Gas Laws Explained Through Basketballs

Submitted by: Allison Hardy, Chemistry
Hillwood High School, Nashville, TN

Target Grade: 10th-12th Grade Chemistry

Time Required: 4 days (three 70-minute block periods and one 45-minute period)

Standards:

Next Generation Science Standards (NGSS):

- HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
- HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
- 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 motion of particles (objects) and energy associated with the relative positions of particles (objects).

Lesson Objectives

Students will be able to:

- Describe the relationship between pressure & temperature using evidence from collected data.
- Represent how temperature and pressure are related graphically.
- Determine if pressure and temperature are indirectly or directly related factors influencing the behavior of a gas.
- Describe the relationship between the volume and pressure of gas particles using patterns identified in collected data.
- Represent how volume and pressure are related graphically.
- Describe the relationship between temperature and volume using observations from a demonstration.
- Model the movement of gas molecules as the temperature of a system is increased.
- Represent an understanding of the behavior of gas molecules using a scientific model.
- Interpret graphical representations of relationships between variables.
- Represent an understanding the movement of gas molecules using the creation of a pictorial model.
- Create an evidence-based explanation of a real-world phenomenon.

Central Focus

The focus of these lessons is to explore how gases are different than the other states of matter and how gases react in response to changes in temperature, pressure, and volume. Students will interact with a lesson that they have not completed before, but a topic that they might have developed questions about in their real-life: **What happened to all of the basketballs between the months of July and December?** Students will construct a series of investigation using both online platforms and in-person labs. They will be required to work in both an individual and a group setting performing labs and creating a final poster presentation explaining the phenomenon.

Key Terms: Kinetic Molecular Theory, Gay Lussac's Law, Boyle's Law, Charles' Law, chemistry, physics

Background Information

In this lesson, students should have a basic knowledge of reading the periodic table and identifying elemental characteristics, which can be seen in the below photo. Furthermore, students will need some understanding of phase changes and energy transfers. Students will use their knowledge of the three gas laws (Gay Lussac's Law, Boyle's Law, and Charles' Law) and the Kinetic Molecular Theory, to better understand the ideal gas law and the mathematical reasoning or calculations associated with it.

The Kinetic Molecular Theory is what explains the behaviour of gasses through experimental observation. It is based on the following assumptions:

- Gases are composed of a large number of particles that behave like hard, spherical objects in a state of constant, random motion;
- These particles move in a straight line until they collide with another particle or the walls of the container;
- These particles are much smaller than the distance between particles. Most of the volume of a gas is therefore empty space;
- There is no force of attraction between gas particles or between the particles and the walls of the container;
- Collisions between gas particles or collisions with the walls of the container are perfectly elastic. None of the energy of a gas particle is lost when it collides with another particle or with the walls of the container; and
- The average kinetic energy of a collection of gas particles depends on the temperature of the gas and nothing else.

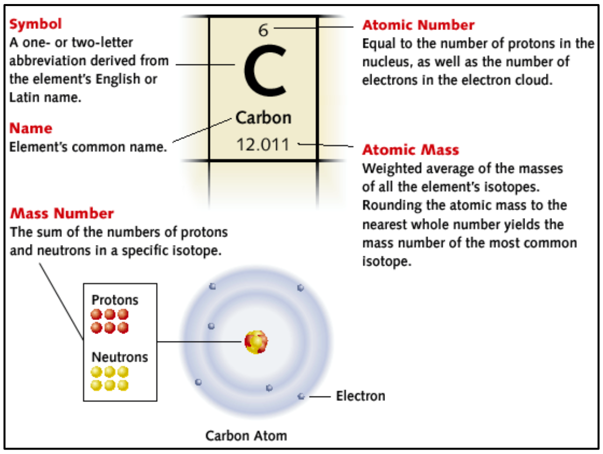
Helpful Link: http://chemed.chem.purdue.edu/genchem/topicreview/bp/ch4/kinetic4.html

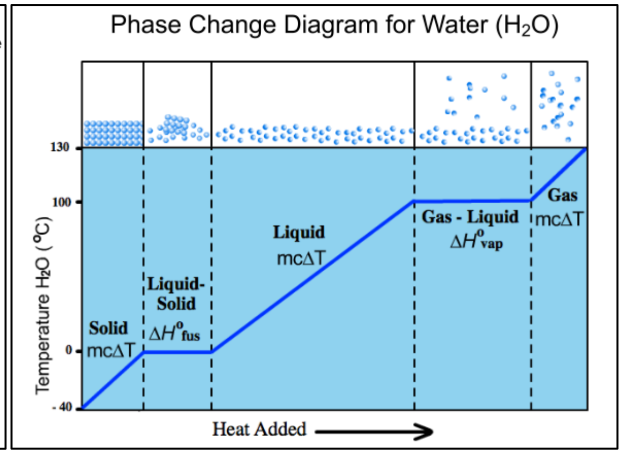
The three primary gas laws for this lesson are Charles' Law, Boyle's Law, and Gay Lussac's Law.

