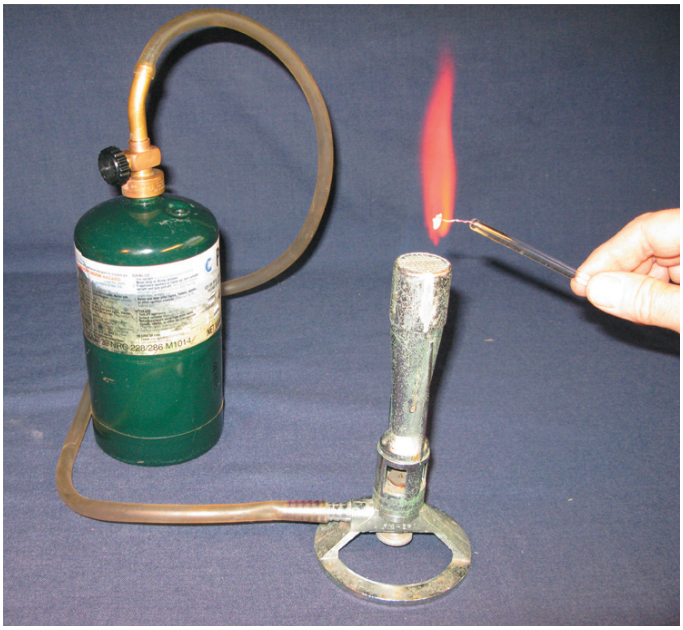
"Minerals that do things…"

Hands-on demonstrations of mineral properties

Provided for the Mineral Information Institute by Andrew A. Sicree, Ph.D.

Tested by Fire



Object: Everyone loves fireworks and students often wonder how fireworks get their rich colors. Using the **flame test**, students can produce their own **colored flames** and learn about fireworks, minerals, and their common elements.

Procedure description: Students use a hammer and chisel to break small chips off specimens. Chips are crushed with a mortar and pestle and the dust placed in a Petri dish. A few drops of 10% hydrochloric acid are dropped on the dust and stirred around. A platinum wire loop is dipped in the mixture; a small amount of solution adheres to it. Placing the loop in the flame, students see a colored flame for a few seconds. Some elements give characteristically unique colors in the flame and thus the flame test yields clues to the elements making up a tested specimen. Clean the loop between tests to avoid cross-contamination (clean the loop by dipping it in clean acid and then heating it in the flame, repeating until no more colors are generated by the loop).

Specimens to test

Malachite; strontianite; celestine; calcite; barite; halite; sylvite or salt substitute (KCl type).

Equipment needed: Safety glasses or goggles; hammer; chisel; 10% hydrochloric acid in small dropper bottle; mortar and pestle (or use a steel plate and small hammer); Petri dishes or small plastic cups; platinum wire loops mounted on glass rods (or long tweezers – a separate pair for each mineral tested); source of flame (Bunsen burner attached to gas jet, an alcohol lamp with alcohol, or a propane torch attached to a gas cylinder); fire extinguisher.

Scientific discussion: Metal cations, dissolved and then ionized in a hot flame, will give off light that is characteristic of the element. The actual color we see is from the combination of a number of discreet bands of colored light; these bands are created by the energy states available to the element's electrons. You can't see the separate bands without a spectroscope, but observing the color a mineral produces in a flame with the naked eye still gives clues to the elements in the mineral.

Strontianite (strontium carbonate) gives a very rich crimson color in the flame, the same crimson color seen in red fireworks. This flame test never fails to impress students.

Barite (barium sulfate) gives a yellowish-green flame.

Calcite (calcium carbonate) yields a yellowish-red flame, often described as a "brick red" as opposed to the crimson of a strontium flame.

Copper can give a green or blue flame dependent upon the cation. In the Cu(II) state (Cu^{+2}) copper gives a strong green flame; in the Cu(I) state (Cu^{+1}), it gives a blue flame.

Malachite is copper(II) carbonate hydroxide with the copper in the +2 state. Thus, it gives a green flame, although in practice you will sometimes see splotches of blue flames as well, especially when using hydrochloric acid to dissolve the malachite.

Sodium gives a very strong yellow color that overwhelms other colors.

Testing for **potassium** is difficult because the lilac color of potassium's flame can't be seen in the presence of sodium. The mineral sylvite (potassium chloride) should give a lilac purple flame but contamination from sodium is difficult to avoid.

Try testing "salt substitutes" sold in the grocery store to see if these are really sodium-free; most of these salt substitutes are potassium chloride (sylvite) rather than "salt" (i.e., halite, or sodium chloride). Sodium is a very common element as it is often difficult to keep samples (and tools) completely free of salt contamination. (There may even be sodium contaminating your 10% hydrochloric acid solution if care was not taken when it was made up.)

Additional possibilities: You may be asked by a student how you know that the metal cation is causing the flame color and not the other ions in the mineral. This is a good question. One way to answer the question is to demonstrate that two different minerals can give the same flame coloration. For instance, if you do a flame test on strontianite (which is a white mineral with an acicular habit) you get a crimson flame. Strontianite is strontium carbonate, $SrCO_3$. If you test celestine (typically a light-blue mineral with more tabular crystals) you will likewise generate a crimson flame. Celestine is strontium sulfate, $SrSO_4$; strontium is common to both minerals. (An observant student will note that oxygen is common to both minerals, too, but a moment's thought will lead one to ask why, if oxygen causes the crimson color, the flame isn't always crimson? After all, the flame burns oxygen from the atmosphere continuously.)

If you don't have a mortar and pestle or a platinum loop tester, alternatives exist. You can use a hammer and a piece of metal to powder small amounts of softer minerals (such as those listed here). An alternative to the platinum loop is to use long-handled tweezers. In this case, don't powder the mineral, just break it into small chips. Then use the point of the tweezers to pick up a small chip, dip it in a drop of acid, and then stick it into the flame. This doesn't work as well as the platinum loop. The acid and the flame's heat will corrode the metal of the tweezers, but you can use them for a number of tests if you clean them promptly. I dedicate a separate pair of tweezers to each mineral being tested to avoid cross-contamination problems.

Notes for demo tables: If you are doing demonstrations for large numbers of visitors (such as at a booth at a trade show), I've found that it is simplest to use a propane torch with a quick-start valve and piezoelectric igniter. This allows me to ignite the flame only when I'm immediately ready to do the flame test. I don't have to leave the flame on, continuously generating fumes and risking an accident. Using the short and stout propane cylinders rather than the long and skinny ones gives the torch more stability, too.

I also pre-crush some malachite and strontianite and store the powders in used plastic film canisters. Pour out a little of the powder, wet it with a few drops of acid, stir it with the platinum loop, then let a visitor insert the loop into the flame. They hold the loop but you control the flame for safety's sake.

Special notes: It is always a good idea to have a fire extinguisher handy when working with flames. Used and unwanted acid can be neutralized with baking soda and washed down a drain.