Connected Chemistry
Gas Laws Unit
Lesson 5: Real vs. Ideal Gases

Student's Lesson at a Glance

Lesson Summary

This lesson has three activities. In the final lesson of this unit, students explore how ideal gases differ from real gases. Using the Connecting Activity, students learn that variations between conceptual and real-world gases could have serious consequences for global conditions. Acknowledging Van der Waal's variation on the Ideal Gas Law, attraction of the molecules is factored to accurately explore real world gases. Students calculate the ideal volume of air at different altitudes with provided data and use calculated values compared with actual volume. Students identify relationships existing between altitude, pressure, temperature, and density. In the final activity, students apply gas laws to conditions observed in a lab. The lab further solidifies connections between real-world situations and gas laws.

SWBAT (Student will be able to)

- Explain why some gases do not behave like ideal gases under certain conditions
- Explain, using specific examples, how pressure and gas laws can be observed in real-world conditions

Essential Vocabulary

Keep a list of all important words from this lesson. This list, in addition to the lists from other lessons, will make studying easier and improve scientific communication skills. The essential vocabulary from the unit is in **bold**. Additional words that will expand your scientific vocabulary are in *italics*.

CCC Reminder

- The Ideal Gas Law is a model. In this unit you will compare this model to how real gases behave. You may want to look back in the Matter unit to review why models are useful, but have specific limitations.
- When completing the gas law lab stations, make sure to follow directions closely and keep accurate notes of your observations.
- The Ideal Gas Law requires the use of the gas law constant (R). The value for R changes depending on the units that are needed in the problem. Make sure you are using the correct value for R.

Notes

Homework

Upcoming Quizzes/ Tests

Activity 1: Connecting

1. What do you think is the difference between a real gas and the model of an ideal gas?

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Chemists work in many different environments all over the world. Since temperature and air pressure may vary, it is necessary to have standard reference conditions for experimentation. Standard temperature and pressure (STP) in chemistry represents normal conditions for comparing the volumes of gases at sea level. **Avogadro's Law** states the volume occupied by an ideal gas is proportional to the amount of molecules in the container. Therefore, 1 mole of any gas at STP has the volume of 22.4 L.

Recall that the model of an ideal gas approximates the behavior of a real gas across a limited range of temperatures and pressures. The behavior of real gases may not necessarily be explained by the **Ideal Gas Law** under all conditions. For example, the mathematical model $PV = nRT$ does not hold true for gases that are massive or voluminous. In these cases, attractions between the real gas molecules must be taken into account. Johannes Diderik van der Waals proposed a variation on the Ideal Gas Law in 1873, which unlike the Ideal Gas Law, factors in attraction between molecules.

Why should we know the difference between how real and ideal gases behave? To utilize gases for practical applications, it is important to understand how gases behave in extreme conditions. People rely on many products from extreme environments like the Arctic, which starts at the North pole and ends at the Arctic Circle. The Arctic has long, cold winters reaching temperatures of 233 K; however, the *wind chill* can be much lower. Mining in the Arctic yields uranium, nickel, copper, zinc, silver, gold, and diamonds. Large amounts of oil and natural gas are also piped and carried to countries all over the world. The waters in the Arctic are also home to many popular seafoods, including crab and cod.

To obtain these resources, companies use machines of all types. Many of the heavy resources must be transferred from stationary locations onto ships, trucks and trains. Engineers must calculate how real gases behave at very low temperatures and pressures so that the machines work properly. Without modified calculations for real gases, many of the resources we enjoy would be become harder to obtain, which would make them more expensive.

2. What conditions could make a real gas violate the gas laws?

3. Scientists use words such as *obey*, *violate*, and *behavior* to describe the movement of molecules. Do gas molecules make conscious decisions about how to behave, or is the behavior of gases a result of external factors? *Support your claim with evidence.*

Activity 2: Comparing Real and Ideal Gases

Using the Ideal Gas Law, **PV = nRT**, *calculate the ideal volume for air from 0 to 5,000 feet. Convert °C into Kelvin.*

Part 1: Average measures of 1 mole of air at different altitudes

Altitude (feet)	Pressure (kPa)	Temp (°C)	Temp (K)	Density (kg/m^3)	Ideal Volume (L)	Actual Volume (L)
-5000	120.5					
-4000	116.5					
-3000	112.7			Varies depending on location.		
-2000	108.8					
-1000	105.0					
0	101.3	15		1.20		0.203
1000	97.63	8.5		1.12		0.191
2000	94.19	2		1.01		0.178
3000	90.81	-4.5		0.91		0.159
4000	87.49	-11.0		0.82		0.145
5000	84.33	-17.5		0.74		0.132

4. If you are at a negative altitude, where is one place on Earth you could be located?

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5. The relationship between altitude and pressure is ***inverse*** or ***direct*** (*circle one*).

6. The relationship between altitude and density is ***inverse*** or ***direct*** (*circle one*).

7. Explain at the submicroscopic level your answers to #5 and #6.

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8. The relationship between pressure and temperature is ***inverse*** or ***direct*** *(circle one)*.

9. The relationship between temperature and volume is ***inverse*** or ***direct*** *(circle one)*.

10. The relationship between altitude and volume is ***inverse*** or ***direct*** *(circle one)*.

11. Considering your calculations for volume using the Ideal Gas Law, how do the actual volumes compare?

12. What are the limitations of using the Ideal Gas Law in all conditions based on the evidence from the data collected?

Part 2: *Use Simulation 3,* ***Set 1***

Compare a real gas to an ideal gas in the simulation by clicking on the Real or Ideal button to change the view.

13. In the simulation, what is the difference between a real and an ideal gas?

14. If you lower the temperature in the simulation, what is the difference between a real and ideal gas?

Lesson Reflection Question

15. How has your understanding of the ideal gas model changed? *Explain your answer with evidence.*

Activity 3: Capstone

Use the Kinetic Molecular Theory postulates to help explain the relationships that are modeled by the Gas Laws. *Be sure to discuss Boyles's Law, Charles's Law, and Gay-Lussac's Law.*

Kinetic Molecular Theory Postulate	How it relates to Boyles's Law	How it relates to Charles's Law	How it relates to Gay-Lussac's Law

1. Discuss the limitations of the Kinetic Molecular Theory model that help explain what we see in real gas behavior under certain conditions.