- Charles' Law: the relationship between volume and temperature if pressure and amount of gas are held constant. If the volume of a container is increased, the temperature increases.

- Boyle's Law: the volume of a given amount of gas held at constant temperature varies inversely with the applied pressure when the temperature and mass are constant.
- Gay Lussac's Law: the pressure of a given amount of gas held at constant volume is directly proportional to the Kelvin temperature.

Helpful Link: https://www.chem.fsu.edu/chemlab/chm1045/gas_laws.html





https://www.classzone.com/books/earth_science/terc/content/investigations/es0501/es0501page06.cfm

Materials

- Projector
- Gas laws packet
- Exit ticket day 1
- Markers
- Three basketballs
- Freezer or bags of ice in a bucket
- Mini-marshmallows
- Erlenmeyer flask
- Example of ideal explanatory model write-up
- Individual laptop and charger per student
- Gas Laws PowerPoint
- Exit ticket day 2
- Explanatory model rubric
- Giant Post-it paper
- Mini Post-it notes
- Rubber stopper
- Plastic syringes
- Glass syringe
- Heated blanket or portable heater

Instruction:

Day 1 (70 minutes):

- Before lesson preparation: Put one basketball in a cooler, one under a heated blanket or next to a heater, and one sitting on a desk to act as a control.

Introduction:

- Students will need the Gas Laws-Lab Packet, which should include Investigation #1- Gay Lussac's Law, Investigation #2-Boyle's Law, and Investigation #3-Charles' Law.

- The students, individually, will read and draw a model to answer the anchoring event and guiding question which can be found on the first page of their Gas Laws-Lab Packet.
  - Scenario: The Hillwood High basketball team has spent the whole summer conditioning, but they took several months off before the season got started. The last time the team actually got to practice using the basketballs was July. When they went to go get the basketballs out of the locker room in December, they found that every single ball was flat.
  - Guiding Question: What happened to the basketballs from July to December?
  - The model should include both observable and unobservable features.

Explain:

- The students will then fill out the guided notes on the Gas Laws-Lab Packet while the teacher shows the Day 1 PowerPoint.
  - The PowerPoint will review Kinetic Molecular Theory (KMT), define pressure, volume, temperature, and gas laws.

Investigation #1- Gay Lussac's Law*:*

- The students, with their lab partners, will go to the NetLogo link given by the teacher to explore the relationship between the temperature and pressure in gases.
- While going through the simulation, the students will answer the guiding questions in the Gas Laws-Lab Packet.
- Students will collect data from the computation model and develop a graph.
- At the end of the investigation, students will create a claim that describes their observations.

Exploration:

- The teacher will then do the bounce test with the class by using the pre-cooled and warmed basketballs.
- Teacher will remove one basketball from the freezer or bucket of ice and the other basketball from the hot blanket or next to the heater.
- Before bouncing the balls, the teacher will ask the class the following questions:
  - Which ball will bounce the highest? Why?
  - How does this connect to what you investigated on the computer?
  - What evidence do you have to support this?
- Students will have time to respond to their peers and ask questions about the difference between the basketballs.
- After the students have had time for investigative questions and answering, the teacher will first bounce a control basketball, then bounce the two balls while the students observe.

Closure:

- To finish the class the individual students will be given the Gas Laws-Day 1 Exit Ticket to assess the students' understanding.
- The exit ticket will ask the following:
    - What **evidence** did you collect from the Heat Box Investigation that will help you refine your model of the anchoring event? Be specific.
    - What **evidence** did you collect from the Bounce Test that will help you refine your model of the anchoring event?
    - Is the relationship between the temperature and the pressure of a gas a **direct** relationship or an **indirect** relationship?

Day 2 (70 minutes):

- Before lesson preparation: Put an Erlenmeyer flask with rubber stopper in a freezer or bags of ice in a bucket.

