XPLORLABS | UL Research Institutes

MODEL INTERACTIONS OF ENERGY AND MATTER IN A GAS PHASE

A. MODELING GAS PARTICLES

1. What do you think ten (10) gas particles would look like if you could see them experiencing different conditions? Draw what you are thinking in the boxes below.

Modeling conventions:

Use ● to show particles
Longer arrows = more velocity

Use → to show movement
The rectangles represent the containers

Models:

High temperature

Low temperature

High volume

Low volume

High pressure

Low pressure

Margin for connections:

e.g. The temperature in the bedroom changed from low to high during overcharge.

2. Where are possible connections to the overcharged e-scooter system? Use the space in the right margin above to write notes about your initial thinking.

   The first one is done as an example: "The temperature changed from low to high when the e-scooter was overcharging." (See example in right margin)

B. IDEAL GAS PROPERTIES PHET SIMULATION

Setting Up the Simulation/Getting an Idea of Its Functionalities:

1. http://phet.colorado.edu/en/simulation/gas-properties
2. Select **Ideal Simulation**
3. Hold Constant: **Volume**
4. Raise, then lower the pump handle **once** for a pump of gas particles to be released into the container.

Describe your observations of all the particles' behaviors over time.

Within 1-2 seconds	Within 5-7 seconds	After 12 seconds

Now, observe only *one* particle. What is the **particle motion** like? Describe your observations.

Does the particle stay at a constant speed?	If not, what causes speed to change?	Does the particle move in the same direction?	If not, what causes direction to change?

Identify a pattern in the motion of the particle. Example: "One pattern I noticed is that collisions between two particles always speed up or slow down the particle." Your pattern:

____

Continue to explore the simulation. Manipulate different variables, observe outcomes, and practice clearing the container. Once you are confident in your ability to manipulate functions of the simulation, then continue with our inquiry.

C. SIMULATION AS E-SCOOTER SYSTEM

1. Reset the simulation, return settings to hold volume constant
2. Click + Particles
3. Click the right double arrow twice for 100 heavy particles to be pumped in the container
4. Observe the particles while pressure stabilizes

Once stabilized: Record the pressure range: ______atm - ______atm

5. Reset the simulation, return settings to hold volume constant
6. Return to the + Particles box
7. Click for "heavy species" to reach zero (0), and "light species" to reach 100

Once stabilized: Record the pressure range: ______atm - ______atm

Pause for Sense-Making

1. Which particle had more mass? ____________ Which particle had less mass? _______________
2. How does the mass of the particles seem to affect its speed? ____________________________
3. How does the mass of the particles affect the pressure of the container? __________________
4. How do these observations inform how and what you are thinking about the room where the e-scooter overcharged? Explain one to two connections you can make from the simulation to the e-scooter situation.

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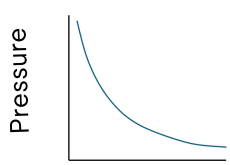
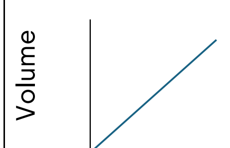
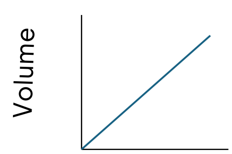
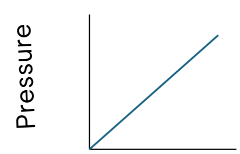
5. Take a moment to think about the components of the system where the e-scooter overcharged before the window blew out. Consider each of the following:

What would be the boundaries of this system?	What are the components within this boundary?	What types of matter and energy are input to this system?	What types of matter and energy are outputs of the system?

D. GAS LAWS

Scientific laws are statements based on repeated observations that can be used to predict outcomes in different situations of a physical system. **Gas laws,** like any scientific law, are statements that can be used to anticipate outcomes and values when particles in a gaseous phases experience different situations, like changes in the amount of gas, temperature, volume, or pressure.

