

PREPARATION AND PROPERTIES OF OXYGEN

EXPERIMENT 3

OBJECTIVE

The objective of this experiment is to demonstrate various reactions that occur with oxygen, and how concentrations of reactants affect the rate of reaction.

EQUIPMENT AND CHEMICALS

Potassium chlorate (KClO₃)

Manganese dioxide (MnO₂)

Sulfur (S)

Magnesium ribbon (Mg)

Steel wool (Fe)

Wood splints

Small candle

Large test tube

Ring stand and clamp

Pneumatic trough

Rubber stoppers and 90° tubing

Bunsen burner

Gas collecting bottles (6)

Deflagration spoon

Glass plates (2)

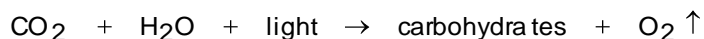
Tongs

Fume hood

Triple beam balance

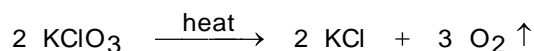
DISCUSSION

Oxygen (O₂) is a diatomic gas (two atoms) that is tasteless, odorless, and colourless. The element oxygen (O) has an atomic weight of 16 and has a density that is greater than air. Oxygen is the most abundant element on earth and is the third most abundant element in the universe (H₂ and He). Air consists of 20-21% oxygen with the rest made up predominately of nitrogen. Most of the oxygen in the earth's atmosphere is produced by photosynthesis in green plants.

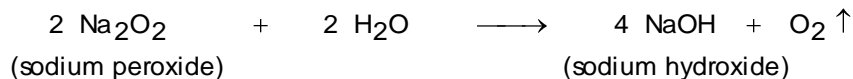


PREPARATION OF OXYGEN IN THE LABORATORY

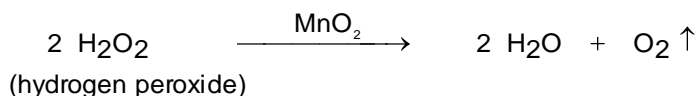
The most frequently used method to prepare oxygen(O₂) in the laboratory is through the decomposition of potassium chlorate (KClO₃). The potassium chlorate is heated and oxygen is evolved leaving KCl.



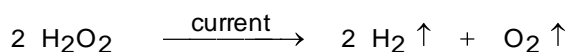
Manganese dioxide (MnO_2) is added to the reaction as a catalyst. A catalyst is a substance which speeds up a reaction but is not changed after the reaction is completed. The MnO_2 , causes the reaction to take place more rapidly at a lower temperature. Alternate methods of producing oxygen in the laboratory are sodium peroxide and water:



Hydrogen peroxide and manganese dioxide:



Electrolysis of water:



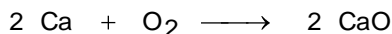
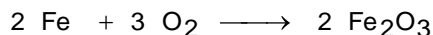
REACTIVITY OF OXYGEN

Oxygen is a very reactive element. It reacts with almost all the other elements with the exception of the noble gases and some of the less reactive metals. The only element that reacts with more elements than oxygen is fluoride (F).

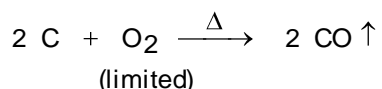
Oxides are compounds of oxygen in which oxygen is attached molecularly to the metal or nonmetal. Normally, oxides contain just the positive cation and oxide (two elements).

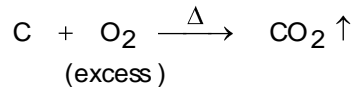
REACTIONS OF OXYGEN

Oxygen forms oxides with many of the elements. Most metals react with oxygen very slowly at room temperatures (i.e., rust which is Fe_2O_3). If the temperatures are increased (burning), the reaction takes place at a more rapid rate.

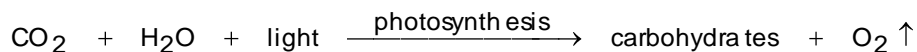


Carbon (wood) reacts with oxygen to produce a carbon oxide. Carbon monoxide (CO) or carbon dioxide (CO_2) can be produced depending on the amount of oxygen (O_2) available.





Carbon monoxide is a poisonous gas that can be burned (oxidized further) to produce carbon dioxide (CO₂). Carbon dioxide is a harmless gas that is used in photosynthesis by plants to produce oxygen.