Introduction (Completed on catalyst sheet):

- Students will answer the following questions displayed on the board on the Catalyst Sheet:
    - According to the Heatbox Lab and Bounce Test from last class, are pressure and temperature directly or indirectly related?
    - A birthday balloon is moved from inside of a cool, air-conditioned house to outside in the summer sun. What will happen to the pressure of the balloon and why?
- Once the students have finished their written responses, the teacher will conduct a full class discussion of the student's answers.

Investigation #2-Boyle's Law:

- Students will work with lab partners or individually to complete the Investigation #2-Boyle's Law 2 found in the Gas Laws-Lab Packet.
- Teacher will ask probing questions like:
    - How does this law differ from the law investigation on day 1?
    - Are they direct or indirect relationships?
    - How do you know?
- Students will then explore the relationship between volume and pressure through the Isothermal Piston NetLogo Lab given by the teacher.

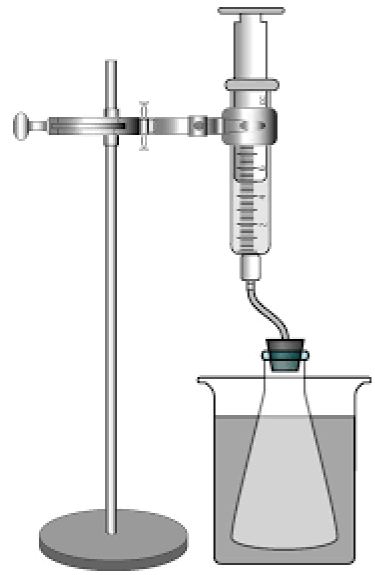
Exploration:

- Teacher will provide each student or partner grouping with a plastic syringe containing a mini marshmallow.
- Teacher will model for students how to change the pressure and volume of the plastic syringe and explain safety precautions.

- Teacher will then provide time for students to explore and play with the syringes to better understand what is happening.
- Teacher will ask pressing questions such as "What do you notice about the force needed to push the syringe down the closer you get to the stopped end?"
- As a class, the teacher will create a graph on the board of this phenomenon.

Investigation #3-Charles' Law:

- Teacher will remove the Erlenmeyer flask from a freezer or bucket of ice bags and poke a hole into the rubber stopper with the glass syringe.
- While the students are following along in the Gas Laws-Lab Packet, teacher will warm hands and instruct students to make observations when the teacher touches the glass syringe.
- Teacher will ask students to explain why what they noticed occurred and what they think is happening inside of the glass syringe which would cause the syringe to rise.
- Students will explore and model the relationship between temperature and volume after watching the movement of a glass syringe when the attached Erlenmeyer Flasks is warmed.



https://www.chem.fsu.edu/chemlab/chm1045/gas_laws.html

Closure:

- Students will answer the two questions below and reflect on what happened during investigations on the Gas Laws-Day 2 Exit Ticket.
    - What evidence did you collect from the Isothermal Piston Investigation that will help you refine your model of the anchoring event of the basketball bounce phenomenon? Be specific.
    - What evidence did you collect from the Glass Syringe Demonstration that will help you refine your model of the anchoring event? Be specific.

<u>Day 3 (45 minutes):</u>

Introduction:

- Completed on Catalyst Sheet, students will answer the questions below to reflect on their understanding of the three gas laws investigated.
    - How does what you have learned about gas laws relate to something you have experienced on a daily basis?
    - Examples to provide students in case they have trouble think of their own: tire pressure changing during the winter, balloon deflating.

Exploration:

- Students will review their graded labs and feedback given on exit tickets to evaluate how their new ideas may refine or change ideas represented in their initial model of the anchoring event.
- Teacher should have the anchoring event scenario of the basketballs written on the board or displayed somewhere in the classroom to remind students.
- Students will have time to draw and create their model on a Giant post-it paper after completing the Anchoring Event Revisions in the Gas Laws-Lab Packet.

Argumentation:

- Each group will prepare a short presentation of their argument of the guiding question: What happened to all of the basketballs between the months of July and December?
- Two students from each group will travel to two other groups to hear the explanation for the anchoring event from another group while filling out the Argumentation Session of their Anchoring Event Revisions. While two other members are presenting their poster.

Closure:

- Students will turn in Gas Laws-Lab Packet with Anchoring Event Revisions completed.

