Light Producing Chemical Reactions

Chemical reactions, especially those involving metals, can give off heat and light energy. This demonstration uses three parts to illustrate these energy exchanges: Part I, the burning of group IA, IIA & Cu salts; Part II, chemiluminescent light sticks; Part III, the burning of Magnesium metal in carbon dioxide.

Materials:

- Insulated container (i.e. small ice chest) for Dry Ice (*you provide*)
- Large aluminum serving tray (or equivalent) for burning Mg in Dry Ice (*you provide*)
- One pair of light cloth or leather gloves for handling the Dry Ice (*you provide*)
- Pencil, metal rod, or butter knife (not plastic or cardboard) (*you provide*)
- Paper towels for cleaning up any spills (*you provide*)
- Propane Torch (*we provide – you must return!!*)
- Spray bottle solutions of Li, Na, K, Ca, Sr, and Cu salts (*we provide – you must return!!*)
- Several plastic safety glasses (*we provide – you must return!!*)
- 6 Chemical Light Sticks (*we provide*)
- 24 g Mg chips (*we provide*)
- Dry Ice (*we provide – return empty container*)

Safety Notes: You are representing LSU. Please be professional and safety conscious. 90% of safety is using good common sense and being cautious. **Wear safety goggles at all times during the demonstration.** Work at safe distance from others. It is a good idea to practice the experiment before attempting it as a class demonstration. You will gain confidence and appear more professional to your audience. You are also working with open flames and flammable liquids: **exercise the proper precautions**.

The methanol salt solutions for Quantum Fireballs is **poisonous (if consumed), flammable and acidic.** Wear gloves and safety glasses when performing this experiment. Keep students at least 10 feet away, and never spray the solution or fire towards any person or object that may catch fire. Make sure to wash your hands after the demonstration.

The burning Mg in dry ice should be performed outside. Keep students back about 10 feet from the experiment because small white-hot Mg sparks sometimes fly out of the burning mixture. The “smoke” produced is MgO and is generally non-toxic – although it may annoy students that are sensitive to fine dust. They should wear safety glasses for this experiment.

Part I: Quantum Fireballs

You have seven spray bottle solutions, each with a different metal salt dissolved in a methanol solution. The propane torch can be set on a table or held during this experiment. Using the spray bottles, spray the solution through the flame to ignite the salt/methanol solution. **Be very careful since methanol is flammable, and do not to let your hand or the sprayer get too close to the flame.**

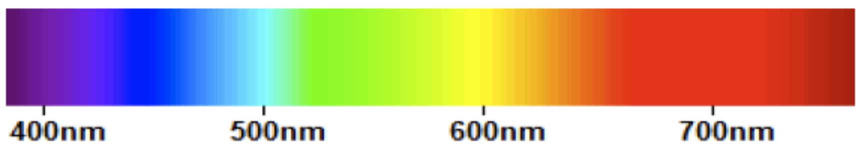
As the solution burns the light given off is from the metal atoms being reduced in the flame. The flame energy excites a metal's electron to a higher energy state, when it returns to a lower energy state energy is given off as light. Each metal has its own light emission profile, due to the differences of electron orbital energies unique to that element. This results in each metal giving off its own distinct color of light. This is the principle chemistry behind the different colors used in fireworks and other pyrotechnics.

Note: The salt solutions may be acidic, so wash your hands and be careful while and after handling these!

General Reaction:

$$M^{+n} \text{ ion} + \text{heat energy} \longrightarrow \{ {}^{*}M^{+n} \text{ excited state} \} \longrightarrow M^{+n} + \text{light emitted}$$

Visible Light Spectrum:



K^{+} - violet, Cu^{2+} - blue / green, Na^{+} - yellow, Ca^{2+} - orange, Li^{+} - pink/red, Sr^{2+} - red

Part II: Light produced from chemiluminescence

Thus far we have demonstrated how light can be produced from inorganic reactions. Certain organic reactions can also produce light either by luminescence or phosphorescence. A familiar example is the glowing produced by the firefly bug. Commercial luminescent light sticks sold as party favors contain organic compounds separated in glass vials, which are encapsulated in plastic. By breaking the glass barriers the organic compounds are allowed to mix. The chemical reactions that occur release energy that is efficiently converted into light, but almost no heat.

Part III: The burning of Magnesium metal in carbon dioxide

Normally, we put out small flames by spraying them with fire extinguishers, containing carbon dioxide. Most combustion reactions stop after the air source is removed. However, the heat produced by this reaction which begins in the open atmosphere is sufficient to decompose the CO2. Mg metal consumes the O2 from the CO2, while the carbon is reduced to its elemental form, carbon black. This reaction produces a lot of heat and light! **Always wear your safety goggles.**

SAFTY NOTE: The Dry Ice (solid CO_2) is very cold. -78°C or -108°F. It can give anyone touching it frostbite relatively quickly**. Do not let students touch or play with Dry Ice! This demonstration must be performed outside!** Keep the students at least 10 feet away from the reaction! Have them wear safety glasses!

Procedure Steps for burning Mg in CO_2:

1. Prior to going outside, explain the chemistry that will happen (you should write this out on the blackboard):

$$Mg(s) + CO_2(g) \longrightarrow MgO(s) + C(s).$$

2. Take the class outside to an open area (check with the teacher first to make sure this is OK!!). Keep the students about 10 feet away, preferably in a semi-circle around the reaction. Explain what you are doing as you do it. Place the aluminum tray on the ground with several folded newspapers underneath used for insulation. Dump in about two thirds of the dry ice and make a circular mound (use gloves!) with a flat top with a small indentation in the middle top. Dump in the 24 g (approximately 1 mole) of Mg chips into this indentation – make sure there is 1-2" of dry ice below the Mg metal.
3. Use the propane torch to light the center of the Mg chip pile. This should take about 15-30 seconds. The Mg will not burn particularly well at this point, but as long as some of it is burning a little that should be good. Turn off the propane torch and quickly dump a fair bit of dry ice on top of the Mg pile. The Mg should "take off" and start burning brilliantly. **Please ask spectators to stand at least 10 feet away.** A fair bit of smoke (MgO dust) and a few burning Mg "sparks" will come off the reaction. The reaction should stop after about 1 minute. While the reaction is occurring explain the chemistry going on.
4. After the reaction has stopped and cooled off for a minute, peel back the top layer of dry ice/MgO mixture with a pencil or butter knife to see the carbon black produced. A fair bit of the MgO product gets blown out of the reaction as the white smoke. