

Properties of Gases: A Case Study of the Bends

by

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Part I – Introduction

Goals/Objectives

- Identify the types and amounts of each gas in the atmosphere.
- Use the behavior of gas mixtures to calculate the amount of gas dissolved in a solution.
- Use conversion factors to calculate pressure in a variety of measurement units.
- Understand how hyperbaric oxygen therapy (HBOT) works and what conditions it is prescribed for.
- Use the kinetic molecular view of gases to explain their behavior at different temperatures and pressures.
- Explain how intermolecular forces change as gas temperature changes.
- Apply the individual and/or combined gas laws to gas samples under various conditions.

This lab is an interrupted (done in parts) case study that addresses the properties of gases. The subject of the case is severe decompression sickness—more commonly referred to as “the bends.” The bends offers an opportunity to see how gas behaviors affect a human illness and what treatments are used to address it.

You will need to read the section(s) in your textbook that address the properties of gases and the gas laws (see Guinn and Brewer, *Essentials of General, Organic and Biochemistry (GOB)*, Ch. 4), as well as the news article below before the lab, and you will need to consult other resources (books, the Internet, health professionals, etc.) to complete the assignments.

You will be working in a group and will be expected to discuss and/or explain individual parts of the lab with other students/groups. The instructor also will do two demonstrations during the lab and you will need to make observations and record them to answer questions and participate in discussions.

The lab consists of:

- Part I – This introduction and the news item included in it.
- Part II – A pre lab.
- Part III – The lab activity/procedure.
- Part IV – A post lab.

Bring your textbook and completed pre-lab worksheet to class.

For the lab activity, you will form small groups and work as a team to address each of the parts of the lab. Following this, you will be put into a larger group and each member will present and discuss one to two of the parts of the lab with the larger group. Use this time for a discussion to be sure that everyone’s responses are accurate and complete. Everyone in the larger group should be interacting and communicating. The final part is the post lab and it will be done both in your original group and as homework.



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Hawaiian Cinematographer Paralyzed

Mike Prickett sustains decompression sickness after saving co-worker's life in Tahiti

By Matt Pruett, originally published March 21, 2012 by *Surflife*, reprinted with permission.
http://www.surflife.com/surf-news/mike-prickett-paralyzed_68245/

World-renowned underwater cinematographer Mike Prickett – known for his spellbinding work on such award-winning documentaries as *Riding Giants* and *Step Into Liquid* – is currently suffering from severe decompression sickness, aka “the bends” or “diver’s disease,” while shooting a commercial video in Rangiora, Tahiti last Wednesday.

Sources say the 47-year-old Hawaiian was sharing air with another diver, drained the tank, and had no choice but go straight to the surface without decompressing. At press time, Mike was undergoing hyperbaric oxygen therapy in a Papeete hospital.

“I was doing an underwater shoot for wetsuits and dive gear,” Prickett told Honolulu-based KITV News. “I saw another diver sinking and panicking. I dove down to 220 feet to save him, but he used up all my air. I’m glad I was able to rescue him and he could walk away from the incident. I want to thank my family and friends for their prayers.”

*I saw another diver
sinking and panicking. I
dove down to 220 feet to
save him, but he used up
all my air.”*

— Mike Prickett

Unfortunately, the bends left Prickett paralyzed from the chest down. And though he has since regained some sensation in his legs, his condition is still serious. Surflife received an update from Tahiti-based photographer and Teahupo’o fixture Tim McKenna after he had returned from the hospital.

“Mike still has to do decompression chamber sessions until next Saturday,” reported Tim. “Forty-eight hours after the last session he can fly back to see a specialist, either in Australia or San Diego. He’s in pain and his spirits are pretty low. He still can’t feel his lower body.”

The best news in all this may actually come from Prickett’s past: An automobile accident back in 1984 shattered Mike’s right leg in 36 places and his left leg in seven. Doctors feared he’d never walk again and suggested swimming as physical therapy. All that rehab ultimately led to an interest in underwater cinematography, which led to a stellar career, which led to numerous awards including “Best Cinematography” at the Sundance Film Festival. In other words, this is a very empowered, industrious man we’re talking about here.

Details on a fundraiser to benefit his medical expenses will be announced soon. In the meantime, please pray for Mike and his wife Marya during this very troubling time.

Update effect Thursday evening, as reported by noted Tahiti photographer Tim McKenna: “He is much more cheerful today and even showed me how he could move his left leg slightly. So he is making some progress and everybody is hopeful he will be able to walk again after some therapy. At this stage he should fly back to L.A next Monday or Tuesday.”

6. The amount of oxygen dissolved in your blood is directly related to the amount of pressure that is exerted by oxygen gas in the air you are breathing. Calculate the partial pressure of oxygen (pO_2) in your arterial blood in mmHg.

7. What does SCUBA stand for and what is it used for? Discuss why Mike needs SCUBA gear and what is in the tank and how it functions.

8. What happens to the pressure of the gases that you breathe from the SCUBA tank as you dive deeper? Why?

9. Discuss what decompression sickness is and why it is called the “bends.” What is “bent” when you are suffering from decompression sickness (the bends)? Explain this topic as fully as possible.

