9.2 - KMT & Gases Unit Packet

First & Last Name: ______________________________ Course:__________

NOTE: Packets are due after completing Part 5. Check each page to be sure all blanks are completed.

Driving Question: What factors influence the behavior of gases and in what ways?

Anchoring Phenomenon: We have an enclosed container of gas. How will altering variables affect the gases behavior?

Deeper Questions
1. How is an ideal gas different from an actual gas?
2. How can we mathematically relate the factors that influence gases?
3. Why is it important to study the behavior of gases?

Schedule

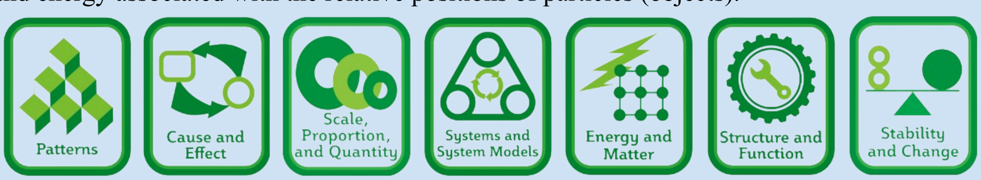
Part 1: Introduction
- Initial Ideas & Data Dive - Looking at the relationship between pressure, volume, and temperature with gas properties PhET
- Discussion & Developing Explanations

Part 2: Core Ideas
- Core Ideas
- Revisions of Part 1 Explanations

Part 3: Investigation
- Exploring the Gas Laws

Part 4: Review & Assessment
- Ranking Your Readiness
- Formative Assessment & Mastery Check

NGSS Standards (PEs & CCCs are summarized below. SEPs are noted throughout the packet).
HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).



Semester Schedule

5. Ionic Bonds
5.1 - Why doesn't pure water conduct electricity?
5.2 - Why is salt safe but sodium and chlorine aren't?

6. Covalent Bonds
6.1 - Why do atoms sometimes share electrons?
6.2 - How does polarity affect the shape/structure of molecules?

7. Moles
7.1 - How can we use moles, number of atoms & mass to reach conclusions?

8. Balancing Equations & Stoichiometry
8.1 - Can we predict the outcomes of reactions?
8.2 - What limits the extent to which reactions can occur?

9. KMT & Gases
9.1 - What is the chemistry of weather?
9.2 - What factors influence the behavior of gases and in what ways?

10. Acids & Bases
10.1 - Why are some substances acidic or basic?

Resource Links: Class Website; Core Ideas; Practice Test; Mastery Check;

Part 1: Introduction – PhET of Gases (9.2.1)

Overview: In this activity you will be manipulating the temperature, pressure and volume of a gas in a closed container. The relationship between these three variables will then be examined further in class.

Initial Ideas - *Record your ideas separately (e.g., on a white board or scratch paper).*
SEP: Engaging in Argument from Evidence.

Background Information: Scientists construct models to explain the behavior of substances. While the gas laws describe how gases behave, they do not explain why gases behave the way they do. The *Kinetic Molecular Theory (KMT)* is a model or theory that is used to explain the behavior of gases. This theory describes the relationships among pressure, volume, velocity, frequency, and force of collisions.

Investigation Questions: How are temperature and volume related? How are pressure and volume related? How are temperature and pressure related?

Procedure: Check each box as you complete each step.

Part 1: Determining the relationship between temperature and volume

1. ☐ Open the PhET simulation and click "ideal"
2. ☐ Add 3 pumps of the blue gas particles and let the pressure generally stabilize (it will always fluctuate slightly)
3. ☐ In the upper right corner, under "Hold Constant", select "Pressure ↕V". This will make sure pressure will not change significantly.
4. ☐ Add heat to the container to increase the temperature; observe and record what happens to the volume of the gas.
5. ☐ Remove heat from the container to decrease the temperature; observe and record what happens to the volume of gas.
6. ☐ What is the relationship between temperature and volume?
7. ☐ Is this a direct or indirect relationship? *Note: a direct relationship is when the variables increase or decrease together. An indirect relationship is when one variable increases or decreases while the other does the opposite.*

Part 2: Determining the relationship between pressure and volume

1. ☐ Hit the reset button.
2. ☐ Add 3 pumps of the blue gas particles and let the pressure generally stabilize.
3. ☐ In the upper right corner, under "Hold Constant", select "Temperature". This will make sure that temperature will not change significantly.