*Day 4 (80 minutes):*

Introduction:

- Students will revisit their final model of the anchoring event and make any final modifications to their representation.
- Teacher will display models on different walls in the classroom.
- The teacher will present the combined chemistry data from the NetLogo models.
    - Students will be asked to compare their data collection and graph to the class's complete data collection.
    - Students will be asked to provide a written interpretation of what each graph is representing about the relationship between temperature/pressure and volume/pressure.
- Teacher will lead students in a class discussion and reflection of data. Examples of class questions are:
    - Do we see any trends in the data?
    - What type of relationships are being represented in the graphs (direct or indirect)?
    - Are there any outliers or data points in our graphs that don't make sense?
    - How could we explain the exceptions to our laws that we have developed?
    - What questions do we still have that this class data does not fully explain about our anchoring event?

Exploration:

- The teacher will review the purpose of each part of the argument in the Argumentation Graphic Organizer.
- The parts of the Argumentation Graphic Organizer are the following:
    - Group Members' Names
    - Guiding Question
    - Claim
    - Evidence
    - Justification of Evidence
    - Limitation of the Data
- Students will complete the table with their guiding question, claim, evidence, and justification.
- Each group decides who the two speakers are and who the two listeners are.
    - Listeners will travel to each group to hear their presentation.
    - Listeners will take notes and ask questions of another group's argument.
    - Speakers will present their information to the listeners.
    - Students will travel to 2 groups in the 20-minute time.
- Listeners bring new information back to group and discuss new or refining information.
- Students will have one last opportunity to change any ideas present in their model based on new ideas learned from other groups.
- Students will practice their presentation once through in their groups.
- Review norms and expectations for presentations.
- Each group will present their final explanation of the anchoring event to the class.
- Students will be able to ask questions of each group following the presentation.

Closure:

- Students will have the remainder of class to construct an explanatory model of the anchoring event.
- Students will be given a rubric, which will be reviewed by the teacher and a "got to have it" list on the Anchoring Event Explanatory Model worksheet to complete their argument.
- Additionally, the teacher will provide students with a class copy example of an exemplary student's model write-up.
- Students will also be told that the model write-up will be due in the next class. This model write-up should be typed.
- Students will travel to other groups to give feedback on their peer's projects.
- Students will leave one "glow" comment and one "grow" comment on each poster.

Differentiation

- Google translate and speech to text is available online and may be utilized for students with special needs or ELL.

- Teacher may allow students to touch, bounce, and move closer to observe any teacher lead observations.
- Students may use the following website if students would like more platforms to investigate gas properties: https://phet.colorado.edu/en/simulation/gas-properties

Assessment

Summative assessment:

- The teacher will review and score each groups final Post-it notes with the given rubric.
- The teacher can check the Gas Laws Packet for understanding how gas laws work and how it relates to the phenomenon

Formative assessment:

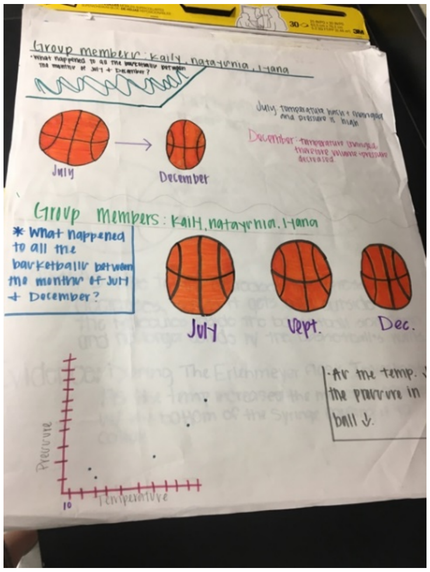
- The teacher will use the exit tickets, catalyst sheets, and class discussions to check for understanding throughout the lesson.
- The teacher will use the probing questions shown above throughout the different labs to gauge the students' understanding.

