

PREPARATION AND PROPERTIES OF HYDROGEN EXPERIMENT 4

OBJECTIVE

The objective of this experiment is to demonstrate various methods by which hydrogen gas (H_2) may be produced and some of the chemical and physical properties of hydrogen gas.

EQUIPMENT AND CHEMICALS

Vacuum Flask (250 ml)	Wood splints
Rubber stopper (no. 6, one-hole)	Zinc metal (mossy Zn)
Thistle tube	Copper metal (Cu)
Plastic tubing	Magnesium metal (Mg)
Pneumatic trough	Iron metal (Fe - wool)
Glass plate (4" x 4")	Sodium metal (Na)
Laboratory tongs	Copper (II) sulfate (0.1M $CuSO_4$)
Test tube rack	Sulfuric acid (3M H_2SO_4)
1 – 8" Test tube (70 ml)	Hydrochloric acid (6M HCl)
4 – 6" Test tubes (50 ml)	Acetic acid (6M $HC_2H_3O_2$)
Gas collecting bottles (5)	Phosphoric acid (3M H_3PO_4)

DISCUSSION

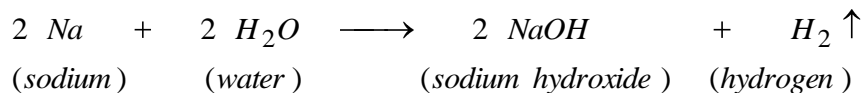
Hydrogen (H_2) is a diatomic gas (two atoms) that is tasteless, colourless, and odourless. The element hydrogen (H) has the lowest atomic weight (1.008 amu), and is the least dense of any known substance. Because of hydrogen's low density ($1/14^{\text{th}}$ the density of air), balloons filled with hydrogen will float. Because of the hydrogen molecule's small size, it will diffuse through many substances.

Hydrogen gas is extremely flammable and will react with oxygen to form water with a release of a great deal of heat. The Hindenburg Zeppelin was destroyed in 1937 because of this reaction. Helium is used nowadays because of its inert behavior.

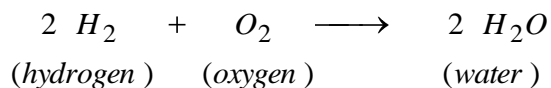
The element hydrogen is the ninth most abundant element on earth, but is the third most common element found in all known compounds. The sun is made up almost entirely of hydrogen gas, which is continually undergoing fusion. Hydrogen gas can be generated in the laboratory by various chemical means.

PRODUCTION OF HYDROGEN USING SODIUM AND WATER

Sodium metal (Na) will react violently with water (H_2O), liberating hydrogen gas (H_2), heat, and light. The reaction is as follows:



If the temperature is hot enough and the hydrogen is mixed with oxygen, combustion can take place resulting in an explosion.

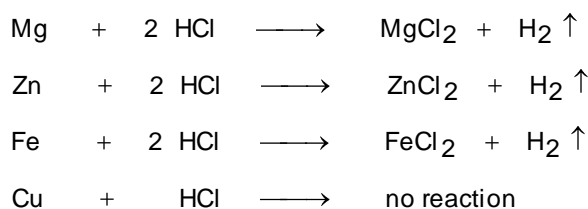


If hydrogen is heated without oxygen, no reaction will take place. This means that hydrogen does not support combustion; it is the fuel.

REACTIONS OF METAL WITH AN ACID TO PRODUCE HYDROGEN

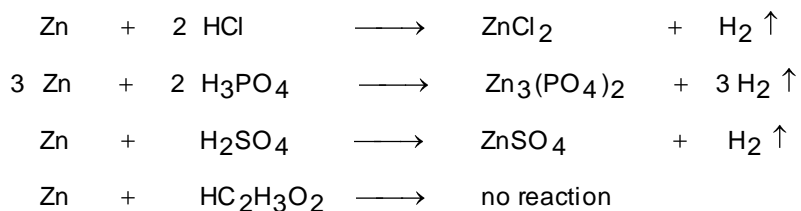
Various metals react with acids to produce hydrogen gas (H₂) and metallic salts. The rate at which the acid reacts with the metals (speed at which hydrogen gas is formed, bubbles) depends upon the reactivity of the metal. The more active the metal is, in regard to hydrogen, the faster hydrogen is produced. This is known as the order of reactivity.