4. ☐ Using the handle, change the size of the container so that it is smaller; observe and record what happens to the pressure of the gas.

5. ☐ Change the size of the container so that it is larger; observe and record what happens to the pressure of the gas.

6. ☐ What is the relationship between volume and pressure?

7. ☐ Is this a direct or indirect relationship?

Part 3: Determining the relationship between temperature and pressure

1. ☐ Hit the reset button. Add 3 pumps of the blue gas particles and let the pressure generally stabilize.
2. ☐ In the upper right corner, under “Hold Constant”, select “Volume”. This will make sure that volume will not change significantly.
3. ☐ Add heat to the container to increase the temperature; observe and record what happens to the pressure of the gas.

4. ☐ Remove heat from the container to decrease the temperature; observe and record what happens to the pressure of the gas.

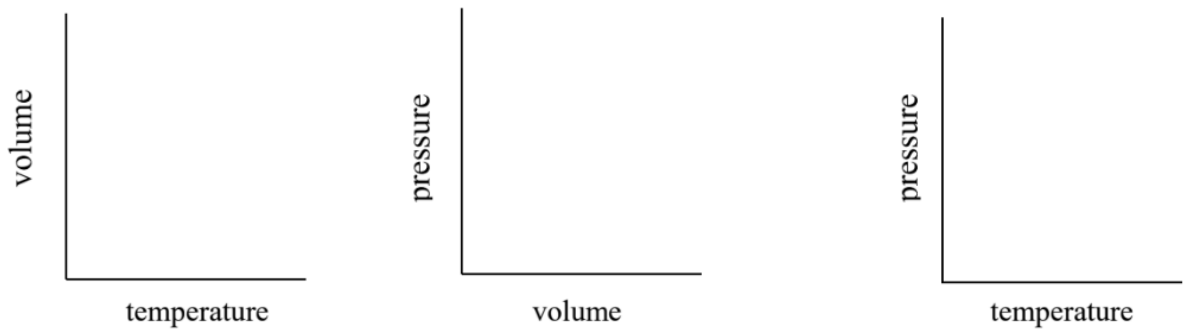
5. ☐ What is the relationship between temperature and pressure?

6. ☐ Is this a direct or indirect relationship?

Data Dive - Read the directions below.
SEP: Analyzing and Interpreting Data.

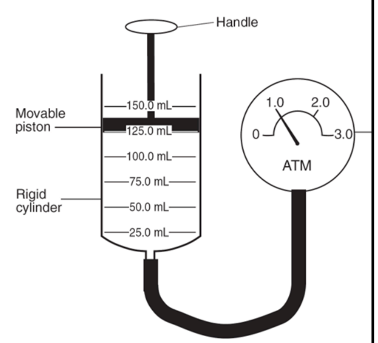
Follow-Up Questions

1. In the spaces below, draw what the graphs would look like for the following relationships:



2. During a demonstration, a scientist takes a deflated balloon out of liquid nitrogen (-196°C). As the balloon rests on the table at room temperature, it begins to expand in volume. Explain this behavior in terms of collisions.

3. A gas is trapped inside a syringe. Explain, in terms of collisions, why the pressure of the gas increases when the movable piston is pushed down.



4. In terms of collisions, explain why on a cold autumn morning a camper's air mattress may appear to have deflated some as opposed to when it was first filled up the afternoon before. Assume no leaks.

5. A sample of a gas is in a sealed, rigid container that maintains a constant volume. Which changes occur between the gas particles when the sample is heated?
   a. The frequency of collisions increases and the pressure decreases
   b. The frequency of collisions increases and the pressure increases
   c. The frequency of collisions decreases and the pressure decreases
   d. The frequency of collisions decreases and the pressure increases

6. As the pressure <u>on</u> a sample of gas increases at constant temperature, the volume of the gas…
   a. Decreases b. Increases c. Remains the same

7. As the temperature of a given sample of a gas increases, the volume of the sample of gas
   a. Decreases b. Increases c. Remains the same

8. As the pressure on a given sample of gas in a fixed container increases at constant temperature, the number of gas particles…
   a. Decreases b. Increases c. Remains the same

Data Dive Questions - *Record your ideas separately*

SEP: Asking Questions and Defining Problems.

