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# K-12 Partnership Lesson Plan

# *Gases Matter*

# *Helping students understand the properties and importance of gases*

## Overview

When understanding the states of matter, students often are able to understand those states they can see and work with the easiest (liquids and solids), and they are less able to reason about gases (and even less able to reason about plasma and Bose-Einstein Condensates: see <http://www.chem4kids.com/files/matter_states.html> for a more complete description of all the states). Gas is all around us, but most students don’t think it weighs anything or matters very much. This exercise is designed to help students realize that gas has mass, and that the gas can add up and affect how the world works. We will weigh a balloon empty and full to see how the gas weighs something. We will watch a glass of soda lose mass as the bubbles leave the pop. We will then compare the temperature within two clear containers (one with classroom air, and the other with the breath of a student) that are placed in the sun to see how particular gases (in this case carbon dioxide) can change the environment.



**Objectives**

At the conclusion of the lesson, students will be able to:

* Recognize that matter in the gas phase has weight
* Describe how there can be different types of gases that can act differently (just like there are different types of liquids or solids)
* Understand that even though we can’t see air, it is still all around us.
* Operate a scale or balance to measure the weight of an object
* Operate a thermometer to measure the temperature

**Length of Lesson**

2- class periods (30-45 minutes each)

**Grade Levels**

Elementary School (see adaptations for upper and lower elementary throughout the lesson)

**Standards covered**

Doing Science

* S.IP.07.15 Construct charts and graphs from data and observations.
* Pretty much all the inquiry standards

Measurement

* S.IP.07.13 Use tools and equipment (spring scales, stop watches, meter sticks and tapes, models, hand lens, thermometer, models, sieves, microscopes, hot plates, pH meters) appropriate to scientiﬁc investigations.
* P.PM.02.15 Compare the weight of objects using balances.
* S.IP.07.14 Use metric measurement devices in an investigation.
* P.PM.04.16 Measure the weight (spring scale) and mass (balances in grams or kilograms) of objects.

States of Matter and Properties of Matter

* P.PM.E.1 Physical Properties- All objects and substances have physical properties that can be measured.
* P.PM.E.2 States of Matter- Matter exists in several different states: solids, liquids and gases. Each state of matter has unique physical properties. Gases are easily compressed but liquids and solids do not compress easily. Solids have their own particular shapes, but liquids and gases take the shape of the container.
* K-7 Standard P.PM: Develop an understanding that all matter has observable attributes with physical and chemical properties that are described, measured, and compared. Understand that states of matter exist as solid, liquid, or gas; and have physical and chemical properties. Understand all matter is composed of combinations of elements, which are organized by common attributes and characteristics on the Periodic Table. Understand that substances can be classified as mixtures or compounds and according to their physical and chemical properties.
* P.PM.E.1 Physical Properties- All objects and substances have physical properties that can be measured.
* P.PM.E.2 States of Matter- Matter exists in several different states: solids, liquids, and gases. Each state of matter has unique physical properties. Gases are easily compressed, but liquids and solids do not compress easily. Solids have their own particular shapes, but liquids and gases take the shape of the container.
* P.PM.04.23 Compare and contrast the states (solids, liquids, gases) of matter.

**Materials**

* One balloon for each child, with a loop of scotch tape for each
* One scale for each pair or group of children (that will weigh up to 200g or 400g)
* A cup for each group
* ½ cup of soda for each group (dispense immediately before placing on the scales)
* At least two plastic containers that form an air tight seal
* One thermometer for each plastic container that can be read without opening the container.

**Background**

The gas phase is one of the hardest phases for students to conceptually grasp. Because they can’t see gases, it is harder for students to give much thought to what gases are made of. Many times they think that when liquids evaporate, they disappear. This lesson is designed to help students have more hands on experiences with gases at a simple level that will help them build a foundation for greater understanding when they are in middle and high school. The main ideas for you to communicate to your students are:

1. Gases have mass;
2. Even though gases don’t weigh much, there is so much gas that it adds up to a lot; and
3. Different gases act differently and have different properties.

