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Title: Physical Science / Chemistry Demos

Subject: Combustion – oxidation by oxygen and chorine

Grades: 8-12

Description: These four demos will be performed during the chemistry unit of Physical Science classes. The demos illustrate several important chemical concepts. Combustion, for example, is a form of oxidation/reduction reactions, and the Law of Conservation of Mass is observed in the formation of reaction products. Additionally, the periodic trend of high electronegativity is observed in the combustion reactions of both oxygen and chlorine due to their locations on the periodic table. All of the demos are real attention getters and should stimulate the students' interest in chemistry.

Length: 1 class period for oxygen family / 1 class period for halogens

Objectives: Students will develop an understanding that:

1. Air is a mixture of gases. The main gas is nitrogen with only 21% oxygen.
2. Combustion reactions are much more vigorous in pure oxygen than in air.
3. Sparkler fireworks are based on burning iron or steel with an oxidizer.
4. Combustion in pure oxygen produces more heat and increases burn rates.
5. Chlorine is a dense yellow gas.
6. Like oxygen, chlorine is a very reactive element due to its electronegativity.
7. Combustion of steel wool can take place in chlorine as well as in oxygen.

Materials and Procedures: {included in attached demo write-ups}

Scientific Explanations: {included in attached demo write-ups}

Assessment: Every student will complete a "Demo Report" which includes the following information for each reaction:

1. a description of the reaction
2. the balanced chemical equation
3. a list of reactants and products
4. the reaction type (classification)
5. a prediction of what substances might produce similar reactions

Kansas Science Standards:

Standard 2A, Benchmark 2, Indicator 2: The student understands the periodic table lists elements according to increasing atomic number. This table organizes physical and chemical trends by groups, periods, and categories.

Standard 2A, Benchmark 2, Indicator 3: The student understands chemical bonds result when valence electrons are transferred or shared between atoms. Ionic compounds result from atoms transferring electrons. Molecular compounds result from atoms sharing electrons.

Standard 2A, Benchmark 3, Indicator 1: The student understands a chemical reaction occurs when one or more substances (reactants) react to form a different chemical substance(s) (products).

Standard 2A, Benchmark 3, Indicator 2: The student understands there are different types of chemical reactions all of which demonstrate the Law of Conservation of Mass (e.g., synthesis, decomposition, combustion, single and double replacement, acid/base, and oxidation/reduction).

Combustion of Steel Wool in Pure Oxygen (Demo 1)

Introduction/Explanation:

Students are surprised to see that very fine steel wool will burn slowly with a red glow in air; however, the combustion of steel wool in pure oxygen is close to spectacular. This demo should remind everyone of the Fourth of July. When the glowing steel wool is immersed in pure oxygen the rate of combustion increases rapidly forming iron oxide in a shower of sparks and beads of hot molten iron.

Procedure:

The oxygen gas is prepared by the decomposition of 3% hydrogen peroxide instead of heating potassium chlorate, as it's much safer. The method of oxygen collection is a standard procedure for gas collection by water displacement. An Erlenmeyer flask with a side arm spout is used as the gas generator.

Step 1 Fill several collection bottles with water and seal them with rubber stoppers.
2 Invert the collection bottles in a pan of water and remove the stoppers.
3 Place approximately 200 ml of H_2O_2 in the side arm flask and attach a rubber or vinyl hose to the spout. Submerge the free end of the hose into the pan of water with the inverted bottles.
4 Place a small amount of MnO_2 catalyst on the bottom of a solid rubber stopper which fits the mouth of the side arm flask.
5 Carefully and quickly seal the flask with the stopper. When the stopper is turned right-side up the catalyst falls into the peroxide as the stopper plugs the flask.
6 Allow the first bubbles of gas produced to escape because they are air bubbles, not oxygen. Begin collecting oxygen gas after the air has been purged from the generator flask by placing the inverted collection bottles over the free end of the hose. Stopper the bottles of oxygen while they are still inverted. Several collection bottles of oxygen can be collected from 200 ml of 3% H_2O_2.

a.) Materials:

1. side arm Erlenmeyer flask with rubber stopper
2. glass collection bottles with rubber stoppers
3. large flat pan for water
4. rubber or vinyl hose
5. 3% hydrogen peroxide
6. manganese dioxide
7. extra fine steel wool, tongs, and matches

b.) Safety: As always, wear safety glasses and use a long pair of tongs to hold the steel wool in the bottle of oxygen. Additionally, the bottle gets very hot during the reaction and the glass may crack.

c.) Disposal: When sufficiently cooled off, the oxidized steel wool can be thrown in the trash, and the MnO_2 can be filtered and reused.

Reflection:

Even at the high school level many students still think that the atmosphere consists mainly of oxygen! As always, students anticipate an explosion, but will certainly be satisfied by lots of sparks. Collect extra bottles of oxygen for additional demonstrations while the apparatus is set up.

Source:

Summerlin and Ealy, *Chemical Demonstrations, Volume 2*, 1988, p.43-44

Combustion of a Candle in Pure Oxygen (Demo 2)

Introduction/Explanation:

The oxygen for this demonstration is produced by the decomposition of 3% hydrogen peroxide, as described in the previous demonstration (Combustion of Steel Wool in Pure Oxygen). Two candles are burned simultaneously, one in a bottle of air and one in a bottle of oxygen. Heat, luminosity, burn rates, and burn times of the two candles are compared. The candle in the bottle of air is extinguished much sooner than the candle in pure oxygen since air only contains around 21% oxygen. Additionally, the candle in pure oxygen burns much brighter and hotter than the candle in air. The intense heat is detectable not only by the amount of candle melted, but also by the temperature of the bottle after combustion.

