7.6 Breaking Molecules Apart: Properties of Hydrogen Peroxide

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Many teeth whiteners contain an ingredient called hydrogen peroxide (Figure 1). The name tells us that this compound is made up of hydrogen atoms and oxygen atoms. The prefix *per–* means *thoroughly*, which in this case refers to the number of oxygen atoms in the molecule. The chemical formula for hydrogen peroxide (H_2O_2) indicates that this molecule has two oxygen atoms compared with the more common H_2O (Figure 2).

Figure 1 A brighter smile is the result of a chemical reaction between hydrogen peroxide and stains on your teeth.

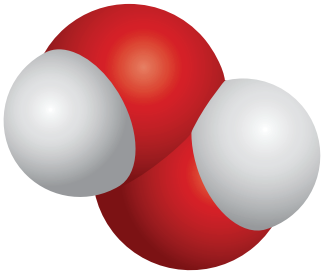

Figure 2 Hydrogen peroxide, H_2O_2

It is this extra oxygen atom that gives hydrogen peroxide its special chemical properties. The molecule easily breaks apart into the more stable H_2O and oxygen (O_2):

hydrogen peroxide → water + oxygen

You have learned that oxygen readily combines with other elements to form new compounds. This process can happen very slowly, such as when iron turns to rust, or very quickly, such as when magnesium is burned to a white powder.

When hydrogen peroxide breaks apart, or decomposes, the oxygen released can bleach a variety of materials. Bleaching occurs when the oxygen reacts with the chemical pigments that give materials their colour. This process can make stained teeth white or turn brown hair blond. Hydrogen peroxide is the key ingredient in many hair bleaches. It is also used in some contact lens soaking solutions. When the lens is placed in the solution, bubbles of oxygen surround the lens and kill bacteria. When the process is complete, it is safe to put that lens back into the eye. Note that this solution is a special mixture. You should never clean your contact lenses with household hydrogen peroxide. It will burn your eyes.

Under ordinary conditions, hydrogen peroxide breaks down into water and oxygen slowly. Nonetheless, precautions must be taken in the storage of this unstable liquid. The bottles are commonly made of plastic to allow for a slight expansion, in case the amount of oxygen gas that is released causes a pressure buildup in the container. Often, the bottles are dark and opaque to reduce the amount of light energy entering the solution, which may speed up its chemical decomposition (Figure 3).

Figure 3 Hydrogen peroxide is kept in special opaque bottles to prevent explosions.

Large bottles of concentrated hydrogen peroxide are designed with venting caps in case a large volume of oxygen is produced over time. Care must be taken in the use and disposal of hydrogen peroxide because it will react wherever it is spilled or poured.

The decomposition of hydrogen peroxide can proceed much more quickly if you add a catalyst to the liquid. A **catalyst** is any substance that speeds up a reaction without being consumed or chemically altered itself. A catalyst does not actually take part in the reaction, but it provides more favourable conditions for the reaction to happen.

catalyst a substance that speeds up a chemical reaction but is not used up in the reaction

TRY THIS WHEN YEAST MEETS BLEACH

SKILLS: Predicting, Performing, Observing, Analyzing, Communicating

In this activity, you will use a living organism as the source of a catalyst. Your own body cells contain this catalyst. That is why the cut on your knee bubbles when you put hydrogen peroxide on it, evidence of the oxygen gas being produced. The oxygen bubbles react with any bacteria in the cut and kill them. We will not use your body cells today. We will use yeast instead.

Equipment and Materials: empty plastic or glass bottle, approximately 500 mL (for example, water bottle); small cup; measuring cup or graduated cylinder; spoon; funnel; 125 mL 3 % hydrogen peroxide (for example, from a pharmacy); 50 mL liquid dishwashing detergent; food colouring; 1 package active yeast (approximately 2 tsp); 50 mL warm water (approximately 30 °C)

1. Mix together 125 mL of 3 % hydrogen peroxide, 50 mL of liquid detergent, and a few drops of food colouring in the bottle.
2. Place the bottle and contents in a sink to avoid spilling.
3. Mix the active yeast with 50 mL of warm water in the small cup. Allow to sit for 10 min until the yeast appears to bubble.
4. Use the funnel to pour the yeast mixture into the bottle. Observe. T/I

A. What evidence is there that oxygen was produced in this activity? T/I

B. Describe a test that you can perform to confirm that the gas produced is oxygen. T/I

C. Was oxygen produced before the yeast was added? What test can you perform to find out? T/I

D. What was the role of the yeast in this activity? T/I

E. What was the role of the detergent in this activity? T/I

F. Predict what you would observe if you repeated the activity without the detergent. A

IN SUMMARY

- The chemical formula for hydrogen peroxide is H_2O_2.
- Hydrogen peroxide easily decomposes into water (H_2O) and oxygen (O_2).
- The newly released oxygen from the decomposition of hydrogen peroxide reacts with other chemicals, often producing a bleaching effect.
- Some substances are able to speed up chemical reactions. These substances are known as catalysts.

CHECK YOUR LEARNING

1. Explain the hazards of the storage, use, and disposal of hydrogen peroxide. K/U
2. Compare water and hydrogen peroxide in terms of formula, stability and shelf life, uses, and safety precautions in use and disposal. K/U
3. How do the properties of hydrogen peroxide make it suitable for use in hair dye? K/U
4. What properties of hydrogen peroxide solution make it strong enough for killing bacteria on skin cuts? K/U
5. Why is hydrogen peroxide sold in opaque plastic bottles? K/U
6. The contact lens storage cases designed for hydrogen peroxide cleaners contain a platinum catalyst. Explain why platinum is added to the storage container and not to the hydrogen peroxide. T/I
7. Give examples of household substances that are stored in opaque plastic bottles. For each substance, assess its purpose and usefulness as well as the hazards associated with its handling and disposal. T/I