Percent Carbon in Sodium Hydrogen Carbonate

Lab Equipment

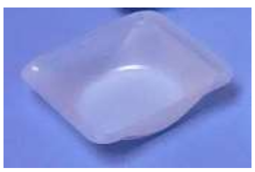

Electronic balance


Graduated Pipette


150-mL Beaker


measuring spoon (spatula)


9.5 oz plastic cup


Weighing paper
(or if you can't find the dish, magazine paper)

Student Supplied

Baking Soda

Vinegar

Slick magazine paper if you don't have a weighing dish

Background Information

Baking soda is close to pure sodium hydrogen carbonate (99.8%). Vinegar is an acetic acid solution. Most vinegars are 4% acid by weight.

Baking soda's original use was as a leavening agent for baked goods. From Arm & Hammer description of its product.

> What does ARM & HAMMER® Baking Soda do when you bake?
>
> ARM & HAMMER® Baking Soda's original use was as an essential ingredient for baking. In dough or a batter, ARM & HAMMER® Baking Soda helps to make the dough rise, also known as leavening. When ARM & HAMMER® Baking Soda in a batter is heated and combined with acidic ingredients (like lemon juice or buttermilk), it prodiuces carbon dioxide bubbles which, in turn, causes the dough to rise and become light and porous.

Sodium hydrogen carbonate and all carbonates react with acids to produce carbon dioxide and water.

Here is the balanced reaction of sodium hydrogen carbonate with acetic acid, a weak acid:

$$NaHCO_3(s) + HC_2H_3O_2\,(aq) \rightarrow Na^+(aq) + C_2H_3O_2^-(aq) + H_2O(l) + CO_2(g)$$

The stoichiometry is a simple 1:1 reaction

You will take advantage of this reaction to remove carbon dioxide from a measured amount of sodium hydrogen carbonate. Using the amount of carbon dioxide lost in the reaction, you can calculate the amount of carbon in sodium hydrogen carbonate.

Hazards for this experiment:

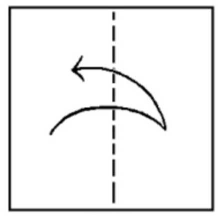
You will be working with chemicals used in baking and food. So, the hazards are minimal. Just be careful not to spill any liquids on your balance. If you spill vinegar on yourself rinse it off, but you will still smell like a Greek salad.

New Lab Technique

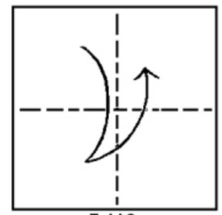
While you may have a weighing boat with your lab kit, weighing papers are more commonly used in taring for solid substances. Make up some weighing papers for this and future experiments and learn the technique for using weighing papers.

(a) Cut up about a dozen approximately 12 cm by 12 cm squares out of some calendered (smooth) magazine paper or waxed paper and put all but one of the squares in an envelope and put the envelope in your lab kit box.

(b) Take the paper square you did not put in the envelope and fold and crease it. Open, fold, and crease again so that you have two valleys in the paper. The folds will keep the solid on the paper and will allow you to easily pour the substance into a container.



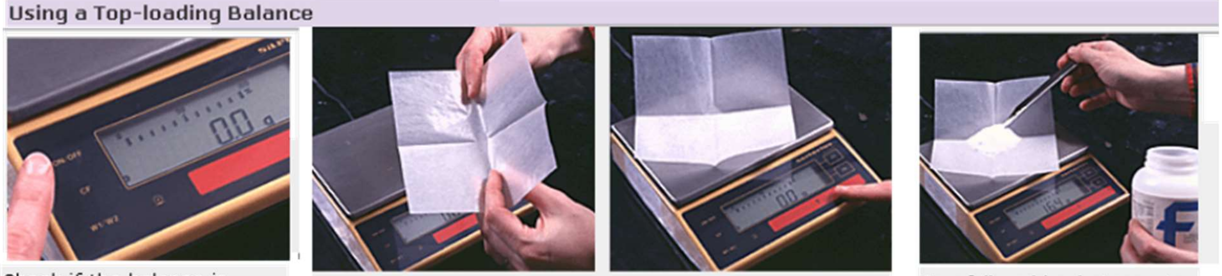
Fold 1



Fold 2

Read the instruction from the Dartmouth Chemistry Lab[1].