Procedure:

a.) Materials:

1. two equal size glass bottles
2. two small birthday candles
3. pure oxygen

b.) Safety:

As always, wear safety glasses and let the bottles cool before handling after the demonstration. The bottle with pure oxygen gets very hot during the reaction and the glass may crack.

c.) Method:

Oxygen is produced using the method described in demo 3. Light two equal size candles at the same time and turn out the room lights. Simultaneously place a bottle of air over one candle and a bottle of oxygen over the other candle. Observe the length of burn times before the flames extinguish and compare the light intensities. Also, compare the candle heights, wax puddles, and bottle temperatures after the reactions.

Reflection:

This demonstration could be done quantitatively by massing the candle wax before and after, if the candles were placed on paper and an appropriate balance was available. The light intensity could also be measured quantitatively with photometers, as long as an opaque divider separated the candles.

Source:

To the best of my knowledge, this is a Lauritzen original demonstration.

Preparation of Chlorine Gas (Demo 3)

Introduction/Explanation:

Many students have the misconception that chlorine is the white powder that is added to swimming pools as a germicide. They are surprised to see that it is really a yellowish gas. Likewise, most students think oxygen is necessary for combustion because they don't understand the concept of oxidation-reduction as an exchange of electrons. In this demonstration students will observe not only the physical characteristics of chlorine, but also one of its chemical properties, the ability to oxidize other substances.

Procedure:

The chlorine gas is prepared by reacting laundry bleach with hydrochloric acid. The gas generating apparatus is a side arm Erlenmeyer flask with a pipette bulb attached to a one hole rubber stopper used to plug the top of the flask. The HCl is stored in the pipette bulb and squeezed into the flask after the stopper is in place. This modification was necessary due to the huge chlorine loss that resulted by following the demo directions. It's impossible to stopper the flask quickly enough to prevent the chlorine from escaping while introducing the acid. The bulb system, however, solves this problem.

Step 1 Attach a short piece of glass tubing to the pipette bulb and another through the one hole stopper.
2 Pour 100 ml of bleach into the side arm flask and fill the pipette bulb with HCl.
3 Position the flask on an iron ring half way up the ring stand and clamp the neck of the flask to the stand. Then attach a section of plastic hose to the side arm spout, long enough to reach the base.
4 Attach a short piece of glass tubing through one of the holes in the two hole collection bottle stopper and attach the flask hose to this glass tube.
5 Place the two hole stopper in a collection bottle and position the bottle lower than the side arm flask, allowing the dense chlorine gas to fall down into the collection bottle through the tube.
6 Connect the pipette bulb and one hole flask stopper with a short section of flexible tubing and squirt the hydrochloric acid into the flask by squeezing the pipette bulb.
7 The yellowish-green chlorine gas will displace the air in the collection bottle by forcing it out the second hole in the stopper. Stopper the collection bottles with solid stoppers when they are filled.

a.) Materials:

1. side arm filter flask with one hole stopper
2. gas collection bottles with two hole and solid stoppers to fit them
3. pipette bulb
4. glass tubing and plastic hose to fit
5. laundry bleach
6. 1.0M HCl
7. ring stand, rings, and clamps

b.) Safety:

This whole activity should be performed in a fume hood. In addition to HCl and bleach being poisonous, both compounds are tissue irritants and hydrochloric acid is corrosive. Both safety glasses and rubber gloves should be worn.

c.) Disposal:

If excess HCl is added, this can be neutralized with NaOH and the resulting salt solution of NaCl is satisfactory for drain disposal.

Source:

Summerlin and Ealy, *Chemical Demonstrations, Volume 1,* 1988, p.13

Combustion of Steel Wool in Pure Chlorine **(Demo 4)**

Introduction/Background:

Students are surprised to see that very fine steel wool will burn not only in oxygen, but also in chlorine to produce very dense brown iron chloride smoke. Just as oxygen reacts with burning steel wool by removing electrons from elemental iron to produce iron oxide, chlorine and steel wool react to produce iron chloride. The reaction is vigorous and produces a bright orange glow with lots of heat and smoke instead of a shower of sparks.

Procedure:

a.) Materials:

1. glass bottle or Erlenmeyer flask
4. metal tongs
5. pure chlorine
6. fine steel wool

b.) Safety: Follow the safety procedures recommended in demo 3. As always, wear safety glasses and use a long pair of tongs to hold the steel wool in the bottle of chlorine. Additionally, the bottle gets very hot during the reaction and the glass may crack. Inspect it carefully and handle with care.

c.) Method: Chlorine is produced using the method described in demo 3. Place a piece of steel wool in the metal tongs and light it. Hold the burning steel wool in the bottle of chlorine gas and watch the combustion continue in the absence of oxygen. The brown smoke is iron chloride. Be sure to perform this demo in a fume hood.

d.) Disposal: Follow the disposal procedure in demo 3 for the byproducts of chlorine gas production. The solid iron chloride can be disposed of in a solid waste landfill as per ***Flinn Method #26a.***

Reflection:

This demo should help students remember the reactive nature of halogens. Ask students to predict how fluorine and bromine might react with burning steel wool.

Source:

To the best of my knowledge this is a Lauritzen original demonstration.