Some common reactions of metals with dilute hydrochloric acid (HCl) are as follows:



REACTION OF ACIDS WITH A METAL TO PRODUCE HYDROGEN

Various acids can also be rated with respect to how fast they react with metals to produce hydrogen. *The stronger the acid, the higher the reactivity (more bubbles).* The reactions are similar to above, producing a metallic salt and hydrogen gas (H₂).



SAFETY PROCEDURES FOR WORKING WITH HYDROGEN AND ACIDS

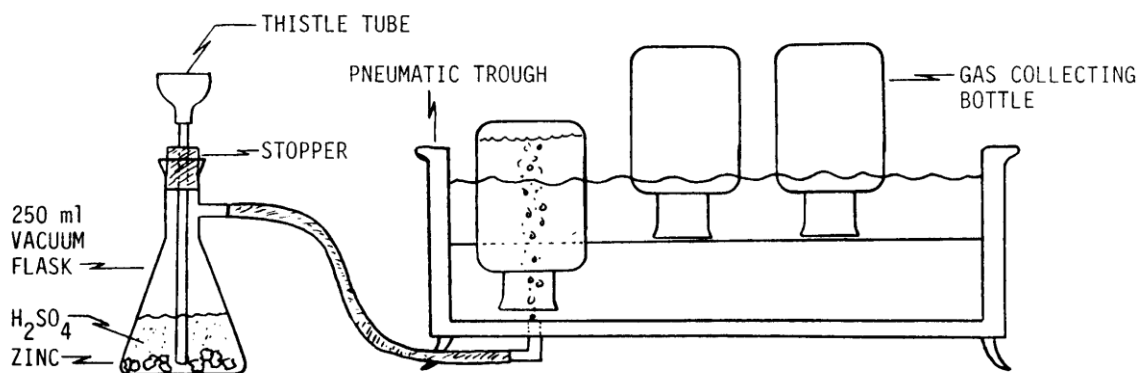
1. Wear safety glasses at all times.
2. Keep open flames away from hydrogen generators.
3. If acid gets on your skin, flush the skin with water.
4. Do not touch sodium metal with your skin.

PROCEDURE

PART A GENERATION OF HYDROGEN

When dilute sulfuric acid ($3M H_2SO_4$) is added to zinc metal (Zn), hydrogen gas (H_2) is evolved. The hydrogen gas can be collected by the downward displacement of water using a gas collecting and a pneumatic trough.

1. Assemble the hydrogen generator using a 250 ml vacuum flask, a plastic thistle tube or funnel, and a stopper.



2. Add approximately eight grams of mossy zinc (Zn) to the bottom of the 250 ml vacuum flask.
3. Make all connections airtight to prevent leakage of the hydrogen gas (H_2).
4. Push the thistle tube to within approximately 0.5cm (1/4") of the bottom of the flask.
5. Add 2 ml of 0.1M copper sulfate ($CuSO_4$) to the thistle tube. The copper sulfate acts as a catalyst in the production of hydrogen gas (speeds up rate of production).
6. Fill a gas-collecting bottle with water and stopper it. Invert the bottle (stopper and downward), and place in the water-filled pneumatic trough. Remove the stopper. The water should remain in the bottle as long as the neck of the bottle remains underneath the surface of the water.

