

## Fireworks Balloons – 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.
  - Gases 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.
  - Magnesium powder, when in contact with water releases flammable gases which may ignite spontaneously; catches fire spontaneously if exposed to air
  - Hydrogen gas is extremely flammable.

#### Materials

- 5 Qualatex balloons
- BBQ lighter
- Hydrogen gas, compressed
- Sodium chloride solution, saturated
- Potassium chloride solution, saturated
- Strontium(II) chloride solution, saturated
- Copper(II) chloride solution, saturated
- Magnesium powder
- Disposable syringes/pipettes
- Candlestick (taper candle attached to wooden dowel)

#### Safety Data Sheet(s)

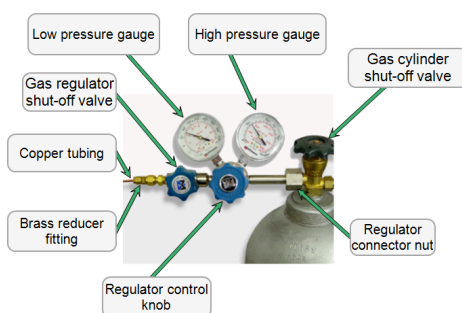
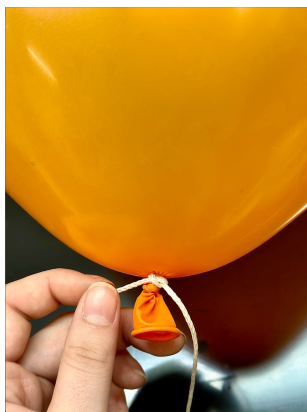
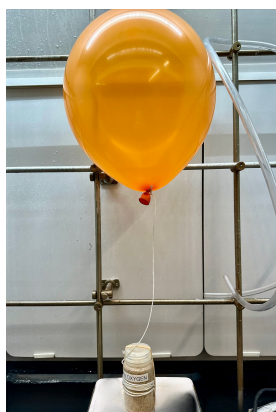
- [Sodium chloride](#)
- [Potassium chloride](#)
- [Strontium chloride](#)
- [Copper\(II\) chloride](#)
- [Magnesium powder](#)
- [Hydrogen, compressed](#)



## Procedure

1. Make saturated solutions for each inorganic salt at room temperature (approximately 20 °C) in 1.0 L plastic bottles. This quantity will last a long time!
  - a. *Sodium chloride*
    - i. Add 357.0 g of sodium chloride to 1.000 L of deionized water. Stir until fully dissolved. This will come out to an approximately 6.22 M solution.
  - b. *Potassium chloride*
    - i. Add 254.0 g of potassium chloride to 1.000 L of deionized water. Stir until fully dissolved. This will come out to an approximately 3.41 M solution.
  - c. *Strontium chloride*
    - i. Add 1,060 g of strontium chloride hexahydrate to 1.000 L of deionized water. Stir until fully dissolved. This will come out to an approximately 3.98 M solution.
  - d. *Copper(II) chloride*
    - i. Add 757.0 g of copper(II) chloride dihydrate to 1.000 L of deionized water. Stir until fully dissolved. This will come out to an approximately 4.44 M solution.
2. Place the correct regulator on your compressed gas cylinder of hydrogen.
  - a. Thread the regulator's CGA connection onto the gas cylinder. Once you cannot thread it any more by hand, tighten it with a wrench to prevent leaking.
  - b. Ensure that the regulator outlet valve is closed before opening the cylinder.
  - c. Open the cylinder by turning the valve handwheel to the left. You should hear the needles on the two gauges jump. If you have Linde's new EZ tanks, all you will need to do to open the cylinder is lift the red lever.
3. Take ~1 to 2 mL of one of your inorganic salt solutions using a disposable pipette or disposable syringe. Fit the end into the balloon you'll be using, and squirt into the body of the balloon. Work the solution around the inside of the balloon by rubbing the exterior for a moment.
  - a. For magnesium powder, weigh out 2.5 g of magnesium powder. Using a plastic funnel fitted into the balloon, carefully pour the magnesium into the balloon. Be careful not to spill powder anywhere!
4. Wrap the open end of your balloon to the regulator's brass reducer fitting (the valve where the gas will release). Tighten it as much as possible by pinching one side of the balloon.
5. Slowly open the regulator shut-off valve to fill the balloon with gas. Be careful not to overinflate it!
6. While still holding the balloon in place, close the regulator shut-off valve.
7. Pinch off the entire stem of the balloon to prevent the gas from leaking and pull it off of the regulator. Tie the balloon tightly.
8. Tie the string of your weight *above* the knot you tied on the balloon. If the balloon is held upright (balloon stem on the bottom), this means the string should be tied between the knot of the balloon and the body of the balloon.
9. Wrap the string around the weight to more easily transport the balloon. You can use a rubber band over the string on the weight to fasten it in place and prevent unraveling.
10. Label the balloon with which salt is inside of it using a Sharpie. Write gently!
11. Close the cylinder by turning the cylinder valve to the right (or snapping the red lever of an EZ tank down), then slowly releasing the pressure within the regulator by opening the regulator shut-off valve and closing it when finished releasing residual gas. Carefully loosen the connector nut with a wrench until you're able to unthread the rest of the way by hand. Be sure to carefully place the safety cap back on your tank.
12. Repeat these steps for the balloon with the other salts.
13. For transportation, cover all balloons with a trash bag to prevent them being exposed to potential ignition sources, including static electricity. The balloons should be set up *at least* 4 feet apart and a full straight arm + candlestick extension up. Magnesium should be performed separately.

### Set-Up Reference Photos



### Tips & Tricks

- For best results, make sure your salt solutions are saturated or, better yet, supersaturated! The quantities above are approximate according to solubility data, but adjust accordingly to ensure a saturated solution.
  - To supersaturate, heat deionized water and slowly add more and more salt, and allow it to slowly cool to room temperature. Some salt may crystallize out of solution if it is supersaturated.
- The larger the balloon, the bigger the flame! But be sure to not *over* inflate them to the point where they're in danger of popping.
- Volumes by Balloon Size:
  - **For 12" Balloons:** 1.50 mL of each saturated salt solution (1.75 mL for potassium chloride), 2.0 g Magnesium powder
  - **For 16" Balloons:** 2.00 mL of each saturated salt solution (2.50 mL for potassium chloride), 2.5 g Magnesium powder
- Suggested order for best visual progression of colors:  $\text{NaCl} \rightarrow \text{SrCl}_2 \rightarrow \text{KCl} \rightarrow \text{CuCl}_2 \rightarrow \text{Mg}$
- Be aware! There's a chance that not all of the magnesium powder will ignite. Be sure to warn the demo performer to stand far away from the magnesium balloon and to be careful not to inhale any powder.

### Clean-Up Procedures

1. Make sure all gas cylinders used are correctly closed as described in the procedure above. Safety caps should always be secured on gas cylinders when they are not in use.
2. Pop the balloons, cut the string where the knot is tied, and discard the balloon in the trash.