### Activities of the session

1. Hand out the student worksheet. Notice that there is an advanced (upper elementary) and introductory (lower elementary) version at the end of this document. Feel free to adjust these to fit the needs of your students.
2. Depending on the age and level of the students, you can remind students about the states of matter: liquids, gases, and solids. Plasma and BE Condensates are also states of matter, but are generally beyond the level of elementary students. For students who haven’t learned the states of matter, you can have the students act out the states of matter.
	1. Put a string circle on the floor, in the middle of an open area (This should be large enough for all students to stand in without crowding.)
	2. Have the whole class stand up and explain that they are now going to "become" molecules. Explain that warm molecules are very active and spread out away from other molecules. Have them spread out and "bounce." Explain that molecules which bounce all over are a gas.
	3. Ask if they've ever seen children "huddle" on the playground on a very cold day. Molecules do the same thing. They slow down and move closer together when they are cold. Ask the students to come into the circle and to huddle close together. They should then "freeze". When molecules get cold enough they freeze, although that does not mean they are totally without motion, even as the children will not be totally without motion. Ask if they can think of an example of something "frozen" (ice). Explain that this is a solid.
	4. Molecules are sometimes in between. We call this state liquid. They spread out a little bit, but they stay inside their container. Have the students bounce slightly and push apart but stay inside the circle. Ask for an example of a liquid (water).
	5. Have them get back in their huddle, very still and "cold." Then have them "warm up" gradually, staying in the circle. Then have them warm up more, and explain that they can now float up over the string because they are a "gas." Ask what would happen if they were even "hotter" (they would spread out even more).
	6. Now you are ready for some exercise. Using the cues Hot, Warm, Cold, etc, or Solid, Liquid, Gas, have them show by their actions what the molecules would do in that state.
3. Ask the students to describe the properties of a gas…how do they know something is a gas and not a solid or liquid?
4. Have the students brainstorm a list of the gases that they know of in their everyday life. This will probably include farts, burps, breathing, car exhaust, helium balloons, gas at the dentist, air in tires, the atmosphere, etc. Try to encourage kids to think of ideas (or ask their parents for ideas). This could be used as a warm up or a take home activity.
5. At this point, have a volunteer exhale into a clear airtight container that has a thermometer in it, closing the lid immediately after the student breaths into the container. Explain to the class that this student is breathing out gases, including carbon dioxide. Fill another airtight container (with a thermometer) with regular classroom air and shut the lid. Label both containers as normal air and student breath (carbon dioxide). Have the students record the starting temperature on each of the thermometers on their worksheet. If you have enough containers and thermometers, it would be good to replicate the containers so you have at least two of each type. Place these containers in either direct sunlight or under a lamp. Let them sit out there till you reach part 13. 
6. Give each group their own balance or scale. Remind the students of the proper way to use a scale and how to be careful with the scales. Next have the students look at a blown up balloon and an empty balloon. Working with a partner, have each student weigh their balloon with a loop of scotch tape (this will be used to help the students weigh the balloon once it’s blown up). **Make sure they write the weight on their worksheet.** Have the students make a prediction on their paper: either they think the balloon will weigh more, less, or the same when it is blown up. Now have all the students blow up the balloons. (Note: many students may have trouble blowing up or tying a balloon, so assist as necessary). The students should now weigh their balloons using their loop of scotch tape to assist in getting the balloon to stay on the scale. Record this weight on their worksheets.
7. Next have the students share what happened to their balloons. The balloons should have gained mass (since air does weigh a little bit), but it may not have gained any if the scale isn’t sensitive enough to register that small of a gain (since it is a very small amount). It also may not have gained much if the students were having trouble getting the balloon to stay on the scale. If you worry that your students may have too much trouble with this, have them practice or repeat their measurement several times. You can also make a “balance” with a ruler, string, and the balloons (see <http://ec.gc.ca/meteoaloeil-skywatchers/default.asp?lang=En&n=B1BF9523-1> for instructions) if you don’t have balances that will work for this activity.

 

Ask the students where the weight in the blown up balloon came from. Most students know that they breathed in air, but they don’t think much about the air. Make sure that you emphasize that the air we breath is called a “gas” and that even though we can’t see gases, they are all around us. The gas in the balloon is a mixture of gases, including carbon dioxide, oxygen, and nitrogen.