7. Repeat Step 6 for a total of five (5) gas-collecting bottles. Make sure the overflow tube is directed toward the sink. Reserve one bottle for mistakes.
8. Place the first bottle directly over the delivery hole in the bottom of the pneumatic trough.
MAKE SURE NO OPEN FLAMES ARE WITHIN 3 FEET OF THE APPARATUS.
9. Carefully pour approximately 50 ml of 3M H_2SO_4 into the thistle tube. Describe what happens on the Report Sheet.
10. The zinc (Zn) and sulfuric acid (H_2SO_4) should start reacting (bubbling) and giving off H_2 gas.
11. Bubbles should start rising to the top of the gas-collecting bottle in the pneumatic trough forcing the water in the bottle downward.
12. 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. Make sure you distinguish the first bottle from the others, since it contains a mixture of air (initially in the flask) and newly generated hydrogen gas. The rest of the bottles should contain pure hydrogen gas.
13. Move the other gas collecting bottles over the H_2 gas inlet and fill in sequence.
14. After all the bottles are filled, disconnected the vacuum flask from the pneumatic trough, and carefully pour the liquid contents down the sink with running water. Rinse the zinc with water (do not pour zinc into the sink) and place the used Zn into a designated waste container.

PART B - REACTIONS OF HYDROGEN

Using the bottle of hydrogen, various experiments will be conducted to demonstrate the properties of hydrogen gas (H_2). Remember that hydrogen in its pure form will NOT BURN. It will only burn if it is mixed with oxygen. Unless instructed otherwise, do all the experiments in Part B with the mouth of the gas-collecting bottle pointed downward.

1. Grasp a wood splint with a pair of tongs and light the splint.
2. Remove the gas-collecting bottle containing the air-hydrogen mixture (1st bottle), and at arms length, insert the burning splint to the bottom of the bottle. Remember to keep the mouth of the bottle face down.
3. Record your observations on the Report Sheet.
4. Using the second bottle of hydrogen (H_2), insert the burning splint to the bottom of the bottle for three seconds. Record what happens.

5. Bring the splint to the mouth of the bottle. What happens?
6. Reinsert the splint to the bottom of the bottle. What happens? Record your results on the Report Sheet. Why is the result of the first bottle different from the second bottle? Record your observations on the Report Sheet.
7. Take the third gas collecting bottle and place on the lab bench with the mouth of the bottle upward. Let stand for one minute.
8. Bring a burning splint to the mouth of the third bottle. What could have happened to the hydrogen? Record your observations on the Report Sheet.
9. Place a glass plate underneath the fourth bottle of hydrogen and remove from the water.
10. Turn mouth upward with the glass plate on top. Place the empty third gas-collecting bottle on top of the gas plate mouth downward.
11. Quickly remove the glass plate so that mouth of both bottles are connected
12. After two minutes, reinsert the glass plate between the two bottles. Raise the top bottle straight up and apply a burning splint into the mouth of the bottle. Record what happens on the Report Sheet.
13. Invert the bottom bottle so that the mouth is downward. Remove the glass plate and insert a burning splint into the mouth. What happens? Record these observations on the Report Sheet.



PART C REACTION OF SODIUM WITH WATER

Sodium (Na) is highly reactive with cold water. During the reaction, heat and hydrogen are generated. Avoid contact with the sodium and keep the reaction at arms length from you.

1. Fill an 8 inch test tube half full with water and place the tube in a test tube rack.
2. Obtain a pea-sized piece of sodium (Na) from your instructor. Use filter paper to carry the sodium. **DO NOT TOUCH** with your fingers.

- Pick up the sodium with a pair of tongs and at arms length, gently drop the sodium (Na) into the test tube. Note the reaction on your Report Sheet.
- Bring a burning splint to the mouth of the test tube while the reaction is still occurring. What does this indicate? Record your observation on the Report Sheet.

PART D ACTIVITY OF METALS WITH ACIDS

Various metals may be reacted with acids to produce hydrogen. Metals that are more active than hydrogen will replace the hydrogen on the acids to form salts plus hydrogen (H_2) gas.