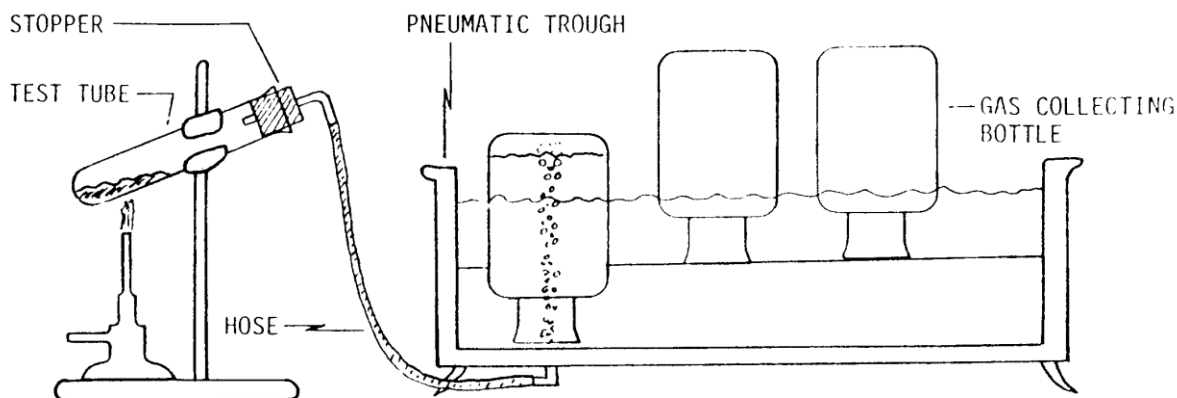
In most cases, if the concentrations (amount) of the reactants are increased, the rate (speed) of the reaction increases. For example, if wood is burned in air (20% oxygen) it burns only so brightly. If it burns in pure oxygen (100%), it burns much brighter and more rapidly.

PROCEDURE

PART A - GENERATION OF OXYGEN

When potassium chlorate (KClO₃) is heated, it decomposes to form potassium chloride (KCl) and oxygen (O₂). The oxygen gas can be collected by the downward displacement of water using a gas collecting bottle and pneumatic trough.

1. Assemble the oxygen generator as shown using a large test tube and stopper.



2. Weigh out approximately 10 grams of KClO₃ and 2 grams of manganese dioxide (MnO₂). The MnO₂ is used as a catalyst (speeds up the reaction).
3. Mix the KClO₃ and MnO₂ together and pour the mixture into the large test tube. Make sure none of the mixture is allowed to come in contact with the rubber stopper.
4. Tilt the test tube at a 30 degree angle and jiggle the tube so as to spread the mixture evenly in the bottom third of the test tube.

5. Attach the rubber stopper and make sure all connections are airtight to prevent leakage of the oxygen gas (O_2).
6. Fill a gas-collecting bottle with water and stopper it. Invert the bottle (stopper and downward) and place it in the water filled pneumatic trough. Remove the stopper. The water should remain in the bottle as long as the neck of the gas-collecting bottle remains underneath the surface of the water.
7. Repeat Step 6 for a total of five (5) gas-collecting bottles.
8. Place the first bottle directly over the delivery hole in the bottom of the pneumatic trough.
9. Carefully and gently heat the $KClO_3$ in the test tube. Increasing or decreasing the temperature of the mixture controls the rate of generation of O_2 . Do not overheat.
10. Bubbles should start rising to the top of the gas-collecting bottle in the pneumatic trough, forcing the water in the bottle downward. The first bottle is not pure O_2 , but a mixture of O_2 and air. Remember which bottle this one is.
11. After the first bottle is filled with gas, place it on the side shelf of the pneumatic trough without moving the neck of the bottle above the surface of the water.
12. Move the other gas collecting bottles over the O_2 gas inlet and fill in sequence.
13. After all the bottles are filled, allow the test tube to cool and rinse the $KClO_3$ down the sink. Do not throw it in the trashcan.

PART B - REACTIONS OF OXYGEN

Using bottles of oxygen, various experiments will be conducted to demonstrate the properties of oxygen (O_2).

1. Light a wood splint and blowout the flame.
2. Insert the glowing splint into the first bottle that contains the oxygen and air mixture. Record your observations on the Report Sheet.
3. Using an extra gas-collecting bottle that was not used for oxygen collection, repeat steps 1 and 2 above. Record your observations on the Report Sheet.

4. Place the second bottle of oxygen over a burning candle and measure the time it takes for the candle to go out. Record your observations on the Report Sheet.
5. Repeat Step 4 using an unused gas collecting bottle that contains just air. Record your observations on the Report Sheet.
6. Place a glass plate underneath the third bottle of oxygen. Place the bottle and plate on top of a bottle of air. Remove the plate so that the mouths overlap. Allow the bottles to stand for two minutes.
8. Cover each bottle with a glass plate and set the bottle on the bench with the mouth of the bottles upward.
9. Quickly insert a glowing splint into each bottle and record your observations on the Report Sheet.



PART C - REACTIONS OF OXYGEN WITH METALS AND NONMETALS

Oxygen will react with iron to produce iron oxide (rust). Magnesium will react with oxygen to produce magnesium oxide (MgO) with the generation of heat and light. Nonmetals, such as sulfur, will also react with oxygen to produce oxides. Sulfur dioxide (SO₂), which is a poisonous gas, is produced in the reaction of sulfur with oxygen.

1. Take a loose wad of steel wool (iron wool) and using tongs, heat the steel wool in a Bunsen burner until glowing.
2. Quickly lower the steel wool (while still glowing) into the fourth bottle of oxygen. Record your observations on the Report Sheet.
3. Repeat Steps 1 and 2 using a bottle of air. Record your observations on the Report Sheet.
4. The following reaction is to be carried out in the fume hood. The produce of this reaction is a poisonous gas.
5. Place a small amount of sulfur (S) in a deflagration spoon and ignite the sulfur by lowering the spoon into a Bunsen burner flame.
6. Lower the burning sulfur into the fifth bottle of oxygen, and record your observations on the Report Sheet.

7. Lower the burning sulfur into a bottle of air, and record your observations on the Report Sheet.
8. Magnesium is a metal that is very reactive. When ignited, the magnesium will react with the oxygen in the air to produce a large quantity of heat and light.
9. Do not look directly into a magnesium (Mg) flame. Large quantities of ultraviolet light are emitted which might damage your eyesight.
10. ***DO NOT PUT THE MAGNESIUM INTO A BOTTLE OF OXYGEN.***
11. Obtain a 5 cm strip of magnesium (Mg) ribbon and, while holding one end of the strip with tongs, light the other end. Record your observations on your Report Sheet.

NAME _____

DATE _____

SECTION _____

**PREPARATION AND PROPERTIES OF OXYGEN
REPORT SHEET
EXPERIMENT 3**

GENERATION OF OXYGEN

1. What happens when heat is applied to the KClO_3 ?
2. Write a balanced equation for the decomposition of KClO_3 when heated.
3. What is the purpose of the MnO_2 in the reaction mixture?

REACTION OF OXYGEN

1. Describe what happens when the glowing splint is lowered into the first bottle of oxygen.
2. What happens when the glowing splint is lowered into the bottle of air?
3. How do you account for the difference between the bottle of air and the bottle of oxygen?

4. How long did the candle burn after lowering the second bottle of oxygen over the candle?
5. What happened to the flame when the bottle of oxygen was first lowered onto the candle?
6. How long did the bottle of air keep the candle burning and what about the flame?
7. How do you account for the difference between the air and oxygen?
8. After the third bottle of oxygen is left standing with the bottle of air, what happens when the glowing splint is lowered into each bottle? How do you account for the difference?
9. Write the balanced equation for the reaction of carbon (C) with excess oxygen.

REACTION OF OXYGEN WITH METALS AND NONMETALS
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1. What happens when the glowing steel wool (Fe) is lowered into the oxygen?
2. What happens when the glowing steel wool is lowered into the air?

3. How do you account for the difference in reaction?

4. Write the balanced equation for the reaction of steel wool (Fe) with oxygen (the product is Fe_2O_3).

5. What happens when the burning sulfur is lowered into the oxygen?

6. What happens when the sulfur is lowered into the air?

7. Account for the difference between the sulfur in the air and oxygen.

8. Write the balanced equation for the reaction of sulfur with oxygen.

9. What happens when the magnesium is ignited?

10. What is the white substance that remains?

11. Write the balanced equation for the reaction of magnesium and oxygen?

QUESTIONS AND PROBLEMS

1. What is the difference between elemental oxygen and oxygen gas? Write the symbols.

2. Which of the following compounds are oxides? (Circle)
 - a) H_2SO_4
 - b) KClO_3
 - c) NaNO_3
 - d) Fe_2O_3
 - e) NaOH
 - f) Cu_2O
 - g) CaCO_3
 - h) MnO_2

3. Using the difference between the rates of the reactions (how fast) just observed, what could you conclude about the concentrations of reactants in a reaction (i.e., pure oxygen vs. air)?