1. **Begin by individually attempting to make sense of this data.** What trends or patterns do you notice? How does this relate to any prior knowledge or experience that you have?

2. **Next, work in your teams to discuss your ideas.** Where do you agree? Where do you disagree? Can you use this data to reach an agreement? Can others' prior knowledge/experience help?

3. **Based on this data, what is one conclusion that would be supported by this data?** How is your conclusion supported by data? What specifically suggests your claim is accurate?

4. **Does this data support or refute any of the claims from the three students on the previous page?** If so, explain.

Discussion - *Record your ideas in the spaces below.*

As a class, discuss your ideas about this data. What are the ideas that most agreed on? Where did your ideas differ as a class? Record your ideas in the spaces below.

What do we know…	***What questions do we still have…***

Initial Explanations - *Record your ideas in the spaces below.*

SEP: Constructing Explanations and Designing Solutions; Asking Questions and Defining Problems.

What factors influence the behavior of gases and in what ways? Record your initial explanation in the space below. It's okay if you aren't completely sure! You will revise this explanation over time.

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Part 2: Core Ideas (9.2.2)

Overview: In this activity, you will begin with a short presentation to provide you with information that will help you improve and revise your initial ideas. Your instructor will decide on how to implement this portion. You will then work in small teams to address the questions listed below.

Driving Questions - *Record your ideas separately (e.g., on a white board or scratch paper).*
SEP: Developing and Using Models.

1. What are the assumptions we make for an ideal gas?
2. What factors affect the behavior of gasses?
3. What is STP? Include its values.
4. What unit does temperature have to be in when doing gas law calculations?
5. Which law relates pressure and volume? How? What must be constant? What is the equation?
    a. Practice problem: if 0.600 L of a gas at 100.0 kPa changes to 62.4 kPa, what is the new volume if temperature remains constant?
    b. Practice problem: A 185 mL sample has a pressure of 4.2 atm. What is its pressure when the volume is 250 mL if the temperature remains constant?
6. Which law relates temperature and volume? How? What must be constant? What is the equation?
    a. Practice problem:A balloon inflated in an air conditioned room at 28°C has a volume of 4.0 L. If it is heated to 58°C, what is the new volume of the balloon if pressure remains constant?
    b. Practice problem: A balloon inflated in an air condition room at 83°C has a volume of 609 mL. If it is changed to standard temperature, what is the new volume of the balloon if pressure remains constant?
7. Which law relates temperature and pressure? How? What must be constant? What is the equation?
    a. Practice problem: The pressure of a gas in a tank is 3.20 atm at 22.0°C. If the temperature is raised to 60.0°C, what is the new pressure if volume is held constant?
8. Which law relates temperature, pressure and volume? How? What must be constant? What is the equation?
    a. Practice problem: Find the volume of a gas at STP if it measures 806 mL at 26.0°C and 103.0 kPa.
9. How are ideal gases different from real gases?

10.

Gas Law	Volume	Temperature	Pressure
	Constant	↓	
		Constant	↑
	↑		Constant
	↓	↓	

Revising Explanations - *Record your ideas in the spaces below.*
SEP: Constructing Explanations and Developing Solutions.

What factors influence the behavior of gases and in what ways?

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Throughout this packet, you will be updating this explanation as you gain more information and more experience. When you complete this packet, compare your initial explanation to your final version. You should see clear improvement with each revision.

$P_1V_1 = P_2V_2$	$\frac{V_1}{T_1} = \frac{V_2}{T_2}$	$\frac{P_1}{T_1} = \frac{P_2}{T_2}$	$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

Celsius to kelvin

$K = °C + 273.15$

NOTE: 700 mmHg = 0.92 atm

9.2 Gas Laws Notes

1. **What are the assumptions we make for an ideal gas?**
   a.

   b.

   c.

   d.

   e.

