



The Patronus *Preparer's Version*

Introduction

The Patronus chemistry demonstration showcases the fascinating chemistry behind metal displacement reactions and the flammability of hydrogen gas. The primary reaction involves dissolving cupric chloride (CuCl_2) in a highly acidic solution of 6 molar hydrochloric acid (HCl), which facilitates the reaction between aluminum (Al) and copper(II) ions. When aluminum foil is dropped into the solution, a displacement reaction occurs, where the more reactive aluminum displaces copper from its salt. Simultaneously, aluminum reacts with hydrochloric acid in a separate reaction to produce aluminum chloride (AlCl_3) and hydrogen gas (H_2). Hydrogen gas, being highly flammable, accumulates at the surface of the liquid, and when ignited, produces a brilliant blue flame.

Safety Hazards

- Personal Protective Equipment:
 - Safety glasses/goggles
 - Nitrile gloves
 - Work Gloves
 - Chemical & flame retardant lab coat
 - Blast shield(s)
- Physical Hazards
 - Utilizes an open flame, produces sparks, and the flask will be extremely hot; may cause serious burns to skin.
 - Concentrated hydrochloric acid may be corrosive to metals.
 - Copper(II) chloride is toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment, and is hygroscopic (absorbs moisture from the air).
 - Hydrogen gas is extremely flammable.

● Chemical Hazards

- Copper(II) chloride is harmful if swallowed and causes eye, skin, and respiratory tract irritation.
- Concentrated hydrochloric acid causes severe skin burns and eye damage and may cause respiratory irritation.

Materials

- 12L round-bottom flask (with cork stand)
- 10 g Copper(II) chloride, dihydrate
- 500 mL 6M Hydrochloric acid
- Aluminum foil
- BBQ and/or long matches

Safety Data Sheet(s)

- [Copper\(II\) chloride, dihydrate](#)
- [Hydrochloric acid, concentrated \(12M\)](#)
- [Aluminum foil](#)
- [Hydrogen](#)



Procedure

1. Measure 500 mL of 6M hydrochloric acid and add it into the flask.
 - a. Measure 250 mL of concentrated hydrochloric acid (12M) and add it to 250 mL of deionized water. *Always add acid to water, not the other way around!*
2. Measure 10 g of copper(II) chloride and add it into the acidic solution in the flask. Swirl the flask carefully to dissolve as much of the solid as possible.
3. Take a 1' x 1' piece of aluminum foil and crumple it loosely into balls.
 - a. You can choose to either do 3–4 larger balls (about 1.5" diameter) of foil or 15 smaller balls (about 0.5" diameter) of foil. The more surface area for the reaction, the better.
4. Make sure the blast shield is between the performer and the flask and that the performer can easily reach to ignite the gas.
5. Stand behind the blast shield and quickly drop the aluminum foil balls into the flask.
6. As soon as hydrogen gas begins generating, hold a BBQ lighter or long match over the mouth of the flask to ignite the gas and step back. Allow the gas to burn out completely. Wear a work glove to protect your hand(s) while handling the lighter/match and hot glassware.

Tips & Tricks

- Having a second person comes in handy! One person can pour the aluminum foil balls into the flask and swirl them around, and the other can be lighting the match and ready to ignite the hydrogen as soon as it starts generating.
- Sometimes, the flames will come up and out of the mouth of the flask. Be careful to stand a good distance away and do not approach the flask until it is completely extinguished.
 - Experimentally, using more (but smaller) foil balls mitigated this issue and generated a large volume of gas that, when ignited, kept the flame mostly in the round body of the flask. With the larger balls, the flame often came out of the top – but could be repeatedly reignited.
- Ensure that the flask is stabilized before igniting it. This can be done with a cork stand or a cork stand and ring stand together.

Clean-Up Procedures

1. Allow the flask to cool and the reaction to stop on its own before cleaning.
2. Fill a carboy or waste bottle with a volume of deionized water equal to or greater than the volume of liquid in the flask. This will be to dilute the products – but the products will still be acidic, so remember to add the acidic waste into deionized water (*acid to water, not the other way around!*).
3. Pour the liquid waste into the carboy or waste bottle of deionized water.
4. Rinse the labware thoroughly with deionized water at least three times, emptying the runoff into the waste stream.
5. Clean thoroughly with laboratory detergent.
6. Leave the carboy or waste bottle open in a fume hood for at least several hours to prevent any residual gas generation from compromising the waste container by building pressure.