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Titulo: Microscale Rockets

Antes:

In the weeks leading up to this lab, the Honors Chemistry class has been learning about rates of reaction, and factors that influence them. Rates of reaction are, rephrased, the rates at which two or more substances react with each other to form products. The most common factors influencing the rate of a given reaction are the molarities of the reactants. For a hypothetical reaction...

$$\text{reactant1} + 2\text{reactant2} \rightarrow \text{product1}$$

...we can measure the rate of reaction in molarity per unit of time. For example, if reactant1 is reacted at one mole per liter per second, and we know that the rate of reaction does not depend on the amount of reactant2, and we know that product1 is produced at the same rate that reactant1 is reacted, then we can say that every second, one mole of product1 will be produced for each liter of reactant1 there is. This is the premise behind the experiment today - that different molarities will produce different rates of reaction.

Porque:

The rationale behind this lab is two-fold. The primary purpose of this lab is to determine the factors affecting reaction rates in the case of hydrogen combustion. This will be done by varying ratios of gases. The secondary purpose of this lab is to determine the optimal combination of hydrogen and oxygen gases. The optimality of a gas will be determined by the amplitude of the BANG that it gives off when ignited as compared to other possible candidates; the gas with the loudest BANG is determined to be optimal.

Lo que tiene que hacer:

To replicate this lab, one needs the following materials:

- One 250mL beaker
- One source of water
- Two test tubes with stoppers and nozzles
- One small pipet bulb
- One class that can sing
- One large pipet bulb
- One source of zinc metal
- One source of 1M (or greater) HCl
- One candle
- One book of matches
- One source of manganese dioxide solid
- One source of 3% (or greater) hydrogen peroxide
- Two labels
- One pencil

The following steps may be taken to replicate this lab.

1. Fill a 250mL beaker 3/4 full with water. This will act as a test tube holder, a temperature regulator, and a water reserve during the experiment.
2. Get a set of equipment as mentioned above.
3. Label the two test tubes with the text "H2" and "O2".

4. For hydrogen generation, place about 1/2 inch of zinc in the bottom of the test tube. Add enough HCl to fill the test tube to within 2cm of the top. Secure the stopper, and place the tube in the beaker of water. Wait 5 seconds.
5. Use suction to fill the collection bulb completely full of water. Place the end of the pipet over the end of the generator nozzle and collect the hydrogen gas. The water from the pipet will dribble out into your water bath as the bulb fills with hydrogen.
6. Light the candle. **CAUTION: Fire burns. See previous labs.**
7. Once the collection bulb is filled with gas, hold it horizontally with its mouth roughly 1cm from the candle flame. Squeeze as much of the gas as you'd like into the flame. **CAUTION: Things could blow up here, depending on the ratio. That's the point. If you're using a big pipet, you might want to do this at a distance.**
8. For oxygen generation, place about 1/4 inch of MnO2 in the bottom of the test tube. Add enough 3% H2O2 to fill the test tube to within 2cm of the top. Secure the topper, and set the generator in the beaker of water. Wait 5 seconds.
9. Use suction to fill the bulb completely full of water. Place the end of the pipet over the end of the generator nozzle and collection the oxygen gas. The water from the pipet will dribble out into your water bath as the bulb fills with oxygen.
10. Once the collection bulb is filled with gas, hold it horizontally with its mouth roughly 1cm from a candle flame. Squeeze as much of the gas as you'd like into the flame. **CAUTION: See step 7.**
11. While generating both gases, collect and test all different possible ratios of hydrogen and oxygen gas. Use the graduated markings on the pipet to measure the relative amounts of each gas collected. Try H2:O2 at 3:3, 5:1, 4:2, 2:4, and 1:5.
12. If either of the two reactions should slow down too much, they have probably run out of reactant. Remove the stopper, pour off the remaining liquid into the sink, and pout in some fresh solution. Replace the stopper and wait 5 seconds. Then resume collecting gas.
13. Record all observations. Which ratio produces the loudest pop?
14. Decide on the ratio with the loudest pop, and fill the large pipet with that ratio. Have the class sing "Happy Birthday", then blow it up.
15. Scrape the wax off of yourself and go to lunch.

