Lab 8: Ideal Gas Law

Experiment: Finding Percent H_2O_2 with Yeast

Materials

Safety Equipment: Safety goggles, gloves

Yeast	Rubber band	Flexible tubing (18 in.)
10 mL Hydrogen peroxide	2 Droppers (pipettes)	250 mL Beaker
10 and 100 mL Graduated cylinders	Stir rod	600 mL Beaker
Erlenmeyer flask	Thermometer	Stopwatch
Stopper with hole	Warm water*	Ring stand*
Rigid plastic tubing (3 in.)	Large ring*	Distilled water*

*You must provide

*Optional Materials (not provided)

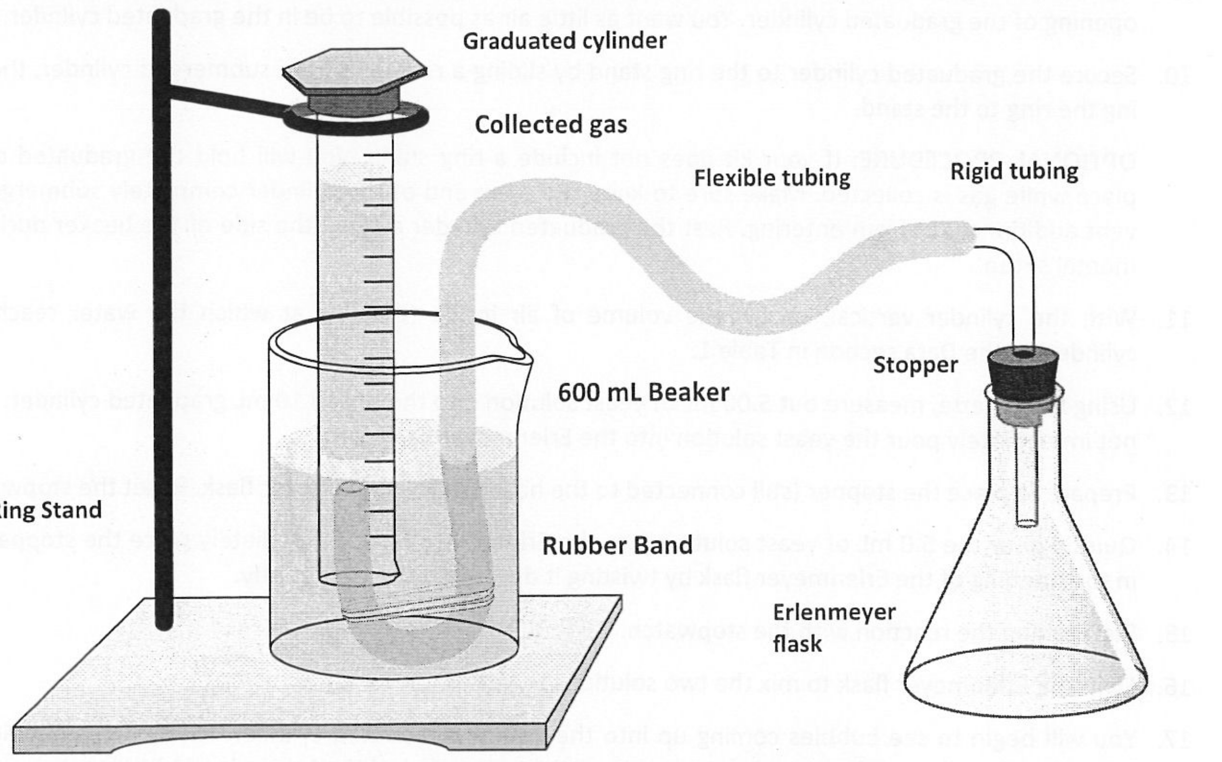

Figure 3: Gas Collection Apparatus (not to exact scale)

Procedure

1. Prepare the materials for the apparatus as shown in Figure 1. Insert the smaller rigid tubing into one end of the larger, flexible tubing. Insert the free end of the rigid tubing securely into the rubber stopper hole.
2. Bend the free end of the flexible tubing into a U shape, and use a rubber band to hold this shape in place. This will allow you to more easily insert this end of the flexible tubing into the inverted graduated cylinder. Make sure the tubing is not pinched and that gas can flow freely through it.
2. Fill the 600 mL beaker with 400 mL distilled water.
3. Fill the 100 mL graduated cylinder with distilled water slightly over the 100 mL mark.

4. Take the temperature of the water in the 600 mL beaker, and record it in the Data section. Also, determine the barometric pressure in the room, and record it in the Data section. **HINT:** The pressure in your region may be found online—if necessary, convert this value to mm Hg.
5. Mix 100 mL of warm water (45°C) and 1 packet of baker's yeast in a 250 mL beaker. This will activate the yeast from the dormant (dry) state. Be sure to mix well with a stir rod until the yeast is completely dissolved.
6. Use a 10 mL graduated cylinder and pipette to measure out 5.00 mL of hydrogen peroxide. Pour this hydrogen peroxide into the Erlenmeyer flask, and place the stopper with stopper tube over the top.
7. Clean the 10 mL graduated cylinder by rinsing it at least three times with distilled water. Dispose of the rinse down the drain.
8. Cover the opening of the graduated cylinder with two or three fingers and **quickly** turn it upside down into the 600 mL beaker already containing 400 mL of water. DO NOT remove your fingers from the opening until the graduated cylinder is fully submerged under the water. If the amount of trapped air exceeds 10 mL, refill the cylinder and try again.
9. Insert the U shaped side of the flexible tubing into the beaker, and carefully snake it into the submerged opening of the graduated cylinder. You want as little air as possible to be in the graduated cylinder.
10. Secure the graduated cylinder to the ring stand by sliding a ring under the submerged cylinder, then attaching the ring to the stand.