2. **What factors affect the behavior of gases?**
   a.
   b.
   c.
   d.

3. **What is STP? What are the values for STP?**

4. **When doing gas law calculations, temperature <u>MUST</u> be in ___________________________!**

5. **______________________ relates ________________ and ________________. They have a(n) __________________ relationship. This means: ____**

   The equation is: _____________________ The constant is: ____________________________

6. **A real world example of Boyle's Law is: ____**

   ____

7. **Practice problem: if 0.600 L of a gas at 100.0 kPa changes to 62.4 kPa, what is the new volume if temperature remains constant?**

8. **Practice problem: A 185 mL sample has a pressure of 4.2 atm. What is its pressure when the volume is 250 mL if the temperature remains constant?**

9. **______________________ relates ________________ and ________________. They have an ________________ relationship. This means: ____**

   The equation is: _____________________ The constant is: ____________________________

10. **A real world example of Charles' Law is: ____**

    ____

11. **Practice problem:A balloon inflated in an air conditioned room at 28°C has a volume of 4.0 L. If it is heated to 58°C, what is the new volume of the balloon if pressure remains constant?**

12. **Practice problem: A balloon inflated in an air condition room at 83°C has a volume of 609 mL. If it is heated to standard temperature, what is the new volume of the balloon if pressure remains constant?**

13. **______________________ relates ________________ and ________________. They have an ________________ relationship. This means: ____**

    The equation is: _____________________ The constant is: ____________________________

14. **A real world example of Gay-Lussac's Law is: ____**

    ____

15. Practice problem: The pressure of a gas in a tank is 3.20 atm at 22.0°C. If the temperature is raised to 60.0°C, what is the new pressure if volume is held constant?

16. ____________________ relates ______________ and ______________ and ______________.

They have an ________________ relationship. This means: ______________________________

The equation is: ___________________ The constant is: __________________________

17. A real world example of The Combined Gas Law is: ____________________________________

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18. Practice problem: Find the volume of a gas at STP if it measures 806 mL at 26.0°C and 103.0 kPa.

19.

Gas Law	Volume	Temperature	Pressure
	Constant	↓	
		Constant	↑
	↑		Constant
	↓	↓	

20. How are ideal gases different from real gases?

Practice Problems

Boyle's Law:

1. A sample of oxygen gas occupies a volume of 250 mL at 740 torr pressure. What volume will it occupy at 800 torr?

2. A sample of carbon dioxide occupies a volume of 3.50 L at 125 kPa. What pressure would the gas exert if the volume was decreased to 2.00 L?

3. A 2.0 L container of nitrogen had a pressure of 3.2 atm. What volume would be necessary to decrease the pressure to 1.0 atm?

4. Ammonia gas occupies a volume of 450 mL at a pressure of 720 mmHg. What volume will it occupy at standard pressure?

5. A 175 mL sample of neon had its pressure changed from 75 kPa to 150 kPa. What is its new volume?

6. A sample of hydrogen at 1.5 atm had its pressure decreased to 0.50 atm producing a new volume of 750 mL. What was its original volume?

7. Chlorine gas occupies a volume of 1.2 L at 720 torr pressure. What volume will it occupy at 1 atm pressure?

8. Fluorine gas exerts a pressure of 900 torr. When the pressure is changed to 1.50 atm, its volume is 250 mL. What was the original volume?

Charles' Law:

1. A sample of nitrogen occupies a volume of 250 mL at 25°C. What volume will it occupy at 95°C?

2. Oxygen gas is at a temperature of 40°C when it occupies a volume of 2.3 L. To what temperature should it be raised to occupy a volume of 6.5 L?

3. Hydrogen gas was cooled from 150°C to 50°C. Its new volume is 75 mL. What was its original volume?

4. Chlorine gas occupies a volume of 25 mL at 300K. What volume will it occupy at 600K?

5. A sample of neon gas at 50°C and a volume of 2.5 L is cooled to 25°C. What is the new volume?

6. Fluorine gas at 300 K occupies a volume of 500 mL. To what temperature should it be lowered to bring the volume to 300 mL?