- Into separate small test tubes, place approximately 5 ml of dilute sulfuric acid (H_2SO_4), dilute hydrochloric acid (HCl), dilute phosphoric acid (H_3PO_4), and dilute acetic acid ($HC_2H_3O_2$). Make sure you label each test tube and only ONE acid is placed in each test tube. Place the test tubes in the test tube rack.
- Obtain four pieces of mossy zinc (Zn) that are about the same size. Carefully drop one piece of zinc (Zn) into each test tube.
- Observe the rate of evolution of gas. The faster the rate of evolution of gas (bubbling), the more active the acid is. Rate the order of reactivity on the Report Sheet.
- Bring a burning splint to the mouth of each test tube and observe the reaction. Does this indicate hydrogen? Record your observation on the Report Sheet.
- Clean the four test tubes and dispose of the used zinc (Zn) into the designated waste container. **DO NOT POUR THE ZINC METAL DOWN THE SINK.**
- Add approximately 5 ml of dilute hydrochloric acid (HCl) to each of the four test tubes.
- Obtain approximately 0.5 grams of each of the following metals: mossy zinc (Zn), magnesium (Mg), copper (Cu), and iron (Fe).
- In rapid succession, carefully drop each metal into separate test tubes that contain the dilute hydrochloric acid (HCl).
- Observe the rate of evolution of gas, and rate the reactivity of each metal with the acid. Rate the order of reactivity (bubbling) on the Report Sheet.
- Bring a burning splint to the mouth of each test tube and observe the result. Is hydrogen being evolved? How do you know? Record your observation on the Report Sheet.
- Clean the test tubes and disposes of the used metals properly (**NOT DOWN THE SINK**).

NAME _____

DATE _____

SECTION _____

**PREPARATION AND PROPERTIES OF HYDROGEN
REPORT SHEET
EXPERIMENT 4**

GENERATION OF HYDROGEN

Describe what happens when the dilute acid is added to the mossy zinc.

REACTIONS OF HYDROGEN

1. Describe what happens when the burning splint is rapidly inserted into the first bottle that contains a mixture of hydrogen and oxygen.

2. When hydrogen and oxygen burn, what product is formed? Write the chemical equation for this reaction.

3. Describe what happens when the burning splint is rapidly inserted into the second bottle of hydrogen.
4. What was the result of inserting the burning splint into the second bottle different than inserting the splint into the first bottle?
5. Does hydrogen support combustion? Explain.
6. Describe what happens when the burning splint is brought to the mouth of the third bottle after setting mouth upward.
7. Explain the above result.
8. When the burning splint is brought to the mouth of the top bottle (previously empty), what happens?
9. What happens to the bottom bottle?
10. Explain these results.

REACTION OF SODIUM METALS WITH WATER

1. Describe what happens when the sodium comes in contact with water.
2. What gas is being produced?
3. Write the chemical equation for this reaction.
4. Describe what happens when the burning splint is brought to the mouth of the test tube, and what can you conclude from this?

ACTIVITY OF METALS WITH ACIDS

1. After observing the rate of evolution of gas from the reaction of the mossy zinc with the four acids, number the acids in order of reactivity (1-4), and write the chemical equation (1 being most active and 4 being the least active).

<i>REACTIVITY</i>		<i>EQUATION</i>
_____	<i>HCl</i>	<i>Zn + HCl →</i>
_____	<i>H₃PO₄</i>	<i>Zn + H₃PO₄ →</i>
_____	<i>H₂SO₄</i>	<i>Zn + H₂SO₄ →</i>
_____	<i>HC₂H₃O₂</i>	<i>Zn + HC₂H₃O₂ →</i>

2. How do you know that hydrogen is being evolved?

3. After observing the rate of evolution of gas from the four metals in dilute HCl, number the metals in order of reactivity (1-4), and write the chemical equation.

REACTIVITY

EQUATION

_____ *Mg*



_____ *Zn*



_____ *Fe*



_____ *Cu*



4. How do you know hydrogen is being evolved?