    OPTIONAL PROCEDURE: If your kit does not include a ring stand, you will hold the graduated cylinder in place while gas is collected. Make sure to keep the open end of the cylinder completely submerged to prevent additional gas from entering. Rest the graduated cylinder against the side of the beaker during experimental setup.
11. With the cylinder vertical, record the volume of air inside (the line at which the water reaches in the cylinder) in the Data section in Table 1.
12. Using the pipette, measure out 5.00 mL of yeast solution into the rinsed 10 mL graduated cylinder. **NOTE:** Do not immediately pour the yeast solution into the Erlenmeyer flask.
13. Prepare to place the stopper (still connected to the hose) on the Erlenmeyer flask. Reset the stopwatch.
14. Quickly pour the 5.0 mL of yeast solution into the Erlenmeyer flask. Immediately place the stopper securely in the opening of the Erlenmeyer flask by twisting it down into the flask gently.
15. Start timing the reaction with the stopwatch.
16. Swirl the Erlenmeyer flask to mix the two solutions together.
17. You will begin to see bubbles coming up into the 100 mL graduated cylinder. **HINT:** If gas bubbles are not immediately visible, make sure the stopper is on tight enough and the tubing is not leaking. You will need to start over after correcting any problems.
18. Continue to swirl the Erlenmeyer flask and let the reaction run until **no more** bubbles form to assure the reaction has gone to completion. This should take approximately 6-10 minutes. **HINT:** Catalase works best around the temperature of the human body. You can speed the reaction up by warming the Erlenmeyer flask with your hands.
19. Record the time when the reaction is finished in Table 2 of the Data section, along with the final volume of air in Table 1. Remember to read it at eye-level and measure from the bottom of the meniscus.
20. Pour all other liquids down the drain and clean the labware.

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Data

Water temperature: ____________________ ^oC

Barometric Pressure: ____________________ mm Hg

Table 1: **Volume data**

Initial volume of air (mL)	Final volume of air after reaction (mL)	Volume of O_2 collected (Final volume - initial volume)

Table 2: **Reaction time data**

Time reaction started	Time reaction ended	Reaction time (s)

Calculations

The goal is to find the percentage of hydrogen peroxide in the solution! This can be found by working through the following steps.

1. Convert the temperature of the water from ^oC to Kelvin (K). Use the equation **K = ^{o}C + 273.** This will be your value for absolute **T** or the temperature in Kelvin.

   T = ______________ ^oC + 273 = ______________ K

2. If necessary, convert the barometric pressure in the room from mm Hg to atmospheres (atm).

   Divide the measured pressure from the Data section by 760 mm Hg. This will give you pressure (**P**) in atmospheres.

   $$\mathbf{P} = \underline{\qquad\qquad} \text{ mm Hg} * \frac{1 \text{ atm}}{760 \text{ mm Hg}} = \underline{\qquad\qquad} \text{ atm}$$

3. Convert the volume of oxygen from mL to liters (L).

$$V = \underline{\hspace{3cm}} \text{ mL} * \frac{1 \text{ L}}{1000 \text{ mL}} = \underline{\hspace{3cm}} \text{ L}$$

4. Rearrange the ideal gas law to solve for **n.**

5. You are now ready to solve for the number of moles of O_2. Be sure the units cancel so that you end up with only the moles of O_2 left. Use the value for the constant R given:

$$R = \mathbf{0.0821} \text{ L·atm/mol·K}$$

***Actual* number of moles of O_2 (n)** = ____________________ moles

6. Calculate the **theoretical number of moles of O_2** there would be if the hydrogen peroxide were 100%, and not an aqueous solution.

$$\textbf{Theoretical moles of } \mathbf{O_2} = H_2O_2 \text{ volume} * H_2O_2 \text{ density} * \frac{\text{mol } H_2O_2}{\text{g } H_2O_2} * \frac{1 \text{ mol } O_2}{2 \text{ mol } H_2O_2}$$

To use the above equation, calculate the following:

- **H_2O_2 volume** is the volume (mL) of hydrogen peroxide used: Volume = ____________ mL H_2O_2
- **H_2O_2 density** is known: Density = **1.02 g/mL**
- $\frac{\textbf{mol } H_2O_2}{\textbf{g } H_2O_2}$ is the reciprocal of the molar mass of H_2O_2. First write the molar mass of H_2O_2 then find the reciprocal.

Molar mass of H_2O_2 = ____________________ g H_2O_2/1 mol H_2O_2

Molar mass of H_2O_2 reciprocal = ____________________

Now you have all of the information needed to solve the equation for the theoretical moles of O_2. All you need to do is fill in the blanks and do the calculations.

Theoretical moles of O_2 = __________ * __________ * __________ * __________

Theoretical moles of O_2 = ____________________ mol

7. Find the percent hydrogen peroxide.

$$\% \; H_2O_2 = \frac{\text{Actual moles } O_2}{\text{Theoretical moles } O_2} * 100\% = \underline{\hspace{3cm}} \%$$

8. You can also easily determine the reaction rate. To do this, divide the total volume of oxygen collected by the total time of the reaction.

$$\textbf{Reaction rate} = \frac{\text{Volume } O_2 \text{ (mL)}}{\text{Reaction time (s)}} = \underline{\hspace{3cm}} \text{ mL/sec}$$

Post-Lab Questions

1. Was the calculated percentage of hydrogen peroxide close to the same as the percentage on the label?

2. Considering that catalysts are not consumed in a reaction, how do you think increasing the amount of catalyst would affect the reaction rate for the decomposition of hydrogen peroxide?