

How much air do you normally exhale?

When you breathe normally, you inhale about 500 mL of air into your lungs. This amount of air is called tidal volume. You also can inhale an additional volume of air called the reserve volume. After exhaling normally, you can forcibly exhale this same additional volume of air. Even after the most forceful exhalation, however, about 1000 mL of air remains in your lungs. This amount of air is called the residual volume.

Carbon dioxide (CO₂) is a waste product of respiration. As you exercise, your respiration rate increases to supply the extra energy your body needs to continue exercising. As a result, the amount of carbon dioxide in your blood also increases. The more strenuous the exercise, the more carbon dioxide is produced.

In this laboratory, you will measure the amount of air you normally exhale. Also, you will use an indicator to find out how exercise affects the amount of carbon dioxide you exhale.

Materials

2 L plastic bottle	food coloring
2-hole rubber stopper	2 pieces of glass tubing, 10 cm and 20 cm long
250 mL beaker	3 30 cm pieces of rubber tubing
100 mL graduated cylinder	bromothymol blue solution
graduated cylinder	dropper
dilute ammonia solution	250-mL beaker
2 drinking straws	stirring rod
timing device	

Procedure

1. Fill a 2 L plastic bottle about three-fourths full of water. Add a few drops of food coloring to the water.
2. Carefully insert two pieces of glass tubing into a 2-hole rubber stopper. Caution: Be careful when inserting the glass tubing; wear gloves.
3. Place the rubber stopper and glass tubing into the plastic bottle. Be sure that the end of the longer glass tubing is below the surface of the water. The end of the shorter piece of glass tubing must be above the surface of the water.
4. Carefully attach one end of a piece of rubber tubing to the longer piece of glass tubing. Caution: Be careful when attaching the rubber tubing; use a slow, twisting motion.
5. Place the free end of the rubber tubing into a 250 mL beaker.
6. Attach a second piece of rubber tubing to the shorter piece of glass tubing.
7. Inhale normally. Then exhale normally through the free end of the rubber tubing attached to the shorter piece of glass tubing. The air you exhale will displace water from the bottle, through the tubing, and into the beaker.
8. The volume of water displaced is equal to the volume of air you exhaled. Measure the volume of water by pouring the water from the beaker into a graduated cylinder. Record this volume as Trial 1 in Table 1.

Table 1 - Volume of Water Displaced

Volume	Partner 1	Partner 2
Trial 1		
Trial 2		
Trial 3		
Average		

9. Pour the water from the graduated cylinder back into the 2 L bottle.
10. Repeat steps 7 to 9 two more times. Record your results as Trials 2 and 3 in Table 1.
11. Calculate and record the average volume of water displaced.
12. Replace the piece of rubber tubing you exhaled into with a new piece of rubber tubing.
13. Have your partner repeat steps 7 to 11 and

record the data.

14. **Caution:** Bromothymol blue and ammonia can stain clothing and irritate skin. Be sure to wear your lab apron and goggles during this laboratory. Pour 100 mL of bromothymol blue solution into a 250 mL beaker.

15. Exhale slowly through a drinking straw into the bromothymol blue for 1 minute, stopping to inhale as necessary. **Caution:** Be sure to take the straw out of your mouth when you inhale.

16. The bromothymol blue should turn yellow as you exhale into it. If the solution does not turn yellow after 1 minute, continue exhaling into the solution until it changes color.

17. Add one drop of ammonia to the yellow solution and stir once with a stirring rod.

18. Continue to add ammonia one drop at a time, stirring once after each drop, until the solution

Drops of Ammonia	Before Exercise	After Exercise
Trial 1		
Trial 2		
Trial 3		
Average		

turns blue and record the number of drops of ammonia you added in Table 2.

19. Repeat steps 15 to 18 twice more and record the results in Table 2.

20. Calculate the average number of drops of ammonia needed to change the color of the bromothymol blue solution from yellow to blue. Record the average in Table 2.

21. Exercise by running in place for 1 minute.

22. Repeat steps 15 to 21. Record the results.

Table 2 - Results of Exercise on CO₂

Questions

1. Who exhaled the greater average volume of air, you or your partner?
2. How does the volume of air you exhaled compare with the volume of air your partner exhaled in each trial?
3. How can you explain any difference in the average volume of air exhaled by you and by your partner?
4. Do you think the average volume of air you exhale will increase or decrease after exercise? Explain your answer.
5. Count the number of breaths you normally take in one minute. Then calculate the average volume of air you exhale in one minute.
6. How much air do you exhale in one class period? Show your calculations.
7. What was the average number of drops of ammonia needed to change the color of the solution from yellow to blue before exercise?
8. What was the average number of drops needed after exercise?

9. Compare your results with two other members of your class. Were the averages the same or different?
10. How is the average number of drops of ammonia related to the amount of carbon dioxide exhaled?
11. How does exercise affect the amount of carbon dioxide you exhale? How do you know? Use your data to support your answer.
12. What was the control in this experiment?
13. List two variables that might have affected the results of this laboratory.