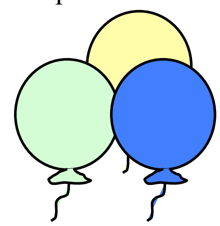
Chemistry Concept Challenge #5: Gases

It's a warm autumn day, and you're drinking some bottled water. You get in your car, drive home, and leave the capped, near-empty bottle on the passenger's seat. The next morning is a bit chilly, and you notice that your water bottle looks like it's been crushed. How can you explain this?



You buy a bunch of helium-filled balloons at the party store for your New Year's Eve party. But when you get them out to your car, they shrink and don't float as well as they did in the store. Should you go back inside and ask for a refund?

Aerosol cans contain labels warning against throwing them into fires. Why?

You encounter gases and phenomena dealing will gases everyday. (Gas laws are at work right now as you breathe in and out!) You can **observe** and **measure** properties of gases such as volume, temperature, pressure, and amount (moles), and gas law equations are useful for **predicting** how changes in one or more properties will affect the others. However, to actually ***explain why*** a helium balloon shrinks when moved from a warm room to a cold car, or ***why*** deep sea divers need to slowly ascend to the surface, you need to apply a theory or model that takes into account gas behavior at the submicroscopic level. Using kinetic molecular theory to visualize what's happening to gaseous atoms and molecules helps you to strengthen your understanding of gases. The more connections you can make—among gas law equations, kinetic molecular theory, and graphical representations of gas behavior—the better you'll understand this concept.

Your Challenge: This week's challenge involves a real-world scenario—checking the pressure in your car's tires. You're going to make a prediction based on gas laws, model what's happening at the molecular level, and connect that to a graphical representation of molecular speeds inside the tire.

Because it's a real-world application (and not simply a piston and steel cylinder like most of the figures and examples in your textbook), you may need to make a few simplifying assumptions about which variables are involved. Identify the variable(s) that are constant (or *nearly* constant) and those that are changing. In the end, you should be able to focus on the *two most important variables* in order to complete this Challenge.

Note: *We encourage you to work with other students; however, THE FINAL PRODUCT MUST BE YOUR OWN, WRITTEN IN YOUR OWN WORDS.*

Challenge Extension:

More connections could have been made in this scenario . . . but no room was left on the page. Here are some more connections and applications to consider. What do you know about the composition of air—are nitrogen and oxygen the *only* gases that would be in your tires? Assume you measured the tire pressure to be 34 psi . . . what is the partial pressure of nitrogen? (Refer to the figure in Part II to help you figure this out.) Focus on a single oxygen molecule in your tire—how would you describe its speed and movement over time?
Also, check out this "Gas Properties" simulation that allows you to model the effects of changing pressure, temperature, volume, and moles of gas: http://phet-web.colorado.edu/web-pages/simulations-base.html

Chemistry Concept Challenge #5

Name: ______________________________

September 29, 2006

Due: Friday, October 6 at 9 a.m. (in your TA's mailbox)

Lab Section #: ______________________

Scenario: It's a warm and sunny day. You decide to drive to Denver, but realize you haven't checked the pressure in your car's tires for a while. You determine the tire pressure is fine, so you take off. Once you arrive, you decide to re-check the pressure.

Part I: Making predictions

1. When you re-check the pressure, you find it to be (circle one)

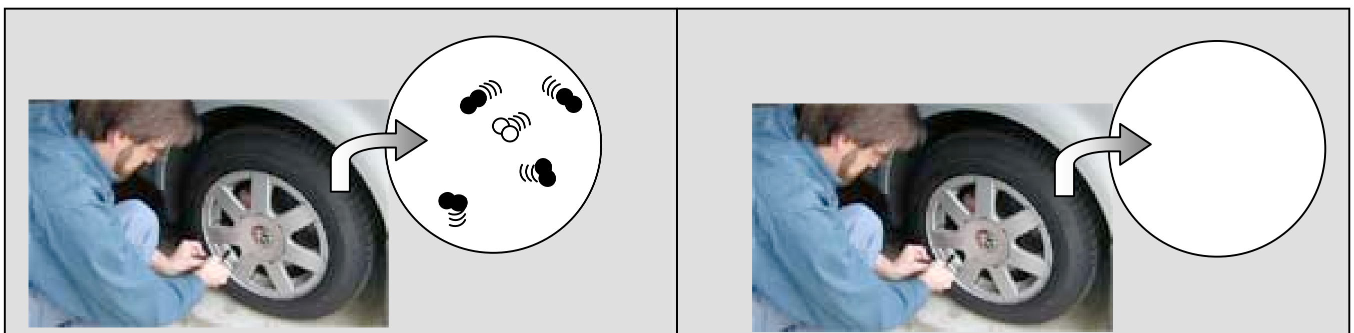
   lower than *the same as* *higher than* before you started driving.

2. Briefly describe how the gas laws support your prediction in Question 1.

Part II: Submicroscopic representations

Explain this tire pressure phenomenon using words AND pictures, in the form of a textbook figure.
Below is the first panel (**A**) in a textbook figure, along with the beginning of a caption.
Here's what you need to do. Complete the figure and caption for panel (**B**) by:

- Drawing submicroscopic representations of the air in your tire after arriving in Denver (**B**).
- Writing a caption for panel (**B**) that describes what's happening at the submicroscopic level as a result of driving the vehicle. If your representation in (**B**) differs from that in (**A**), your caption should explain why.



A Checking tire pressure before driving **B** Checking tire pressure after driving

Figure 1 Checking tire pressure before and after driving.
A Submicroscopic representations depict air inside the tire before driving. Nitrogen ( ) and oxygen ( ) molecules move in straight-line paths as they collide with each other and with the walls of the tire, creating pressure.

B

Part III: Graphical representations

To the right is a graph of the distribution of molecular speeds for oxygen molecules in the tire before driving.

Add these two plots to the graph (and label each):

- Distribution of nitrogen molecules before driving
- Distribution of nitrogen molecules after driving