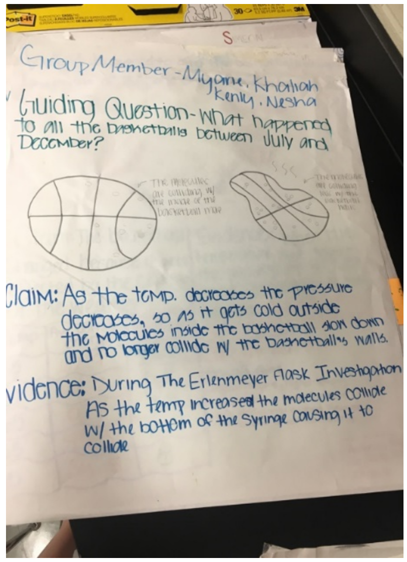
NetLogo Link and Instructions:

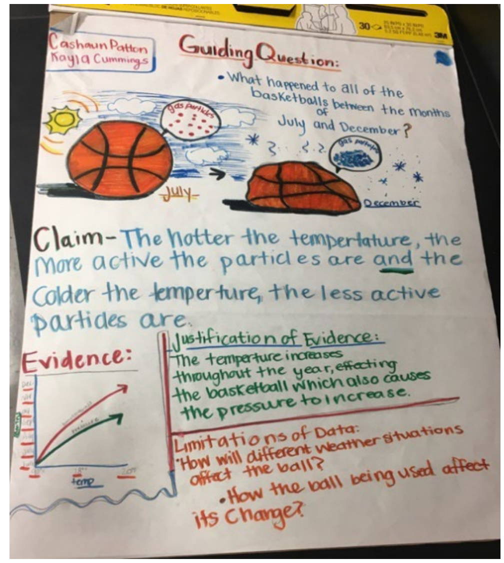
- NetLogo Heat Box Link: http://netlogoweb.org/launch#http://netlogoweb.org/assets/modelslib/Sample%20Models/Chemistry%20&%20Physics/GasLab/Unverified/GasLab%20Heat%20Box.nlogo
- NetLogo Isothermal Piston: https://ccl.northwestern.edu/netlogo/models/GasLabIsothermalPiston
- NetLogo has an option to either download the application or play online. For play online, google chrome works best.
- If links above are not working, go to: http://netlogoweb.org/
- From the above link, the students will be able to select "Runs in Your Brower" which will open the simulation. The students may have to search the Models Library to find the correct simulation. The links above can be found by searching "Heat Box" and "Isothermal Piston."

Example of Students' Work

Students' Posters







Name: ______________________________________ **Block:** ______

Gas Laws – Lab Packet

Initial Individual Model of Basketball

Anchoring Event: The East High basketball team has spent the whole summer conditioning, but they took several months off before the season got started. The last time the team actually got to practice using the basketballs was July. When they went to go get the basketballs out of the locker room in December, they found that every single ball was flat.
Guiding Question: **What happened to all of the basketballs between the months of July and December?**

Step 1. Describe your answer to the problem/question above. Write at least 3 sentences!

-
-
-

Step 2. Draw an image of what is happening to the basketballs between July and December. If you don't know where to start, then **draw a basketball!**

Be sure to include:

- **Labels for any big ideas occurring**
- **Visible and invisible(zoom-in) processes occurring to the basketball**

Guided Notes:

Review - The 3 states of matter are ________________ → ________________ → __________________.

The **Kinetic Molecular Theory** says that…

_______________ will have the highest energy, move at the fastest speed, and have the largest amount of space between molecules.

Throughout this lab, we will be using mathematical models to explain the behavior of gases. We will be investigating how the following factors will affect the behavior of gas molecules…

Pressure (P) =

Units:

1 atm (__________________) = 760 mm Hg (__________________)= 101.325 kPa (__________________)

Volume (V) =

Units:

Temperature (T) =

Units:

TEMPERATURE MUST BE IN KELVIN!

To find degrees Kelvin, add 273 to the Celsius temperature.

°C + 273 = K

We will be using the following laws to determine the relationship between each factor, pressure, volume, and temperature…

Gay Lussac's Law –

Boyle's Law –

Charles' Law -

A **direct relationship** between variables means that the variables are positively correlated. An **indirect relationship** between variables means that variables are negatively correlated.