1. If you have older students, have them calculate the air they exhale in one year (based on the weight of the balloon). Or you can work through the calculation as a class. See the advanced student worksheet for calculations. Emphasize here that even though your balloon doesn’t weigh much, it adds up to a lot over a year.
2. Next talk about how cows don’t just breath, they also fart and burp a LOT. Each produces about 300 liters of gas a day. For advanced kids, you can have them calculate how much gas is produced by all the cows in the world (all 1.5 billion of them).

(if you have to do this in two class periods, this is a good stopping point).

1. Soda pop exploration: Ask the students if any of them drink pop or soda. Ask the students what makes pop different than water. Ask them to then predict what will happen to the weight of the can of soda when we open the can or pour the soda into a cup and let the bubbles escape.
2. Each group should still have their own balance/scale. Each group will also either need their own can of pop or a cup to pour the pop into from a larger class container. Immediately upon pouring or opening the pop, the students should record a starting weight for the pop. They can use the chart in the worksheet to record their data. The students can all have their own type of pop, or the students can all have the same types of pop. Note that each type of pop will have different amounts of carbon dioxide in it (and will produce slightly different weight changes). Also, make sure the pop is at room temperature (NOT COLD) so there isn’t condensation building up on the outside of the cups. Have the students record the weight of the pop at one minute intervals for 10 minutes. For more advanced students, have them graph the weight over time.
3. Have the students share with the class what happened with their pop. Talk about how the pop lost bubbles of carbon dioxide to the atmosphere, and thus lost the weight of the carbon dioxide. For further reading on soda pop, see <http://www.science-house.org/index.php/component/content/article/142-how-much-carbon-dioxide-is-in-a-bottle-of-soda>
4. Return to the idea that even though there might have only been a little bit of carbon dioxide lost from the soda, since we drink so much soda, it adds up to a lot of carbon dioxide over time. Advanced students can multiply consider how many cans of soda everyone in America drinks in a year (see advanced worksheet).
5. Remind students that the gas in the pop was carbon dioxide, and also that they breathed out carbon dioxide into the balloons. Explain that there are many gases in the atmosphere, and that air is a mixture of gases like nitrogen, oxygen, and carbon dioxide. The mixture of gases that exist in the atmosphere can change how the atmosphere acts. Returning to the containers you filled up in part 4, remove them from the direct sunlight or under the lamp.
6. Remind the students that one of the containers has regular air, and the other is full of carbon dioxide from one of the students. Have the students read the thermometers and record the data in their worksheet. If the experiment has gone well, both of the containers should have increased in temperature, and the one with carbon dioxide should have increased a bit more than the one with regular classroom air. This is one way of illustrating how our atmosphere is changing because of the greenhouse gas, carbon dioxide. For younger students, it may be enough to explain that different gases act differently or have different properties just like different solids or liquids do. For more advanced students, this is a nice way of getting them to start thinking about things like climate change and greenhouse gases.
7. As an extension, Futurama has a nice cartoon that was featured in “An Inconvenient Truth” that explains things fairly clearly in a way kids can understand. <http://www.youtube.com/watch?v=OqVyRa1iuMc> The Magic School Bus also has a nice book “The Magic School Bus and the Climate Challenge.”
8. As a wrap up, remind kids that
	1. gases have mass;
	2. Even though gases don’t weigh much, there is so much gas that it adds up to a lot; and
	3. Different gases act differently and have different properties.

**Resources**

* [http://www.amazon.com/The-Magic-School-Climate-Challenge/dp/0590108263/ref=pd\_sim\_sbs\_b\_3](http://www.amazon.com/The-Magic-School-Climate-Challenge/dp/0590108263/ref%3Dpd_sim_sbs_b_3)
* <http://www.epa.gov/climatechange/kids/>

**Extensions and Modifications**

There are many places were this could be modified. There is already a regular and advanced worksheet. All of the explorations/experiments can be done in small groups or as a class depending on the level of the students. The math contained in the worksheet can also be simplified depending on the level of the students.

Extension to get over the idea that gas weighs less than liquids or solids…Have a glass jar with a balloon over the top, add a little water, stick it in the freezer. When frozen, take it out and have the class look at it. Weigh the jar and record the temperature. Have the students predict if the weight of the jar will change when the water changes from ice to water to gas. Let the jar adjust to room temperature so water is in liquid phase. Reweigh the jar and record the weight. Heat the jar so the water evaporates. Reweigh the jar carefully. Record all the weights, and discuss the results with the students. Did what happened match their predictions? Why or why not?

