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CTE Science Laboratory Investigation

THE SUBLIMATION OF CO2

**Introduction**

Sublimation occurs when a solid goes through a phase change and turns directly into a gas, giving the liquid stage a miss altogether. Almost any compound can sublime, given the proper temperature and pressure, but there are some common compounds that sublime under fairly normal conditions. Ice, for example, will “disappear” if left for too long in your freezer. Of course, it’s not actually doing anything magic, it’s simply subliming.

Carbon dioxide will sublime as well, but to get the substance to become solid, it must be cooled to -78°C. The reason that both carbon dioxide and water (and many other substances, including iodine and arsenic) sublime is that the molecules are set up in such a way so as to make the gaseous stage more favorable than the liquid stage under certain conditions. In essence, it’s easier to turn right into a gas and skip the liquid stage.

Sublimation doesn’t have too many uses outside the laboratory (where it is use to purify compounds), but it can help us understand the concept of moles. We know that at standard temperature and pressure (STP – 0°C and 1 atm) one mole of an ideal gas takes up 22.4 L of space. But in our situation, we can’t get the gas cooled down to 0°C; we’ll have to do the whole experiment at room temperature. You know that as you warm up a gas, it expands as the molecules gain kinetic energy, move faster and bump into each other more often. So for the purposes of this lab, one mole of a gas will not take up 22.4 L, but rather:

**24.3 L/mol**

***FOR THIS LAB ONLY!***

There is a fairly simple equation that your kind and caring teacher used to determine how much space one mole of an ideal gas takes up at room temperature, instead of at 0°C. A good way to thank your teacher for performing this calculation is with cupcakes.

**Purpose**

The purpose of this investigation is for you to use the concept of sublimation, which is a physical change, to explore the volume and mass of one mole of a pure substance. You’ll use a large bag of a known volume, then figure out what mass of dry ice (solid carbon dioxide) you’ll need to place into it in order to fill it up with the gaseous carbon dioxide that is formed when the solid sublimes.

**Materials**

PENCIL Large garbage bag

Dry ice Gloves

Digital balance Safety goggles

**Procedures**

PART I – DETERMINE HOW MANY MOLES OF GAS YOU NEED TO FILL YOUR BAG

1. Determine the volume of the bag that you will use, in liters, by reading the label on the box. Record this information in table 1.
2. Determine the molar mass of carbon dioxide, CO2, and record it in table 1.
3. Determine how many moles of gaseous CO2 will fit into the bag, with the knowledge that one mole of an ideal gas at room temperature (*NOT* at STP), takes up 24.3 L of space. Record this information in table 1.
4. Now you know how many moles of gas you need to fill the bag completely, but you need to figure out how many grams that is. Using the information that you’ve already put into table 1, determine how many grams of dry ice you will need to place into the bag in order to create enough gas to just fill up the bag, not pop it!

|  |  |  |  |
| --- | --- | --- | --- |
| **Volume of Bag (L)** | **Number of Moles Needed to Fill Bag (mol)** | **Molar Mass of CO2 (g)** | **Number of Grams Needed to Fill Bag (g)** |
|  |  |  |  |

Table 1. Data for part I calculations.

PART II – FILL UP YOUR BAG!

1. Place a foam cup on the digital balance and zero out the mass of the cup.
2. Using gloves, measure out the number of grams of dry ice that you need to fill the bag with gas completely. If you need to break apart a chunk of dry ice, do so *carefully* and only with the tools provided. Work quickly; the dry ice is subliming as you read this!
3. Load the dry ice into the bag and tie it off as quickly as possible. Make sure that there is as little air left in the bag as possible; we want the gas created to be the thing filling the bag, not leftover room air.
4. Wait until all the dry ice has sublimed and see if your bag is full! You can check for any remaining dry ice by shaking the bag and listening for it to rattle.
5. Dispose of your bag as directed by your teacher.

**Analysis**

QUESTION 1: Did your bag fill up all the way? Was the number on the box accurate? Explain why your results might not have matched your expectations.

QUESTION 2: How would this lab be different if we had used solid nitrogen or oxygen instead of solid carbon dioxide?

QUESTION 3: How would this lab have been different if the temperature of the room was a lot higher? Would we have needed more dry ice or less dry ice to fill the bag completely with ice?

QUESTION 4: It turns out that a gentleman by the name of Jacques Charles discovered a law that describes how gasses expand and contract at different temperatures. The law can be written as:

**T1/V1 = T2/V2**

Where V is the volume and T is the temperature. The law is useful if you are trying to figure out how much space a gas will take up at a given temperature. If you know that a certain amount of hydrogen takes up 30 L at 23 °C, then how much space will that same amount of hydrogen take up if the temperature is raised to 40 °C?

QUESTION 5: Why do some gasses have a greater molar mass than others?

QUESTION 6: What are two things about this lab that you would change if you could?