Using a Top-loading Balance



Check if the balance is turned on. If not, press the on/off button and wait until the display reads 0.0 g.

Place a container or large, creased weighing paper on the balance pan. Push tare button to zero the balance.

Carefully add substance to the container or paper. Record mass.

Procedure:

(1) Pour about 60-mL of vinegar (acetic acid solution) into the 150-mL plastic beaker using the marking on the side of the plastic beaker as your guide.

(2) Pour the vinegar into the 9.5-oz plastic cup and set it to the side.

(3) Tare a weighing paper or weighing dish, and then spoon out approximately 2.5 grams of the baking soda onto the tared weighing paper. Record the mass to the nearest centigram.

(4) Place the plastic cup and vinegar on the balance and rest the baking soda weighing paper on top of the plastic cup. Do this carefully so as not to spill any baking soda into the cup. Find the mass.

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[1] https://sites.dartmouth.edu/genchemlab/ A Dartmouth 1st Year Chem Lab session is 4 hours long.

(5) Take the plastic cup with the vinegar and baking soda weighing paper off the balance and lift the baking soda weighing paper off the cup.

(6) Slowly pour in small amounts of the sodium hydrogen carbonate from the weighing paper into the vinegar in the cup. Add the sodium hydrogen carbonate slowly enough so that no solution splatters or foams out of the beaker. Record your observations as this occurs. Continue to add the sodium hydrogen carbonate into the vinegar until all the sodium hydrogen carbonate has been added to the cup.

(7) Gently swirl the cup to assure that all the sodium hydrogen carbonate reacts with the vinegar.

(8) **Replace the weighing paper on top of the cup and** find the combined mass of the plastic cup-solution-weighing paper.

(9) Remove the weighing paper and blow and/or pour out the dense carbon dioxide gas that is still in the cup. Take care not to allow any solution to spill out.[2]

(10) **Replace the weighing paper on top of the cup** and find the combined mass of the plastic cup-solution-weighing paper. You should notice slight decrease in mass, due the CO_2 that was removed from the cup.

(12) You can pour the solution down the drain. If you would like, you can pour a few mL of the solution onto a disposable plastic plate and wait a day or two after which the solution will evaporate to produce some very pretty sodium acetate crystals. However the area will smell vinegary for a while.

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[2] Carbon dioxide candle trick: Light a small votive candle and repeat the experiment. If you pour the carbon dioxide from the cup onto the candle, you can extinguish the flame.

% by Mass Carbon in Sodium Hydrogen Carbonate	DATE Unambiguous Date	05

This experiment is being performed to experimentally determine the % carbon in sodium hydrogen carbonate.

Apparatus:

- Balance
- 150-mL beaker
- 9.5 oz plastic cup
- Digital balance
- Weighing paper

Procedure data and observations

I filled my 150-mL plastic beaker with 4% by weight vinegar to just above the 50-mL mark.
I poured the vinegar solution into the 9.5 oz. plastic cup.
I tared an empty weighing paper and added about 2.5 g of sodium hydrogen carbonate (Arm and Hammer Baking Soda) and recorded the exact mass of the sodium hydrogen carbonate.
I rested the weighing paper on top of the plastic cup and weighed the plastic cup-vinegar-weighing paper-baking soda all together on the balance.

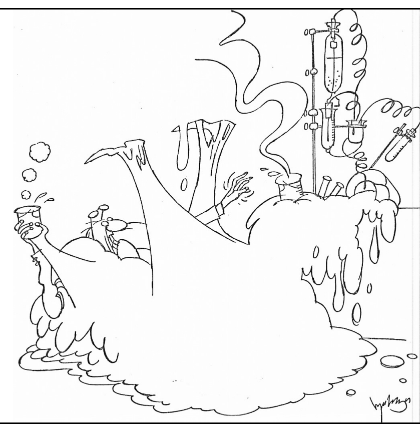
I took the assembly off the balance and then slowly added the sodium hydrogen carbonate into the acetic acid solution. As I did this, the solution foamed, but I added the sodium hydrogen carbonate slowly enough so that none of the solution splattered of foamed out of the beaker.