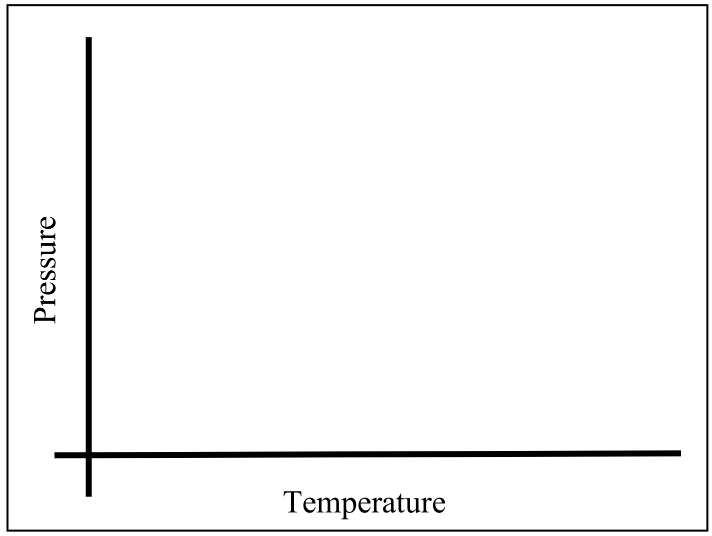
Investigation #1 – Gay Lussac's Law

Heatbox Netlogo Lab

Objective: after completing this investigation, students will be able to describe the relationship between **temperature** and **pressure**.

Instructions: Record your data for the average particle energy, the sum of the force on the walls (the pressure), and the wall hits per particle per tick at 5 different temperatures of your choosing. Create a line graph by plotting the temperature and each corresponding pressure at the 5 different readings.

Temperature	**Ave. Particle Energy**	**Sum of Force on Walls (Pressure)**	**Wall hits per particle per tick**



1. What pattern did you observe between the **pressure** or the **sum of force on the walls** from the gas particles and the **temperature** of the system?

2. What did you notice about the **average particle speed** and the **average particle energy** as the **temperature** of the system was increased?

3. What happened to the **pressure** of the system as the **temperature** was increased? Using your response to question 2, explain why you think the pressure changed with the temperature.

Your Claim:

As the **temperature** of a gas _______, the **pressure** of the gas will _______, if the volume is held constant. This represents a(n) direct/indirect relationship. (circle one)

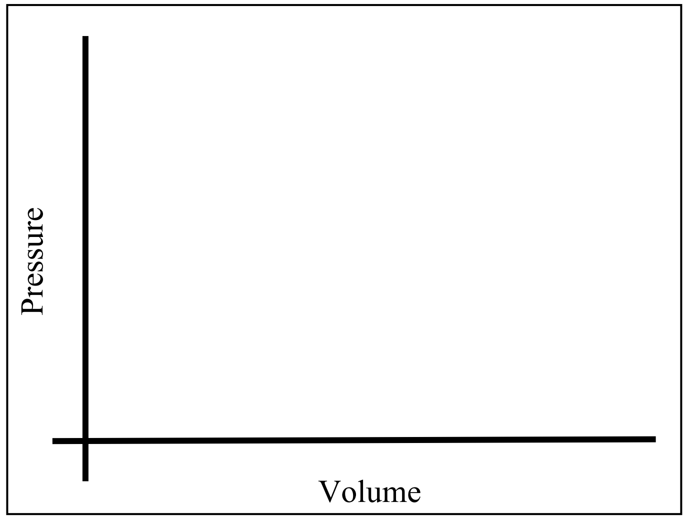
Investigation #2 – Boyle's Law

Isothermal Piston Netlogo Lab

Objective: after completing this investigation, students will be able to describe the relationship between **volume** and **pressure**.

Instructions: Collect data on the pressure of the gas from moving the piston to 5 different positions. To move the piston select "**Move Piston**", then click anywhere on the outside of the box to change the piston position.

Piston Position (Volume)	**Pressure**



1. Looking at your data, what pattern did you observe between the **volume** of the system and the **pressure** of the system?

2. Move the piston position close to -30 and start your model. After 10 seconds, move the piston close to +30. Describe the motion of the molecules as the volume of the system increased.

3. What happened to the **pressure** of the system when the **volume** was decreased? Why did this happen? (Hint: think about the definition of pressure from Gas Laws – Day 2 Notes).

Your Claim:

As the **volume** of a gas _____, the **pressure** of the gas will _____, if the temperature is held constant.
This represents a(n) direct/indirect relationship. (circle one)

Investigation #3 – Charles' Law

Glass Syringe Phenomenon

Objective: after completing this investigation, students will be able to describe the relationship between **temperature** and **volume**.

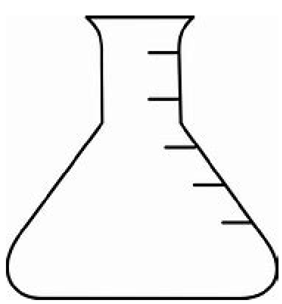
Instructions: Observe what happens to the glass syringe while the Erlenmeyer Flask is being held.