Understanding gas laws can help us make connections to what we observed in our overcharged e-scooter system. Outlined below are explanations for three fundamental gas laws:

Boyle's Law	Charles's Law	Avogadro's Law	Gay-Lussac's Law
If temperature and number of molecules remain constant, then as volume increases, pressure decreases.	If pressure and number of molecules remain constant, then as temperature increases, volume also increases.	If temperature and pressure remain constant, then as number of molecules (moles) increases, volume also increases.	If volume and number of molecules remain constant, then as temperature increases, pressure also increases.
Pressure and Volume  Volume	Volume and Temperature  Temperature	Volume and Moles  Moles	Pressure and Temperature  Temperature

Pause for Sense-Making

1. Which of these gas laws seems like it will be the most connected to what we observed in the overcharged e-scooter?

   ____

2. Why do you think this law has the best connection?

   ____

   ____

Setting Up the Simulation to Explore Gas Laws:

1. http://phet.colorado.edu/en/simulation/gas-properties
2. Select Ideal Simulation

BOYLE'S LAW

Since Boyle's Law deals with pressure and volume, temperature must be constant. Therefore, *Hold Constant: Temperature*

3. + Particles
4. Click to set heavy particles at 200, and light particles at 0
5. Use the handle on the left to change the volume of the container.

What happens to the pressure as the volume changes? ____

As the volume goes______________ the pressure goes____________________.

This is a(n) ______________________ relationship.

Model the interactions of matter (use ●) and energy (use →) that represent Boyle's Law. Label the variables below each box.

Further investigate these properties by changing the number of "species," volume, and pressure. What combination do you need to blow off the top?

____

Would this be possible in the overcharged e-scooter system? _______ Explain your thinking:

____

CHARLES'S LAW

Since Charles's Law deals with temperature and volume, _____________must be constant.

3. Therefore, *Hold Constant: ______________,* Pressure ↕V
4. + Particles
5. Click for "heavy species" at 200, and "light species" to 0
6. Use the hot/cold slider on the bucket at the bottom to add thermal energy to the container

Note: For this simulation you have to put the "species" in the container BEFORE you set the constant parameter.

What happens to the volume as the temperature changes? _________________________

As the temperature goes_____________ the volume goes___________________.

This is a(n) _____________________ relationship.

Model the interactions of matter (use ●) and energy (use →) that represent Charles' s Law. Label the variables below each box.

Further investigate these properties by changing the temperature and volume. What combination do you need to blow off the top?

____

Would this be possible in the overcharged e-scooter system? _______ Explain your thinking:

____

AVOGADRO'S LAW

Since Avogadro's Law deals with pressure and temperature, _____________must be constant.

3. Therefore, *Hold Constant:* ______________, Pressure ↕T
4. + Particles
5. Click for "heavy species" at 200, and "light species" to 0
6. Use the hot/cold slider on the bucket at the bottom to add thermal energy to the container

What happens to the pressure as the temperature changes? _________________________

As the temperature goes______________ the pressure goes___________________.

This is a(n) _____________________ relationship.

Model the interactions of matter (use ●) and energy (use →) that represent Avogadro' s Law. Label the variables below each box.

Further investigate these properties by changing the number of "species," temperature, and pressure. What combination do you need to blow off the top?

____

Would this be possible in the overcharged e-scooter system? _______ Explain your thinking:

____

GAY-LUSSAC'S LAW

Since Gay-Lussac's Law deals with ____________and ______________, _____________must be constant.

3. Therefore, *Hold Constant*: Volume
4. Then, use the hot/cold slider on the bucket at the bottom to add thermal energy to the container.
5. + Particles
6. Click for "heavy species" at 200, and "light species" to 0

What happens to the pressure as the temperature changes? __________________________

As the temperature goes______________ the pressure goes___________________. This is a(n) _____________________ relationship.

Model the interactions of matter (use ●) and energy (use →) that represent Avogadro's Law. Label the variables below each box.

Further investigate these properties by changing number of particles, temperature, and pressure. What combination do you need to blow off the top?

____

Would this be possible in the overcharged e-scooter system? _______ Explain your thinking:

____