I swirled the solution to be sure that all the sodium hydrogen carbonate reacted. The solution was clear, but it had bubbles that clung to its sides.

I replaced the weighing paper on top of the plastic cup and reweighed the cup, solution, and weighing paper.

I took the cup off the balance, removed the weighing paper, and gently blew into cup. I also tipped the cup so as to pour out any denser carbon dioxide gas produced in the reaction.

I replaced the weighing paper and reweighed the cup, solution, and weighing paper. The cup was noticeably lighter indicating that there was a denser gas left in the cup.

Drawing of experiment: This is what would happen if you poured too quickly.	

Data:

(a)	2.42 g	mass of sodium hydrogen carbonate
(b)	76.34 g	mass of cup, vinegar, weighing paper and baking soda before rx
(c)	75.35 g	mass of cup, solution, and weighing paper after rx with some CO_2
(d)	75.20 g	mass of cup, solution, and weighing paper after rx without CO_2
(e)	1.14 g	loss of mass because of escaped CO_2 (b)-(d)

Calculations
I calculated the amounts of the two reactants, acetic acid and sodium hydrogen carbonate

I assumed that the density of the 4% vinegar was close to 1.0 g/mL, so the approximate mass of vinegar was 60 g.

$$50.\text{ g vinegar} \times \frac{4.0\text{ g } HC_2H_3O_2}{100.\text{ g vinegar}} = 2.0\text{ g } HC_2H_3O_2$$

$$2.4\text{ g } HC_2H_3O_2 \times \frac{1\text{ mol } HC_2H_3O_2}{60.05\text{ g } HC_2H_3O_2} = 0.033\text{ mol } HC_2H_3O_2$$

Moles of sodium hydrogen carbonate

$$2.42\text{ g } NaHCO_3 \times \frac{1\text{ mole } NaHCO_3}{84.01\text{ g } NaHCO_3} = 0.0288\text{ mol } NaHCO_3$$

The balanced reaction and molar amounts of reactants:

$$NaHCO_3(s) + HC_2H_3O_2(aq) \rightarrow Na^+(aq) + C_2H_3O_2^-(aq) + H_2O(l) + CO_2(g)$$

0.0288 mol   0.040 mol

Since 33. mmol $HC_2H_3O_2$ is significantly larger than the 28.8 mmol $NaHCO_3$, the limiting reactant was the sodium hydrogen carbonate. Therefore, all the sodium carbonate should have reacted producing carbon dioxide gas, water and sodium acetate solution.

From this data the experimental % C by mass in $NaHCO_3$ can be calculated by finding the moles of carbon dioxide and from that the moles of carbon:

$$1.14\text{ mass } CO_2 \times \frac{1\text{ mol } CO_2}{44.01\text{g } CO_2} \times \frac{1\text{ C}}{1\text{ } CO_2} \frac{12.01\text{ g C}}{1\text{ mol C}} = 0.311\text{ g C}$$

$$\frac{0.311\text{g C}}{2.42\text{ g } NaHCO_3} \times 100 = 12.8\%\text{ by mass C / } NaHCO_3$$

The theoretical % C/ $NaHCO_3$ can be calculated using the molar mass of each substance:

$$\frac{\frac{12.01\ g}{mol}\ C}{\frac{84.00\ g}{mol}\ NaHCO_3} \times 100 = \text{Theoretical \% by mass } C / NaHCO_3$$

The deviation (experimental- theoretical) from the theoretical % was _________ %

*Select the cause of error that fits **your** deviation:*

Positive deviation
A positive deviation is the result of too large of a C %.
A greater loss of carbon dioxide than expected indicates that extra mass was lost from the beaker. This common source of error could be explained by splattering of the solution out of the beaker.

Negative deviation
A negative deviation indicates that not all the carbon dioxide escaped. This can be explained by the fact that carbon dioxide can dissolve in water forming carbonic acid.