# Elephant's Toothpaste Demonstration

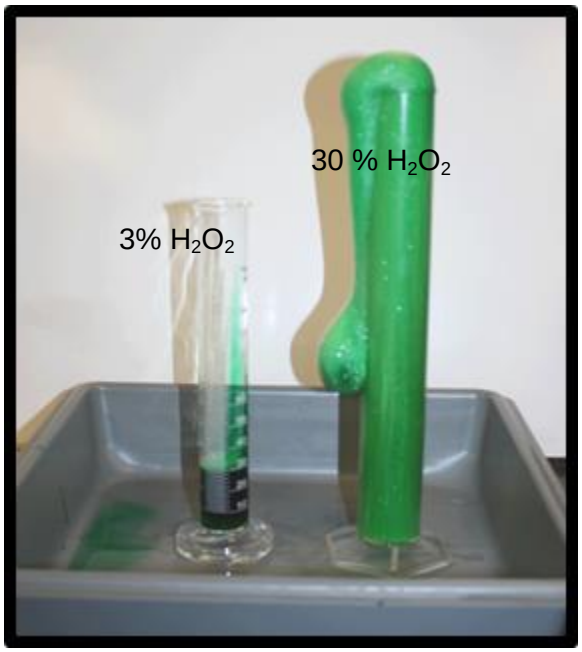
## *Background:*

Hydrogen peroxide, $H_2O_2$, is a water-soluble compound. In a chemical demonstration 20. mL of hydrogen peroxide is catalyzed by potassium iodide to produce water vapor and oxygen gas. The presence of oxygen gas in the foam is demonstrated by the glowing splint test. The green foam is produced due to the presence of food coloring and dish soap in the graduated cylinder prior to initiating the reaction. The reaction was performed with two different concentrations of $H_2O_2$, 3 % solution as shown in each picture on the left and 30 % $H_2O_2$ as shown in each picture on the right. The first picture was taken 5 seconds after the reaction was initiated and second picture was taken thirty seconds after the first.

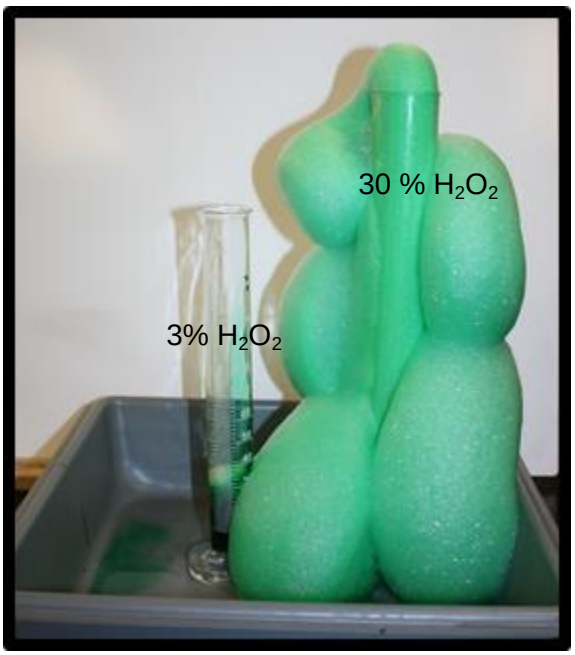
The reaction is represented by the **unbalanced** equation below:

$$\mathbf{H_2O_{2\,(aq)} \rightarrow H_2O_{(g)} + O_{2(g)} \qquad \Delta H = -392.2\ kJ}$$

**Time: 5 seconds after start of reaction**




**Time: 30 seconds later**



## *Questions:*

1. Indicate Classify the type of chemical reaction represented by the equation.
   a) Balance the reaction using the smallest whole-number coefficients.

   $$\_\_\_\_\_ H_2O_{2\,(aq)} \rightarrow \_\_\_\_\_ H_2O_{(g)} + \_\_\_\_\_ O_{2(g)}$$

   b) What is the sum of the coefficients?

2. State the oxidation state of oxygen in the reactant.

3. Write a balanced half-reaction equation for the oxidation that occurs.

4. Determine the number of moles of $O_2(g)$ produced when 8 moles of $H_2O_2$ is completely consumed?

5. 

   a) On the set of axes above, sketch a potential energy diagram for the reaction.
   b) Draw a dotted line on the diagram to show the reaction pathway upon the addition of a catalyst.
   c) Explain, in terms of the function of a catalyst, why the curves on the potential energy diagram are different.

6. Where should the *energy* term be written in the balanced reaction?

7. Describe what happens to the entropy (**ΔS**) as the reaction goes to completion.

8. Determine the total amount of heat released when one mole of $H_2O_{(g)}$ is formed at 101.3kPa and 298 K,

9. Based on the pictures above:
   a) Describe the relationship between the concentration of 3% $H_2O_2$ solution and 30% $H_2O_2$ solution and rate of reaction.

   b) Identify one factor, other than the addition of a catalyst and concentration of the solutions, that could increase the rate of a reaction.

10. At 20°C the density of the $H_2O_2$ solution is 1.135g/cm$^3$. Calculate the number of grams of $H_2O_2$ contained in 20. cm$^3$ of this solution.

11. Calculate the total mass of $H_2O_2$ required to make 20.0 grams of an aqueous $H_2O_2$ solution which is 30 percent by mass?

12. When a glowing splint is inserted into the foam, it spontaneously reignites. Draw a Lewis dot diagram for the gas that causes the splint to reignite?

13. The molarity of the potassium iodide solution is 2.0 M.
   a) Write the chemical formula for potassium iodide

   b) Calculate the gram formula mass of potassium iodide.

   c) Show a correct numerical setup for calculating the number of moles contained in the 5 mL solution?

   d) Determine the percent error of a student that determined the molarity of the potassium iodide solution to

be 2.3 M.

14. According to Reference Table G, identify the type of solution formed when 80 grams of potassium iodide, is dissolved 100g of water at 25°C?

15. Explain, in terms of charged particles, why the solution of potassium iodide is considered an electrolyte.

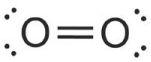
16. Describe, in terms of electrons, the bonding in potassium iodide.

## ***Extensions:***

Rate law
Surfactant
Dilution

***ANSWER KEY:***

1. $2\ \mathbf{H_2O_{2\,(aq)}} \rightarrow \mathbf{2\ H_2O_{(g)} + O_{2(g)}}$
2. 5
3. $2\ O^{-1} \rightarrow O_2^0 + 2\ e^-$
4. 4 moles
5. 

   *c.* a catalyst provides an alternate reaction pathway with lowered activiation energy
6. on the right side; on the product side
7. entropy increases
8. 196.1 kJ
9. *a*. as concentration increases, the rate of the reaction increases
   *b*. increase the temperature
10. 22.7 g
11. 6 g
12. 
13. *a*. KI
    *b*. 166.0 g/mol

    *c.* 0.005 L x 2.0 M
    *d.* 11.5%
14. unsaturated
15. a solution of potassium iodide contains mobile ions
16. bonding involves the transfer of electrons