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University of California Berkeley

Applied Design Engineering Project Teams (ADEPT)

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Particle Party Balloons

Objective/Purpose:

Students will observe whether balloons filled with various gases float or sink in air, and measure volume and mass of the balloons to learn what it takes to make an object float. This module may be used alone, but is designed to be done in parallel with module 'Hot Air Balloons'.

Prep—Time: ~30 minutes

Lesson Time: ~120 minutes

Material List:

Per Student—

- Instructions and Data worksheet
- Graph paper
- Results and Questions worksheet

Per Group—

- 4-6 balloons, ideally color coded for each gas and with relatively small necks (5" decorative balloons work best)
- Flexible measuring tape (or string and a ruler)

Per Class

- Electronic balance
- String (to tie helium balloons)
- (ideally) Scale or force meter
- Gas sources (see below for suggestions on obtaining inexpensive gas supplies)
- Several CO2 bicycle pumps, preferably one for each gas obtained as a gas cartridge

Topic:

Properties of gases, density, buoyancy, periodic table

Grade Level: 7-9

Pre-Requisites:

Particle model of matter

- Know that matter, including gases, is made up of particles
- Know that gas particles are widely separated and not bound together like liquids or solids, but can be compressed into a smaller space.

Periodic table

- Able to locate element symbols, numbers, and masses in the periodic table
- Know that matter can consist of elements or compounds, which are combinations of 2 or more elements.

Density

- Some familiarity with the relative density of physical objects

Inquiry Skills

- ✍✍Able to use a graph to measure a dependent variable given a measurement of the independent variable

Lesson Process Summary:

✍Preparation For The Lesson

1. Acquire supplies. Some lead time is required, as many gas cartridges are available inexpensively through mail/internet order.
2. To save time during the class, it is helpful to fill helium balloons beforehand, tie them off, and store them in a bag until ready. Fill the He balloons so that half the balloons are large enough to float, and half are too small and sink. Be aware that the He balloons will deflate over time, so the best time to fill the balloons is immediately before class.

✍Initiating The Class

1. Warm-up: Use "Do Now" worksheet to introduce students to using the periodic table to calculate atomic mass, and to practice with the graph relating circumference of a balloon to its volume (PPB_DoNow_Introduction.doc)
2. Divide students into pairs.
3. Arranged in a circle or from the front of the class, introduce the lab. Begin by showing the students balloons filled with CO_2 and air, and ask them to predict what would happen if we let go (but don't demonstrate yet).
4. Demonstrate how to measure the circumference of a balloon using string and a ruler.
5. Introduce the second lab by inflating two helium balloons to different volumes, and again asking for prediction, but not demonstrating yet.
6. Pass out experiment worksheets (PPB_Experiment_Worksheet.doc). Instruct students to write down their predictions in the "Predict" section of their worksheets, and when they are done, to come fill a balloon with CO_2.

Gas Sources:

Small, inexpensive supplies of various gases may be found from a variety of sources. 12 and 16g cartridges will typically fill 2-4 small balloons:

He: Party stores, in many sizes
CO_2: 12g or 16g cartridges for filling bicycle tires or charging paintball guns (~$1-$2/cartridge)
Ar: 12g cartridges used for preserving open wine bottles (~$3/cartridge)
N_2: 12g cartridges available from brewers, used for pressurizing taps (~$1.5/cartridge)
NO_2: 8g cartridges used to whip cream (~$1/cartridge), though must be handled with care among students
Propane/Butane: On some camp stoves, the burner may be removed to leave a simple nozzle that can be used to fill a balloon. However, a larger balloon with neck held very tightly around the nozzle is required, and this is not a recommended gas to use for the test.

✍Procedure for Session

1. Distribute worksheets
2. Students write down predictions in the "Predict" portion of the worksheet.
3. As students are ready, step students through the process of filling balloons with CO_2:
   a. Weigh the empty balloon
   b. Weigh the pump before filling
   c. Fill the balloon
   d. Weigh the pump after filling

Note: This step is likely to be the main bottleneck in the lab, since a teacher should fill the balloons. Sharing balloons between groups or having a classroom assistant help with this step may help the lab go more smoothly.

4. Give students a balloon color-coded for air, and ask them to blow up the balloon to the same size as the CO_2-filled balloons.
5. Students perform volume measurements with string and ruler.
6. Students drop the air and CO_2 balloons at the same time, observing which sinks faster.
7. Students use periodic table to explain balloon behavior.
8. When part 1 of the lab is completed, students may be given one large and one small helium balloon, to perform volume measurements and observe behavior.
9. Students should try to explain the behavior of the helium balloons using the idea of part of the balloon being solid, and part of the balloon being a very light gas.
10. Help students who finish early fill balloons with more exotic gases, such as Argon, Nitrogen, Nitrous

Vocabulary:

- ✍ *Particle*
- ✍ *Element*
- ✍ *Compound*
- ✍ *Density*
- ✍ *Mass*
- ✍ *Volume*
- ✍ *Conservation of Mass*
- ✍ *Buoyancy*

CA Science and Math Standards:

ID those standards met by this module
http://www.cde.ca.gov/be/st/ss/index.asp

Grade 8: Science Standards
Structure of Matter
3.D Students know the states of matter (solid, liquid, gas) depend on molecular motion.
3.E Students know that in solids the atoms are closely locked in position and can only vibrate; in liquids the atoms and molecules are more loosely connected and can collide with and move past one another; and in gases the atoms and molecules are free to move independently, colliding frequently.

Density and Buoyancy
8.A Students know density is mass per unit volume.
8.B Students know how to calculate the density of substances (regular and irregular solids and liquids) from measurements of mass and volume.
8.C Students know the buoyant force on an object in a fluid is an upward force equal to the weight of the fluid the object has displaced.
8.D Students know how to predict whether an object will float or sink.

Investigation and Experimentation
9.C Distinguish between variable and controlled parameters in a test.

Oxide, or Propane (Argon and Nitrogen preferred).

Reflections

1. Provide students with graph paper marked with "Volume (cm^3)" on the x-axis and "Mass (g)" on the y-axis.
2. Either have students use their own measurements or distribute the measurement compilation (PPB_Graphing_Instructions.doc) to mark balloons on the graph using mass or volume. Tell students to use an 'o' to mark balloons that float, and an 'x' to mark balloons that sink.
3. As students finish, recommend three tasks for understanding the data:
4. Discuss the idea of both mass and volume affecting whether something floats. If students appear ready, introduce 'density = mass ? volume' as a way of combining mass and volume in a single measurement.
5. Perform a post-assessment. A suggested assessment, used as a mid-summative assessment when combined with the hot air balloons, presents two students building hot air balloons, one of which wants to make a balloon with small mass, the other with large volume, and asks students to explain if either student is correct, and why. See PPB_Mid_Sum_Quiz.doc

Note: We found that additional exercises were required to convince students that volume matters, and that it is the volume, not the mass, that helium or hot air adds to a balloon that makes it float. These exercises are described in 'Lesson Plan, Volume Extension.doc'