon dioxide reacts with water, a weak acid (carbonic acid) is formed. The more carbon dioxide you breathe into the BTB solution, the faster it will change color to yellow.

### **Materials:**

goggles	graduated cylinder	water	small cup	bromothymol blue solution (BTB)
straw	stop watch	“dump cup”		

### **Establish a hypothesis for the following question:**

*How does exercise affect carbon dioxide production, breathing rate, and heart rate?*

## **Procedures:**

### PART A: Resting (no exercise)

#### Measuring Carbon Dioxide Production:

1. Use a graduated cylinder to measure out 20 mL of tap water and pour it into a small cup.
2. Use a dropper to add 8 drops of bromothymol blue to make a BTB solution.
3. Using a straw, exhale into the BTB solution but do not submerge the straw. (CAUTION: Do not inhale the solution!)
4. Time how long it takes for the blue solution to turn yellow. Record the time in Table 1.
5. Empty the cup and repeat steps 1-4 one more time.
6. Average the results of the 2 trials. Record this in Table 1.

#### Measuring Breathing Rate:

1. Count the number of breaths (1 breath = inhale + exhale) you take in 1 minute.
2. Record this in Table 2.
3. Repeat this 1 more time.
4. Average the 2 trials to get your average breathing rate. Record this in Table 2.

#### Measuring Heart Rate:

1. Take your pulse by counting the number of beats in 30 seconds and multiplying that number by 2.
2. Record this in Table 3.
3. Repeat this 1 more time.
4. Average the 2 trials to get your average heart rate. Record this in Table 3.

### PART B: Increased Muscle Activity (Exercise)

1. Exercise for exactly 1 minute by "running in your chair." Lift your legs and pump your arms.
2. While you are exercising, your partner should get the BTB solution ready as in Part A.
3. After 1 minute of exercise, immediately exhale through the straw into the BTB solution. Time how long it takes for the BTB to turn yellow. Record this in Table 1.
4. Then quickly calculate and record your breathing and heart rates as you did before. You only need to do this once.
5. Remake your BTB solution .
6. Exercise as you did before, but for 2 continuous minutes.
7. Immediately exhale through the straw into the BTB solution. Time how long it takes for the BTB to turn yellow. Record this in Table 1.
8. Then quickly calculate your breathing and heart rates as you did before. You only need to do this once.
9. Record these values in Tables 2 & 3.

#### **In your conclusion, be sure to address the following:**

1. How did exercise affect the time needed for the solution to change color?  
Explain why the color change occurred (How does BTB work?)
2. What can you conclude about the effect of exercise on the amount of carbon dioxide that is present in your exhaled breath? Explain.
3. What can you conclude about the effect of exercise on breathing rate? Explain.
4. What can you conclude about the effect of exercise on heart rate? Explain.
5. Describe the multiple body systems that work together to transport oxygen to muscles and remove carbon dioxide, as well as how the muscle cells get the energy needed to continue contracting.

**Establish a hypothesis for the following question:**

*How does exercise affect carbon dioxide production, breathing rate, and heart rate?*

Table 1:

		Student 1	Student 2	Student 3	Student 4	Average
<b>Resting</b>	Trial 1					
	Trial 2					
	Average					
<b>Exercise</b>	1 minute					
	2 minuets					

Table 2:

		Student 1	Student 2	Student 3	Student 4	Average
<b>Resting</b>	Trial 1					
	Trial 2					
	Average					
<b>Exercise</b>	1 minute					
	2 minuets					

Table 3:

		Student 1	Student 2	Student 3	Student 4	Average
<b>Resting</b>	Trial 1					
	Trial 2					
	Average					
<b>Exercise</b>	1 minute					
	2 minuets					

**In your conclusion, be sure to address the following:**

1. How did exercise affect the time needed for the solution to change color?  
Explain why the color change occurred (How does BTB work?)
2. What can you conclude about the effect of exercise on the amount of carbon dioxide that is present in your exhaled breath? Explain.
3. What can you conclude about the effect of exercise on breathing rate? Explain.
4. What can you conclude about the effect of exercise on heart rate? Explain.
5. Describe the multiple body systems that work together to transport oxygen to muscles and remove carbon dioxide, as well as how the muscle cells get the energy needed to continue contracting.

	3	2	1
<b>Data Tables</b>	Table(s) show individual and larger sample data with a title, units and numbers (including averages) rounded to the nearest tenth.  All data is calculated and recorded thoroughly and accurately. There are no major errors.	Most data is calculated and recorded thoroughly and accurately.  There are few major errors.	Little data is calculated and recorded thoroughly and accurately.  There are many major errors.
<b>Graph</b>	The graph clearly shows the relationship between both variables (for individual and larger sample data). The graph accurately includes all of the following: -a title -axes labels (with units of measure) -units following constant scale -bars/lines represent correct values -a key (or labels) identify all lines/bars	The graph shows the relationship between both variables. The graph accurately includes most of the following: -a title -axes labels (with units of measure) -units following constant scale -bars/lines represent correct values -a key (or labels) identify all lines/bars	The graph partially shows the relationship between both variables. The graph accurately includes few of the following: -a title -axes labels (with units of measure) -units following constant scale -bars/lines represent correct values - a key (or labels) identify all lines/bars
<b>Conclusion</b>	Conclusion is thorough. Specific data evidence and reasoning are included.	Conclusion is general. Specific data evidence/reasoning is limited.	Conclusion is incomplete. Specific data evidence/reasoning is not used.
<b>Analysis</b>	Analysis contains many thorough, thoughtful, and relevant reflections that communicate purpose, sources of error and next steps.	Analysis contains several thorough, thoughtful, and relevant reflections that communicate purpose, sources of error and next steps.	Analysis contains few thorough, thoughtful, and relevant reflections that communicate purpose, sources of error and next steps.

<b>Participation</b>					
I often contributed good ideas that were relevant to the topic and task. I came to meetings prepared. I did my share of the work.	4	3	2	1	I seldom contributed good ideas. Sometimes I was talking off-task. I did not come to meetings prepared. I did not do my share of the work.
<b>Working with Others</b>					
I often compromised and cooperated. I did take initiative when needed and/or listened and respected the ideas of others.	4	3	2	1	I seldom compromised and cooperated. I did not take initiative when needed and/or did not listen and respect the ideas of others.
<b>Product</b>					
My part of the task is complete and accurate. My work was submitted on time.	4	3	2	1	I did not complete my part of the task. The information I presented was inaccurate and/or not done correctly. It was not completed on time.
<b>Understanding Content</b>					
I can speak about the topic and group work knowledgeably. I can sum-up the lesson.	4	3	2	1	I do not understand what I did in my group. I did not ask or answer questions. I cannot sum-up the lesson.