The University of Texas at Austin
Department of Chemistry
College of Natural Sciences

Flame Tests – Atomic Emission Spectra

Preparer's Version

Introduction

Electrons, like most matter, will occupy the lowest energy state possible at rest – this is the configuration that offers the most stability, and is known as the *ground state*. In the context of atomic orbitals, this means that an electron will tend to be housed in the lowest energy orbital available to it. When energy is absorbed by that electron, however, it can jump up to a higher energy orbital; this energy jump is known as *excitation*. An excited electron won't stay excited forever, though – eventually, the electron will want to return to the ground state. In order to drop back down, the electron needs to release the energy it absorbed to become excited in the first place; this release, which is characterized by the magnitude of the energy gap between the excited state and ground state, is called *emission*. Electromagnetic radiation of a wide variety of energies can be emitted through this process – infrared waves, microwaves, x-rays, ultraviolet rays – depending on how much energy is absorbed by the given electron. What's most exciting for the classroom is when this emission falls within the visible light spectrum, energies of light directly relating to wavelengths we perceive as colors. Flame tests are used to showcase the vibrant spectrum of unique emissions different elements can give off with similar quantities of absorbed energy; each element has a special configuration of its orbitals and energy levels that are so specific to it that it's considered an identifying feature.

Safety Hazards

- Personal Protective Equipment:
  - Safety glasses/goggles
  - Nitrile gloves
  - Chemical & flame retardant lab coat
  - Fire extinguisher
- Physical Hazards
  - Utilizes an open flame; may cause serious burns to skin.
  - Propane is an extremely flammable gas.
  - Gasses under pressure may explode if heated and/or form explosive mixtures with air.
- Chemical Hazards
  - Strontium chloride may cause serious eye damage and respiratory irritation.
  - Copper(II) chloride may cause serious eye damage, skin irritation, and is harmful if swallowed or in contact with skin.
  - Propane may displace oxygen and cause rapid suffocation.

Materials

- Blow torch
- Wooden splints soaked in various metal salt solutions.
- Metal tray
- Watch glass for each metal salt demonstrated
- Metal forceps
- Large beaker
- Squirt bottle of deionized water.

Safety Data Sheet(s)

- Propane
- Sodium chloride
- Potassium chloride
- Strontium chloride
- Copper(II) chloride

Procedure

1. Label each 500 mL plastic bottle with the respective salt and concentration. Be sure to add what date the solution was made and note any relevant hazards on the container.
2. Make saturated solutions for each inorganic salt at room temperature (approximately 20ºC) in 500 mL plastic bottles.
    a. *Sodium chloride*
        i. Add 89.75 g of sodium chloride to 250. mL of deionized water. Stir until fully dissolved. This will come out to an approximately 6.14 M solution.
    b. *Potassium chloride*
        i. Add 86.75 g of potassium chloride to 250. mL of deionized water. Stir until fully dissolved. This will come out to an approximately 4.66 M solution.
    c. *Strontium chloride*
        i. Add 265.0 g of strontium chloride hexahydrate to 250. mL of deionized water. Stir until fully dissolved. This will come out to an approximately 3.98 M solution.
    d. *Copper(II) chloride*
        i. Add 287.5 g of copper(II) chloride dihydrate to 250. mL of deionized water. Stir until fully dissolved. This will come out to an approximately 6.75 M solution.
3. Place wooden popsicle sticks into each inorganic salt solution, and cap the bottles. Use two sticks per demonstration.
4. Soak the wooden popsicle sticks *at least* overnight.
5. Fill a 1 L plastic bottle with deionized water about halfway. Label the bottle “Waste Container”, and cap the bottle.
6. Using a small propane blowtorch, ignite a flame and place each popsicle stick into the base of the flame. Sodium chloride should be orange, potassium chloride pink/lilac, strontium chloride red, and copper(II) chloride green.
7. Used sticks should be placed in the waste container with the burnt side of the stick submerged.
8. Ensure that the propane torch is entirely turned off (no more gas is coming out) before transporting!

Tips & Tricks

- For best results, soak the popsicle sticks for several days with periods of drying in between.
    - DAY 1: Place popsicle sticks into containers, and soak overnight.
    - DAY 2: In a fume hood or isolated area, place sticks on paper towels to dry. Be sure to separate your sticks by solution! You should have four different paper towels in order to prevent contamination. Allow to dry completely. Place back in solution to soak overnight.
    - Repeat DAY 2 process for 3 – 5 days.
- For the most visually appealing flame, hold the stick flat to the flame and at a 90º angle. The flame should be long and not blocked by the stick.

Clean-Up Procedures

- Ensure the propane tank is entirely turned off and no gas is being released. Remove the torch head from the canister and store away. Be sure to store the propane canister in a flammable cabinet.
- Remove wooden sticks from waste container and dispose in trash.
- Pour out water in sink. Thoroughly rinse the plastic waste bottle and clean with lab soap and water.
- The inorganic salt solutions can be preserved for several months and do not need to be immediately disposed of.