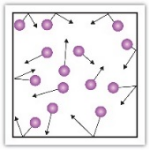
An Investigation of Gas Laws
(Inquiry & Particle Diagrams)

Name_____
Partner_____

Kinetic Molecular Theory of Gases (KMT of Gases):

- All gases consist of particles (atoms and molecules) that are in constant random motion.
- Gas particles are constantly colliding with each other and the walls of a container.
- The average kinetic energy of molecules is proportional to temperature.



Pressure: Pressure is defined as the force (or "push") per unit area. **Pressure** $= \frac{Force}{area}$

- Gas particles exert pressure on a container wall by colliding with the wall.

Directions: *Watch demonstration/video of each scenario. Use the PhET simulation called, "Gas Properties" to help visualize molecules. For each scenario, draw representations of gas particles by using a "●" for each particle. If temperature changes, use shorter arrows (→) and longer arrows (⟶) to show slower and faster speeds of molecules. Explanations should use concepts of KMT and pressure. Key terms to use are particles, collisions, frequent, and forceful. (After you finish a scenario with the PhET, hit "reset" before starting another.)*

1) **Pressure vs. moles (constant volume and temperature): Air is pumped into a ball.**
   - Demo: Observe how pressure changes when air is pumped into a soccer/basketball. *(Assume the volume of the ball stays completely constant even though in reality it increases slightly.)*
   - Use PhET: Set constant parameter to volume. Pump in some particles and let pressure stabilize. Now, pump in more particles and observe pressure.

Ball with some particles (Draw 4 particles)	Ball with more particles (Draw 8 particles)	When moles of air increases, the pressure inside ball _____ because….

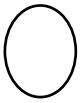
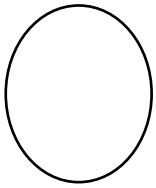
2) **Pressure vs. Temperature (constant moles and volume): Rigid, sealed bulb placed in hot water.**
   - Demo: Observe how the pressure changes when a rigid, sealed bulb connected to a pressure gauge is immersed into boiling water.
   - Use PhET: Set constant parameter to volume. Pump in some particles. Add heat. Observe pressure.

Rigid bulb with air. (Draw 4 particles)	Temperature is increased.	When temperature increased, the pressure inside bulb_____ because….

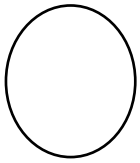
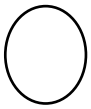
3) **Pressure vs. Volume (constant moles and temp): Plunger of syringe filled with air is pushed in.**
   - Demo: Remove cap of syringe and fill syringe with air to 60 mL mark. Put cap back on. Push down on plunger of syringe so that the volume of air inside the syringe decreases.
   - Use PhET: Set constant parameter to temp. Pump in some particles. Wait for pressure to stabilize. Slide "handle" to right to decrease volume. Wait for temperature to return to initial temp. Observe P

Syringe filled with air (Draw 4 particles.)	Volume is decreased.	When volume decreased, the pressure inside the syringe _____ because….

4) **Volume vs. moles (constant pressure and temperature): Air is blown into a balloon.**
   - Procedure: Observe how the volume of a balloon changes when air is blown into balloon under constant atmospheric pressure.
   - Use PhET. Set constant parameter to "none". Pump in some particles and let pressure stabilize. Now, change constant parameter to pressure. Add one "pump" of air. Observe volume.

Balloon with "4" particles inside and "4" particles outside.	Balloon with "8" particles inside and still "4" particles outside.	When moles increased inside balloon, the volume of the balloon _____ because….
		

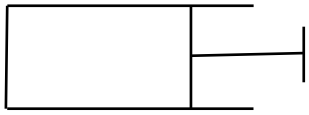
5) **Volume vs. temperature (constant pressure and moles): Liquid nitrogen is poured onto balloon**
   - Video Clip: Watch the 45 sec video clip called, "Liquid Nitrogen on a balloon." Observe how the volume of a balloon changes when liquid nitrogen is poured onto the sealed balloon.
   - Use PhET. Set constant parameter to "none". Manually set # particles to 200. Let pressure stabilize. Change constant parameter to pressure. Slowly remove heat. Observe volume.

Balloon with "4" particles inside and "4" particles outside.	Temperature inside balloon is decreased.	When temperature decreased, the volume of the balloon _____ because….
		

6) **Moles vs. Temperature(constant volume and pressure): Air pumped into rigid bulb, keeping P constant**
   - Imagine: Suppose air is pumped into a rigid bulb connected to a pressure gauge. How would the temperature need to be changed to keep the pressure constant? _____
   - Use PhET: Set constant parameter to vol. Pump in some particles and let pressure stabilize. Pump in more particles and add/remove heat to keep pressure constant.

Rigid bulb with "4" particles of air at room temperature	Rigid bulb with "8" particles and _____ temperature (same P)	When moles of particles increased, the temperature needed to be _____ to keep the pressure constant. This is because….
		

7) **Apply your understanding:** Obtain a syringe, remove the cap and push the plunger all the way in so that all air is removed. Put cap back on. Pull the plunger part way out. In diagram, draw particles to represent what is inside and outside the syringe. (Assume the cap has a perfect seal.)

	Why is it so difficult to pull out the plunger?

8) **For fun:** Remove cap and plunger of syringe. Put a mini-marshmallow inside syringe. With cap still off, push plunger all the way in until it barely touches marshmallow. Put on cap and pull plunger out. What happens to marshmallow?_____ Why?