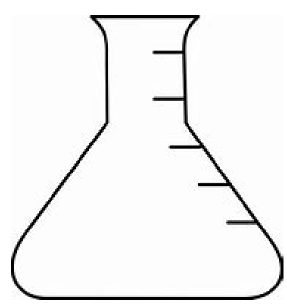
1. What is happening to the glass syringe the longer that the Erlenmeyer Flask is held? Why do you think this is happening?

2. What happens to the **motion** and **energy** of gas molecules as the **temperature** of a system is increased?

3. How does the **volume** of a system change based on the **temperature** of the system? Use your response to question 2 to explain why this happens.

4. Draw a model of what is happening inside of the Erlenmeyer Flask over time. Include a drawing of the glass syringe and how the gas molecules are moving.





Your Claim:

As the **temperature** of a gas _____, the **volume** of the gas will ____, if the pressure is held constant. This represents a(n) direct/indirect relationship. (circle one)

Anchoring Event Revisions

Evaluate your Model:

Using any new information you have received and the feedback given on your **Labs** and your **Day 1 and Day 2 Exit Tickets**, describe the modifications you would make to your initial claim and anchoring event model to more accurately describe what is happening to the basketballs between the months of July and December.

In your groups, respond to each of the following prompts before creating a revised version of your anchoring event model.

- *Revise Part of an Idea*: We think that (**evidence from investigation/demonstration**) supports part of our model, but we would like to change ____ to make it more accurate.

- *Add a New Idea*: We think that (**evidence from investigation/demonstration**) supports our model, but it also tells us that ____ should be added to make it more accurate.

- *Remove or Find Out More*: We think that (**evidence from investigation/demonstration**) contradicts ____ in our original model, and that we need to remove or find out more about it.

- *Questions*: We still have questions about ____.

Argument Graphic Organizer

Group Members:	
Guiding Question:	
Claim:	
Evidence:	**Justification of Evidence (using chemistry concepts):**
Limitations of the Data:	

Argumentation Session:

Group 1 Comments:

1. How does this group's claim and model differ from your group's model?
2. How could this group's argument be made more accurate?

Group 2 Comments:

1. How does this group's claim and model differ from your group's model?
2. How could this group's argument be made more accurate?

After visiting 2 other groups, return to your speaker(s). Review the comments your model received. Determine if you agree or disagree with the changes and revise your model as necessary. Once your claim and model have been revised, revisit the above table to match your group's final explanation of the anchoring event.

Name: ______________________________________ **Block:** ______

Gas Laws – Day 1 Exit Ticket

1. What **evidence** did you collect from the Heat Box investigation that will help you refine your model of the anchoring event? Be specific.

2. What **evidence** did you collect from the Bounce Test that will help you refine your model of the anchoring event? Be specific.

3. Is the relationship between the temperature and the pressure of a gas a **direct** relationship or an **indirect** relationship? In other words, as the temperature increases, does the pressure also increase (direct) or does it move in the opposite direction and decrease (indirect)? Explain why you think this happens.

Name: ____ **Block:** ____________

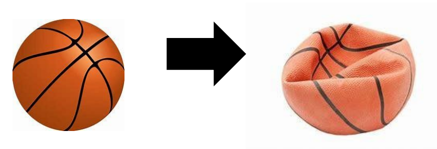
Gas Laws – Day 2 Exit Ticket

1. What **evidence** did you collect from the Isothermal Piston investigation that will help you refine your model of the anchoring event? Be specific.

2. What **evidence** did you collect from the Glass Syringe demonstration that will help you refine your model of the anchoring event? Be specific.

Name: ______________________________________ Block: ______

Anchoring Event Explanatory Model



?

Your task - Each student in the group will write a final report explaining the **seen** and **unseen** events occurring throughout the anchoring event. Your final report should include the following:

Paragraph 1: Introduction.

1. What was the guiding question you were investigating?

Paragraph 2: Initial Explanation of Anchoring Event.

2. What was your group's initial explanation of the anchoring event?
    a. What was your claim for the guiding question?
    b. What was your evidence?
    c. What was the justification?

Paragraph 3: Final Revised Explanation of the Anchoring Event.

3. What was your group's final claim or answer to the guiding question?
4. What evidence did you use from labs, demonstrations, or discussions to support your final claim?
    a. How did you determine what was happening?
    b. How did you collect data? What data did you collect?
    c. What patterns did you notice in the data?