7. Helium occupies a volume of 3.8 L at -45°C. What volume will it occupy at 45°C?

8. A sample of argon gas is cooled and its volume went from 380 mL to 250 mL. If its final temperature was 55°C, what was its original temperature?

Gay-Lussac's Law:

1. A container of gas is initially at 0.500 atm and 25°C. What will the pressure be at 125°C?

2. A gas container is initially at 47 mmHg and 77K. What will the pressure be when the container warms up to 25°C?

3. A gas is collected at 22.0°C and 745.0 mmHg. When the temperature is changed to 0°C, what is the resulting pressure?

4. A gas has a pressure of 699.0 mmHg at 40.0°C. What is the temperature at standard pressure?

5. If a gas is cooled from 323 K to 273 K and volume is kept constant what final pressure would result if the original pressure was 750 mmHg?

6. Calculate the final pressure inside a scuba tank after it cools from 1.00×10^{3}°C to 25°C. The initial pressure in the tank is 130 atm.

Combined Gas Law:

	P_1	V_1	T_1	P_2	V_2	T_2
1	1.5 atm	3.0 L	20°C	2.5 atm		30°C
2	720 torr	256 mL	25°C		250 mL	50°C
3	600 mmHg	2.5 L	22°C	760 mmHg	1.8 L	
4		750 mL	0°C	2.0 atm	500 mL	25°C
5	95 kPa	4.0 L		101 kPa	6.0 L	198°C
6	650 torr		100°C	900 torr	225 mL	150°C
7	850 mmHg	1.5 L	15°C		2.5 L	30°C
8	125 kPa	125 mL		100 kPa	100 mL	75°C

Part 4: Review & Assessment (9.2.4)

Step 1: Rank each Driving Question in Part 2 based on your comprehension (you can rank them as *1,2,3* or *green/yellow/red*, or any other method). Then work in teams to review anything that is still unclear.
Step 2: Identify any remaining areas of confusion or concern. Then review these topics with your instructor.
Step 3: Complete the Formative Assessment (*last page of the packet*). Your instructor will determine if you will work individually, in pairs, or in small groups. Then compare and evaluate your responses as a class.
Step 4: Individually complete a Mastery Check (link on pg. 1). If your performance indicates that additional support is needed, your instructor will determine how to help you move forward.

What factors influence the behavior of gases and in what ways?

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Note: At this point, you may still be uncertain about your answer. That is ok! We still have unanswered questions about this topic. If time allows, discuss when information is still needed to answer this question.

KMT & Gases Unit - Packet 2 Formative Assessment (9.2.4)

Name: ____ Hour: ___ Score: ______/______

Directions: A 3x5 notecard with handwritten notes can be used to guide your answers. Remember to show all work for credit and include units in your answers.

$$P_1V_1 = P_2V_2 \qquad \frac{V_1}{T_1} = \frac{V_2}{T_2} \qquad \frac{P_1}{T_1} = \frac{P_2}{T_2} \qquad \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

1. **A moveable piston filled with carbon dioxide gas has a volume of 10.0 L and a pressure of 2 atm. What is the volume of the cylinder when it becomes pressurized to 4 atm if temperature remains constant?** (*3 points*)

2. **Explain how volume and pressure are related at the particulate level.** (*3 points*)

3. **The pressure of air outside a hot air balloon is 1.0 atm with an air temperature of 10°C. The temperature of air inside a hot air balloon has been heated to 25°C. What is the pressure inside the balloon if volume remains constant?** (*3 points*)

4. **Explain how temperature and pressure are related at the particulate level.** (*3 points*)

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5. **A sample of gas occupies 50 L at 51°C and 640 mmHg of pressure. What is its volume at STP?** (*3 points*)

6. **A balloon is inflated to 6.22 L of helium at a temperature of 36°C. What is the volume of the balloon when the temperature is 22°C if pressure remains constant?** (*3 points*)

7. **Explain how volume and temperature are related at the particulate level.** (*3 points*)

8. **In an airplane, potato chip bags often become quite large. How can you explain this observation based on differences in air pressure inside the bag and in the airplane cabin?** (*3 points*)

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