

Inflate-a-mole

Finding the volume of a mole of gas can be sublime



Materials

dry ice
ziploc bag (gallon size)
straw (bendy is nice)
masking tape
water
2L bottle or large graduated cylinders
balance
scissors
large basin

To do and notice

1. Cut a small hole in the bottom corner of the ziploc bag. Insert the straw and tape the bag around it so that it makes an airtight seal. For now, twist the bag above the straw's entry point so no gas can escape through the straw.
2. Mass out 4.4 g of dry ice. Place it in the bag, squeeze out all the air and zip it shut. As the dry ice sublimates, make sure there is no gas escaping from the top or bottom of the bag.
3. Fill the 2L bottle up to the very top with water. Add enough water to the basin so that it is a few inches deep.
4. Cover the 2L bottle with your hand, quickly flip it upside down, and submerge it in the basin so that the opening is underwater. When you remove your hand, the water should remain in the 2L bottle.
5. Carefully place the straw into the opening of the 2L bottle. Slowly untwist the bag and let the CO₂ bubble up into the bottle. Water from the bottle should enter the basin as it is displaced by gas.
6. Keep going until all the gas is gone from the bag. You may have to squeeze the bag to get it all out. If the bottle holds a little more than 2L, how much gas would you estimate was in the bag?



What's going on?

A mole of gas at standard temperature and pressure takes up 22.4 L of space. Dry ice is the solid form of carbon dioxide, CO₂, which has a molecular weight of 44 g/mol. By measuring

out 4.4 g of dry ice, you had a sample that was 1/10 of a mole. At room temperature and pressure, the CO₂ that makes up dry ice sublimates into a gas. You captured that gas in a ziploc bag and used water displacement to measure its volume. The total volume of a 2L bottle including the air gap above the soda is around 2.1 L. You should have seen all of the water displaced by the gas with very little left in the ziploc bag. That means a mole of gas is about ten times this volume, or around 21+ L of gas – pretty close to the literature value! You can visualize 1 mole of gas by placing eleven 2L bottles together. This method is a nice and easy way to estimate the volume of a mole of gas. If you want to be more quantitative, you can use 1 or 2L graduated cylinders during the water displacement and measure the exact volume of gas in the bag. Just be careful because you'll probably have to use more than one cylinder, so watch out for leaking bubbles!