Names _____

Launching Rockets using H_2O

You will make a rocket using plastic bottles with volumes between $1L$ and $2L$. You will fill the bottles with a mixture of hydrogen gas and oxygen gas in an appropriate ratio. When ignited, the reaction will produce water gas at a very high temperature. The hot molecules will generate a propulsive force (or the bottle will simply blow up).

The first thing to determine is the appropriate ratio of hydrogen and oxygen to use in your rocket. You need an explosive mixture to launch your rocket. A mixture too rich in H_2 will burn quietly like a Bunsen burner instead of igniting explosively. A mixture too rich in O_2 will explode, but weakly. A mixture that is just right will produce maximum power for your rocket. The unbalanced equation for the propulsion reaction is as follows:

$$\_H_{2(g)} + O_{2(g)} \longrightarrow \_H_2O_{(g)}$$

If you balance the equation shown above, you will know the correct mole ratio of H_2 to O_2 needed to achieve the maximum propulsive force.

Use a $500ml$ graduated cylinder to accurately measure the total volume of your bottle. Using the mole ratio of H_2 to O_2 that you discovered from your balanced equation, you can figure out how much H_2 and how much O_2 you will need to fill the plastic bottle. In the space below, sketch a picture of your bottle (label total volume) and draw a line showing what fraction of the bottle you will fill with H_2 and what fraction you will fill with O_2. Convert these fractions into actual volumes of H_2 and O_2 (in liters). Discuss how the mole ratio compares to the volume ratio that you sketch in your picture.

You just determined how much H_2 and O_2 you need for your rocket, but you will have to generate these gases by running chemical reactions.

This part discusses production of O_2 gas.

O_2 can be generated from the decomposition of H_2O_2. The unbalanced equation is:

$$H_2O_{2(l)} \longrightarrow H_2O_{(l)} + O_{2(g)}$$

The reactant in this reaction, hydrogen peroxide, is thermodynamically unstable and can rearrange its atoms to form water and oxygen gas. This reaction is extremely slow at room temperature unless a catalyst is added. You will use potassium iodide (KI) as a catalyst to speed up this reaction. When running the actual reaction, a small scoop of the catalyst (about 0.7 grams) will be "packaged" in weighing paper and then added to the H_2O_2. You will place the stopper on the reaction flask and then shake it to allow KI to come out of its package. This method should enable you to collect ~100% of the gas created in this reaction.

This part discusses the production of H_2 gas

Hydrogen can be generated in many ways. You will use the method shown below:

$$Ca_{(s)} + H_2O_{(l)} \longrightarrow H_{2(g)} + Ca(OH)_{2(s)}$$

Balance the equation shown above.

The amount of H_2O you have calculated is the amount that will actually react with the Ca that you will weigh out. This is not a smart way to run this reaction. Circle two of the choices below that express reasons why it is a good idea to add excess H_2O when you carry out this reaction. When you run the reaction, you will want to use a large excess (as large as your reaction flask permits). To the right, sketch what your flask should look like if you use a large excess of H_2O.

extra water will create extra hydrogen extra water will create more heat in the reaction flask extra water will keep the reaction flask cool extra water will reduce the amount of air that goes into the rocket

Calcium is a very reactive metal. Even while inside its jar, the outer surface of calcium is oxidized to some extent (forming CaO). This reduces the amount of actual calcium in the lumps that you will use. How can you correct for this problem?

After you launch your rocket, answer these questions:

Why does the bottle actually lift off? (Note: the ignition of the H_2/O_2 mixture generates very hot gas molecules with lots of kinetic energy. What do you think these hot molecules do?)

Step-by-step instructions for preparing and launching your rocket

Materials

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- two reaction flasks-small and large
- stoppers that fit each flask
- rubber hose with glass dropper tip
- water trough (or bucket)
- the bottle that is to be your rocket (with lid)
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Instructions

- Fill your rocket bottle completely with water, cap it, and invert it in the sink. You can leave the cap on the bottle until you are ready to load the first gas (O_2).
- Measure the appropriate volume of 12% H_2O_2 and place it in your small reaction flask. Use of the small flask (as opposed to the large flask) will minimize the amount of air that goes into your rocket.
- Fold your weighing paper around the catalyst so that it makes a loose package, like an envelope. This packaging of the catalyst will delay the decomposition reaction until you have a stopper on the reaction flask. The goal is to get 100% of your O_2 transferred to the rocket, without losing the initial "burst" of gas that will be produced when catalyst hits H_2O_2.
- Take the lid off your bottle that is sitting in the sink. Feed the end of the rubber tube into the mouth of the bottle. Attach the other end of the rubber tube (with glass dropper tip) to the stopper that fits in the flask. You are now ready to transfer gases.
- Drop the package of catalyst into the reaction flask, which already contains the measured volume of H_2O_2. Place the stopper on the flask and shake the flask so that the catalyst comes out of its envelope. O_2 should begin bubbling out of the flask and into the rocket bottle.
- Continue the collection of O_2 until the reaction in the flask stops. When no more bubbles are being transferred, remove the rubber hose from the rocket bottle. You may wish to replace the cap on the rocket bottle at this time. Note: Your bottle should be 1/3-filled with O_2!
- Pour the remaining liquid in the reaction flask down the drain. Take the paper out of the reaction flask and put it into the trash can, not the sink.

- Fill your large reaction flask to the 150-mL mark with tap water. This water will be used in the reaction that generates H_2.
- Find the quantity of calcium metal that is appropriate for your rocket (). It is recommended that you use approximately 0.3 grams more calcium than your calculated quantity. This extra calcium will ensure that you fill your bottle completely with gas. Weigh out the recommended quantity of calcium metal on weighing paper.
- Make sure your hose and stopper are set up so that you can transfer gas from the reaction flask to the rocket bottle.
- **Read this entire paragraph before doing any of the steps involved.** Drop the calcium metal into the reaction flask (that already should contain $150mL$ of tap water). You do not need to "package" the calcium metal like you did the KI. Quickly put the stopper on and allow the calcium to react until the rocket bottle is filled with gas. As soon as the bubbles start coming out the bottom of the rocket bottle, you should remove the hose from the mouth of the bottle. Your goal is to fill the bottle with gas—adding more H_2 after this point will make the fuel mixture too rich in H_2! Note: As the rocket bottle gets filled with H_2, it will become very light, which will cause it to float in water. One member of your group should firmly hold the bottle so it does not tip over.
- If your rocket bottle is not completely filled with gas (i.e. if there is some water still inside the bottle), you may either generate a bit more H_2 by throwing a couple more rocks of calcium into the reaction flask to displace the remaining water or you can physically lift up the bottle and let the water drain out of the bottle (recommended only if you have a very small amount of water left in the bottle).
- Once your rocket bottle is completely filled with gas, you should lift it out of the water trough and cap the bottle tightly. Note: the gas mixture in the rocket bottle is lighter than air, therefore you must hold the bottle in an inverted orientation to avoid losing all your fuel!!!!
- Clean up the reaction flask by pouring the white liquid down the drain and rinsing the flask with water. If the flask is still hazy with white residue, you can either scrub it or use some wash acid to clean out the flask.
- Keep your safety glasses on even though you think you are "done" with the experimental part of the lab. Your rocket is an explosive device and you must continue to think about safety precautions.
- Your rocket is now ready to launch. You are responsible for bringing your rocket bottle and your igniters to the designated launch area. You are also responsible for cleaning up the launch area after the launches are finished.