**Assessment**

You can collect the worksheet and evaluate based on the level of the students (an answer key is provided at the end of this document).

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Gases Matter! Student Worksheet Advanced

1. How do you know something is a gas? What are the properties of gases?
2. Where do you find gases in your life?
3. Prediction: If you blow up a balloon with air, do you think the weight of the balloon will:

Circle one: Decrease Stay the same Increase

1. Weigh your empty balloon with your piece of tape or cup. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_grams

Weigh your blown up balloon with your piece of tape or cup. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_grams

Weight of blown up balloon \_\_\_\_\_\_\_\_grams

– weight of empty balloon \_\_\_\_\_\_\_\_grams

= weight of air \_\_\_\_\_\_\_\_grams

1. How much air do you breath in a year?

\_\_\_\_\_\_\_\_g Weight of air x 28,800 breaths x 365 days =\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_g

Balloon breath day year year

1. How much methane gas do all the cows in the world fart or burp in a year?

1.5 billion cows x 300 liters of gas x 365 days =\_\_\_\_\_\_\_\_\_\_\_\_liters

 Cow-day year year

1. What is pop? How is it different than water?
2. Prediction: What do you think will happen to the weight of the pop can when we open it and let the bubbles out?

Circle one: Decrease Stay the same Increase

1. Record the weight of the soda pop in the chart below:

|  |  |
| --- | --- |
| Time (in Minutes) | Mass (in grams) |
| Start: 0 minutes |  |
| 1 |  |
| 2 |  |
| 3 |  |
| 4 |  |
| 5 |  |
| 6 |  |
| 7 |  |
| 8 |  |
| 9 |  |
| 10 |  |

1. Graph your results below:

 

1. Describe what happened to the soda pop. Did the soda lose or gain weight? Write your observations.

1. Prediction: What do you think will to the containers of air filled with classroom air and exhaled air when they are placed in the sun?
	1. The temperature will not change in the containers
	2. Both will increase in temperature the same amount
	3. The exhaled air will increase more
	4. The classroom air will increase more
2. For the containers of classroom air and exhaled air, record the beginning and end temperature of the containers here.

|  |  |  |
| --- | --- | --- |
| Type of Air | Classroom Air | Exhaled Air |
| Beginning Temperature |  |  |
| Ending Temperature |  |  |
| Difference (Ending-Beginning) |  |  |

1. Describe what happened in the containers when they were placed in the sun.

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Gases Matter! Student Worksheet Simple

1. How do you know something is a gas? What are the properties of gases?
2. Where do you find gases in your life?
3. Prediction: If you blow up a balloon with air, do you think the weight of the balloon will:

Circle one: Decrease Stay the same Increase

1. Weigh your empty balloon with your piece of tape or cup. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_grams

Weigh your blown up balloon with your piece of tape or cup. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_grams

Weight of blown up balloon \_\_\_\_\_\_\_\_grams

– weight of empty balloon \_\_\_\_\_\_\_\_grams

= weight of air \_\_\_\_\_\_\_\_grams

1. What is pop? How is it different than water?
2. Prediction: What do you think will happen to the weight of the pop can when we open it and let the bubbles out?

Circle one: Decrease Stay the same Increase

1. Record the weight of the soda pop in the chart below:

|  |  |
| --- | --- |
| Time (in Minutes) | Mass (in grams) |
| Start: 0 minutes |  |
| 1 |  |
| 2 |  |
| 3 |  |
| 4 |  |
| 5 |  |

1. Describe what happened to the soda pop. Did the soda lose or gain weight? Write your observations.

1. What do you think will to the containers of air filled with classroom air and exhaled air when they are placed in the sun?
	1. The temperature will not change in the containers
	2. Both will increase in temperature the same amount
	3. The exhaled air will increase more
	4. The classroom air will increase more
2. For the containers of classroom air and exhaled air, record the beginning and end temperature of the containers here.

|  |  |  |
| --- | --- | --- |
| Type of Air | Classroom Air | Exhaled Air |
| Beginning Temperature |  |  |
| Ending Temperature |  |  |
| Difference (Ending-Beginning) |  |  |

1. Describe what happened in the containers when they were placed in the sun.

Name: \_**ANSWER KEY**

Gases Matter! Student Worksheet Advanced

1. How do you know something is a gas? What are the properties of gases?

Gases fit the shapes of their containers, they are less dense than liquids or solids, they have more energy that liquids or gases, they are invisible, and the particles of a gas move around freely.