10. What is decompressing and how does this process prevent the bends?

11. Could divers avoid the bends by filling their SCUBA tank with pure oxygen? Explain.

Part III – Lab Activity / Procedure

Name: _____

Date: _____

Section: _____

Instructor: _____

You will form groups of 3–4 and work together. For each of the following activities, spend the first minutes reading the statement silently. Then use the next 1–2 minutes brainstorming and discussing it as a group (without writing anything). Spend the next 1–2 minutes recording the answer that you arrived at as a group (45 min. total). Each person from the group will need to present and lead a discussion on one of the following items in a larger group.

1. *Drawing activity:* Each member of a group needs to have a different role in this activity. There should be a reader/researcher, a calculator, a drawer, and a labeler/writer. Label your drawing with your lab section # and the name of each group member. Turn in your drawing before leaving class.
 - a. Using the poster paper and markers provided, sketch a diagram showing different locations or places (3–4, or more) that are referred to or discussed within the story about Mike Prickett’s *diving accident* (e.g., don’t include his car accident). Label each location with a number (1, 2, etc.) and a short description.
 - b. Label the relative pressure at each point. (Just show the pressure relative to the pressure at sea level e.g. >>, >, =, <, << sea level.)
 - c. Briefly describe the changes in the pressure of the gas that Mike is breathing through his SCUBA tank regulator at each of his different locations in the water.
 - d. Think about the demonstration at the start of lab with the soda and write a brief description about what is happening to the gases in Mike’s blood and how that might affect his body at each point in your drawing (both in and out of the water). Include this information on your drawing.
2. As a group, calculate the total amount of pressure (absolute pres.) in atmospheres that Mike is exposed to at 220 feet under water. (33 ft. water = 1 atmosphere of pressure)
3. Calculate the partial pressures (in atmospheres) of both nitrogen and oxygen in Mike’s blood at a depth of 220 feet and at sea level. Assume the SCUBA tank contains air.

- b. What can you say about the pressure of the gas inside the balloon as the temperature decreases?
- c. Use the kinetic molecular view of gases to explain why the pressure and the volume change.
- d. Does the number of gas molecules in the balloon (mols of gas) change as the temperature changes? What observation supports your answer?
- e. Write a statement that describes the relationship between gas volume and temperature. Is this a direct or inverse relationship?
- f. Write a statement that describes the relationship between gas pressure and temperature. Is this a direct or an inverse relationship?
3. Use the kinetic molecular view of gases and intermolecular forces to discuss the following questions. (2 points each)
- a. Discuss how the gas molecules are behaving (moving, interacting, etc.) in the balloon when it is at room temperature.

b. Nitrogen is usually a gas; what has happened to it in order for it to become a liquid? Be complete.

4. Use the following story as a case study on carbon monoxide (CO) poisoning and hyperbaric oxygen therapy (HBOT). (2 points. each)

2 Women Critical after Carbon Monoxide Incident

http://abclocal.go.com/wabc/story?section=news/local/new_york&id=8944932 (accessed 11/16/14)

NEW YORK (WABC) – Two women were critical after being overcome by carbon monoxide poisoning during an apparent boiler leak in a home in Queens. The women, one in her 20s and one in her 50s, were pulled from the house on 114th Street in Ozone Park just before 8 a.m. Monday. They were listed in critical condition at Jamaica Medical Center, where they were being treated in the hyperbaric chamber. Carbon monoxide readings were as high as 500 parts per million when firefighters arrived at the house. They were able to quickly vent the house, and the levels dropped to normal. A faulty boiler is believed to have caused the leak. Fire officials said there were no carbon monoxide alarms in the house.

a. What is the function of a boiler and why is it believed to be the cause of the CO poisoning?

b. Why is a hyperbaric chamber being used to treat the victims?

c. What is the partial pressure of oxygen (pO_2) in the patient's blood if the hyperbaric chamber has 2.0 atm of air pressure inside? Give your answer in mmHg.

5. Gas law calculations (lab and text material). *Remember to show all of your work!*
- a. Use Henry's Law to discuss the changes in the concentration (solubility) of nitrogen gas in the blood between these two locations: (1) at 220 feet of depth and (2) at sea level. Explain the difference. (5 points)

 - b. Use Henry's Law to calculate the concentration (in molarity) of $N_2(g)$ at the two locations above (5.a.), Henry's constant (k) = $6.40 \times 10^{-4} \text{ M/atm}$. (5 points)

 - c. The demonstrations above can be described in a single equation called the combined gas law. It is used to relate the conditions of a single sample of gas (the balloon) to different initial and final environments.
 - i. Use the combined gas law to find the final pressure of a gas sample if it was initially at a pressure of 1.5 atm, a temperature of 25°C , and a volume of 5.0 liters. The final temperature and volume are 100°C and 7.0 liters. (4 points)

 - ii. Use the combined gas law to find the initial temperature (in $^\circ\text{F}$) of a gas sample if it was at a volume of 1.5 liters and a pressure of 29.4psi. Its final conditions are; pressure = 1520mmHg, volume = 2.0 liters, and temperature = 200°C . (5 points)