

Genie in a Bottle: The Decomposition of Hydrogen Peroxide by Manganese Catalysts

Performer's Version

Safety Hazards

- Personal Protective Equipment:
 - Safety glasses/goggles
 - Nitrile gloves
 - Chemical & flame retardant lab coat
- Physical Hazards
 - Hydrogen peroxide is extremely flammable and may intensify fire.
 - Manganese (III) oxide can release reactive gases.
- Chemical Hazards
 - Hydrogen peroxide is harmful if swallowed or inhaled and may irritate skin and eyes.
 - Manganese (III) oxide may cause skin irritation and eye damage.

Materials

- Plastic 2 L soda bottle *or* 250 mL Erlenmeyer flask
- 50 mL 30% Hydrogen peroxide
- Manganese (III) oxide powder
- Metal scoopula

Safety Data Sheet(s)

- [Manganese \(III\) oxide](#)
- [Hydrogen peroxide](#)

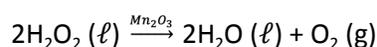
Procedure

1. Place either a 2L plastic soda bottle or a 250 mL glass Erlenmeyer flask in the center of a table.
2. Pour the entire 50 mL aliquot of hydrogen peroxide into your reaction vessel.
3. Using the metal scoopula, scoop up a small amount of manganese (III) oxide and pour it into the reaction vessel as quickly as possible. The faster it is added, the faster the reaction will take place. Step back and let the reaction proceed. A large amount of steam will be produced from the neck of the bottle and the bottle will shrink due to the heat.
4. When the reaction is finished, place the cap on the soda bottle or a black stopper on the glass Erlenmeyer flask and secure it for disposal. Be careful – it will be extremely hot!

Pedagogy & Supplemental Information

The catalyzed decomposition of 30% hydrogen peroxide, facilitated by manganese(III) oxide, is a notable chemical reaction that demonstrates both thermodynamic and kinetic principles. Thermodynamically, the reaction involves breaking the bonds within hydrogen peroxide molecules to form water and oxygen gas. This process requires energy to break apart the stabilizing bonds of the reactants, but releases even more energy once bonds are formed in the products, making it ultimately exothermic. However, without a catalyst, the decomposition of hydrogen peroxide occurs at a relatively slow rate due to the high activation energy barrier required to initiate the reaction. This is where kinetics come into play.

The decomposition of hydrogen peroxide can be described by the reaction below:



The kinetics of the reaction describe how quickly the reactants are transformed into products. The rate of a chemical reaction is influenced by factors such as temperature, concentration of reactants, and the presence of a catalyst. The Arrhenius equation, which relates the rate constant of a reaction to the temperature and activation energy, helps elucidate the kinetics of the catalyzed decomposition of hydrogen peroxide. By lowering the activation energy required for the reaction to proceed, catalysts like manganese(III) oxide increase the rate of the decomposition reaction significantly. This catalytic effect allows the reaction to occur at lower temperatures and faster rates, making it more feasible for practical applications. The Arrhenius equation is:

$$k = A \cdot e^{\frac{-E_a}{RT}}$$

The catalyzed decomposition of hydrogen peroxide finds numerous applications in the real world across various industries. One notable application is in the field of environmental remediation. Hydrogen peroxide is used as an oxidizing agent to remove pollutants and contaminants from soil and water. The catalytic decomposition of hydrogen peroxide by manganese(III) oxide provides an efficient and environmentally friendly method for generating reactive oxygen species, which can then degrade organic pollutants and detoxify harmful substances.

Furthermore, the reaction has applications in the production of various chemicals and materials. Hydrogen peroxide is used in the synthesis of bleaching agents, disinfectants, and pharmaceuticals. By employing manganese(III) oxide as a catalyst, manufacturers can enhance the efficiency and yield of these chemical processes, thereby reducing costs and minimizing waste. Additionally, the decomposition of hydrogen peroxide is utilized in the production of foam plastics and in certain medical and dental applications, demonstrating the versatility and importance of catalytic reactions in modern technology and industry.