1. Where do you find gases in your life?

This likely will include things like steam, farts, burps, breathing, laughing gas (nitrous oxide), and other gases they may think of.

1. Prediction: If you blow up a balloon with air, do you think the weight of the balloon will:

Circle one: Decrease Stay the same Increase

There is no wrong or right answer, since it is a prediction. However, the balloon should gain mass during the experiment. Looking at this question can help you see what your students were thinking beforehand and you should have students reflect on their predictions.

1. Weigh your empty balloon with your piece of tape. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_grams

Weigh your blown up balloon with your piece of tape. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_grams

Weight of blown up balloon \_\_\_\_\_\_\_\_grams

– weight of empty balloon \_\_\_\_\_\_\_\_grams

= weight of air \_\_\_\_\_\_\_\_grams

The air should weight 0.1 to 1 gram (or so) depending on the size of your balloons.

1. How much air do you breath in a year?

\_\_\_\_\_\_\_\_g Weight of air x 28,800 breaths x 365 days =\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_g

Balloon breath day year year

1. How much methane gas do all the cows in the world fart or burp in a year?

1.5 billion cows x 300 liters of gas x 365 days =164.25 trillion liters

 Cow-day year year

1. What is pop? How is it different than water?

Pop contains water, sometimes caffeine, flavors, sweeteners, and carbonation (the water is infused with carbon dioxide).

1. Prediction: What do you think will happen to the weight of the pop can when we open it and let the bubbles out?

Circle one: Decrease Stay the same Increase

(Again, no right answer here since you want students to make a prediction, but students should compare their prediction with what happened and reflect upon what they have learned. They should eventually realize that the weight of the pop can should decrease since some of the mass is escaping as a gas).

1. Record the weight of the soda pop in the chart below: Results will vary by brand of soda and size of the container, but the soda should lose weight as the gases escape.

|  |  |
| --- | --- |
| Time (in Minutes) | Mass (in grams) |
| Start: 0 minutes |  |
| 1 |  |
| 2 |  |
| 3 |  |
| 4 |  |
| 5 |  |
| 6 |  |
| 7 |  |
| 8 |  |
| 9 |  |
| 10 |  |

1. Graph your results below:

 Make sure the students include labels and units for the axes, and have them use as much of the graph area as possible.

1. Describe what happened to the soda pop. Did the soda lose or gain weight? Write your observations.

The soda should have produced bubbles as the gas escaped. The soda should have lost weight as the gases left the soda. Students could describe the sound, size of bubbles, etc.

1. Prediction: What do you think will to the containers of air filled with classroom air and exhaled air when they are placed in the sun?
	1. The temperature will not change in the containers
	2. Both will increase in temperature the same amount
	3. The exhaled air will increase more
	4. The classroom air will increase more

Students should realize that the sun warms things up because of the solar energy radiating to earth. That’s why the earth is warmer during the day than at night. However, it is often harder for students to realize that different gases have different properties. They will have to connect the idea that you breath out carbon dioxide and that carbon dioxide is a greenhouse gas in order to realize that the exhaled air should warm up more than the regular classroom air.

1. For the containers of classroom air and exhaled air, record the beginning and end temperature of the containers here. Both containers should increase in temperature, though the exhaled air should increase more. If possible, do more than one replicate of each treatment.

|  |  |  |
| --- | --- | --- |
| Type of Air | Classroom Air | Exhaled Air |
| Beginning Temperature |  |  |
| Ending Temperature |  |  |
| Difference (Ending-Beginning) |  |  |

1. Describe what happened in the containers when they were placed in the sun.

Students should talk about the energy from the sun going into the containers (since the containers are clear), and the gases in the containers capture some of the energy. Because the exhaled air contains more of the greenhouse gas carbon dioxide, the exhaled air should capture more energy than the classroom air.