*Use at least **2 pieces** of evidence to defend or prove your claim!
(Evidence = data table, graph, picture, personal experience)

5. What is your justification for why your evidence is significant in explaining the anchoring event?

Paragraph 4: Conclusion.

6. What did you revise, modify, or change about your initial claim and model of the anchoring event?
7. What did other students ask or say about your model?
8. What major chemistry concept was being investigated in the anchoring event?

Use your Gas Laws lab packet along with your group's poster and argumentation table to complete each paragraph. Use the proper scientific terms listed below to explain why the basketballs became flat between July and December.

Word Bank		
Pressure	Temperature	Volume
Motion	Collisions	Energy
Kinetic Molecular Theory	Direct/Indirect Relationship	

Final Explanatory Model Rubric	Yes	No	Score
1. Did the author (you!) state the **guiding question**?			/5
2. Did the author describe the **initial explanation** or the initial ideas for the anchoring event?			/10
3. For the **final explanation**, did the author provide a claim that answers the guiding question?			/10
4. Did the author include high-quality **evidence** in his/her argument? **(Use 2 different pieces of evidence to defend your claim)**			/10
5. Did the author present the evidence in an appropriate manner by using a correctly formatted and labeled graph or table?			/5
6. Is the claim consistent with the evidence?			/5
7. Did the author include a **justification** of the evidence that explains why the evidence is important or how it proves the claim?			/5
8. Did the author include the correct underlying science concepts relating to the represented gas laws?			/5
9. Did the author use scientific terms correctly? (ex: data, evidence, observations, pressure, volume, temperature)?			/5
10. Did the author discuss how well his/her claim agrees with the claims made by other groups and explain any disagreements?			/5
11. Group Presentation Score			/10
	Total Score		**/75**

Catalyst Sheet:

DATE:	READINESS CHECK:
QUESTION (write the prompt or question here):	○ Pencil ○ Paper ○ Assignment(s) Turned In ○ Phone Away
RESPONSE (write your response here):	

DATE:	READINESS CHECK:
QUESTION (write the prompt or question here):	○ Pencil ○ Paper ○ Assignment(s) Turned In ○ Phone Away
RESPONSE (write your response here):	

DATE:	READINESS CHECK:
QUESTION (write the prompt or question here):	○ Pencil ○ Paper ○ Assignment(s) Turned In ○ Phone Away
RESPONSE (write your response here):	

GAS LAWS

WELCOME, STUDENTS!

INSTRUCTIONS

On the second page of your packet, describe and draw your answer to the following problem...

The East High basketball team has spent the whole summer conditioning, but they took several months off before the season got started. The last time the team actually got to practice using the basketballs was July. When they went to go get the basketballs out of the locker room in December, they found that every single ball was flat.

What happened to all of the basketballs between the months of July and December?

REVIEW

The three states of matter are

Solid

Liquid

Gas

KINETIC MOLECULAR THEORY

The Kinetic Molecular Theory says that the average energy of molecules is related to the temperature.
Increasing the temperature of molecules cause an increase in the energy and motion of the molecules.

GASES will have the highest energy, move at the fastest speed, and have the largest amount of space between molecules.

PRESSURE

Force per unit area →
Amount of collisions between gas particles and the walls of a container

Units:
1 atm (Atmospheres) =
760 mm Hg (millimeters of Mercury)=
101.325 kPa (kiloPascals)

VOLUME

The amount of space occupied by a sample of matter.

Units:
mL

TEMPERATURE

The measure of the average kinetic energy of particles in matter.

Units:
Must be in kelvin!
Degrees Celsius + 273= Degrees Kelvin

THE GAS LAWS

Gay Lussac's Law

Describes the relationship between temperature and pressure.

Boyle's Law

Describes the relationship between volume and pressure.

Charles' Law

Describes the relationship between temperature and volume

EXIT TICKET

What evidence did you collect from the Heat Box investigation that will help you understand the anchoring event?

What evidence did you collect from the bounce investigation that will help you understand the anchoring event?

Is the relationship between the temperature and the pressure of a gas a direct or indirect relationship?

EXIT TICKET

What evidence did you collect from the Isothermal Piston investigation that will help you understand the anchoring event?

What evidence did you collect from the glass syringe that will help you understand the anchoring event?

GLOWS

I appreciate how you...
I see you're thinking about...

GROWS

It would be more clear if...
I think you should change...because...