Los datos:

The author observed the following data:

Gas or Mixture	Effects
Pure hydrogen (H2)	Small "woof"
Pure oxygen (O2)	No combustion
H2:O2 at 3:3	"Bang", blew out candle, fired wax at operator
H2:O2 at 5:1	"Bang!!", blew out candle
H2:O2 at 4:2	Loud bang!!, did not blow out candle
H2:O2 at 2:4	Little "pip"
H2:O2 at 1:5	Little "floop", blew out candle

The loudest bang was 4:2.

The majority of the class successfully matched pitch with the song.

It took two attempts to ignite the 4:2 in a large quantity.

On the successful ignition of the large quantity of 4:2, wax was fired at the operator and the operator's hand had approximately a 5cm recoil.

Lo que pensamos:

From the given evidence, it can be stated that 4:2 is the most efficient mixture of hydrogen and oxygen that is possible in a 6-part container.

Preguntas:

1. Write balanced chemical equations for the reactions taking place in each generator.
    1.1. $Zn(s) + 2HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$
    1.2. $2H_2O_{2(aq)}$ ($MnO_{2(aq)} \rightarrow MnO_{2(aq)}$) $2H2O_{(l)} + O_{2(g)}$
2. Which do you think will have to be replaced first: the zinc in the hydrogen generator or the manganese dioxide in the oxygen generator? Why?
    2.1. I predict that the zinc will have to be replaced first - the manganese dioxide is a catalyst, and is not reacted. Theoretically, the manganese dioxide will never need to be replaced.
3. There are two reasons for filling the generators up so full. Can you think of what they might be?
    3.1. The first reason is to have the maximum amount of reactant possible, in order to generate the most product possible.
    3.2. The second reason is to have as little "dead space" as possible; i.e., we wish to keep air out, and reactant in.
4. Discuss your observations for the pop-test of pure hydrogen.
    4.1. From evidence, hydrogen needs oxygen to react, and when the only oxygen available must slowly mix with the hydrogen, the hydrogen reacts slowly.
5. Discuss your observations for the pop-test of pure oxygen.
    5.1. From evidence, oxygen needs hydrogen to react. Hydrogen is not generally available, so the oxygen does not react.
6. Did you find any mixtures that produced no reaction at all? Discuss.
    6.1. The mixture that did not react was pure oxygen. Please see the answer to question number 5.
7. What proportion of hydrogen and oxygen produced the most explosive mixture?
    7.1. 4 parts hydrogen, 2 parts oxygen.
8. Write a balanced equation for the reaction of hydrogen and oxygen.
    8.1. $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)}$
9. Can you see any similarity in the balanced equation for the formation of water and your proportion of hydrogen and oxygen that produced the most explosive mixture?
    9.1. Yes -- 4 parts hydrogen are proportional to the 2 parts hydrogen shown in the equation as 2 parts oxygen are proportional to the 1 part oxygen.
10. Why don't the hydrogen and oxygen in the collection bulb react as soon as they mix? What role does the flame play?
    10.1. Evidently the reaction needs some energy to start. The fact that it is exothermic probably helps it to sustain itself.

<u>En f'in, y como puedo equivocado:</u>

In conclusion, this lab has conclusively proved that 4:2 is the optimal mixture of hydrogen and oxygen, if the mixture is limited to a total of 6 parts. The lab has also proved that the class is capable of singing, and that candles melt wax, and that hydrogen combustion reactions are capable of flinging aforementioned wax.

Error in this lab was very possible. The markings for the sixths of the container kept washing off. For the 4:2 in the large pipet, the generators were running low on reactants, which may have caused the initial failure. The pipet was unmarked, which may have caused more error.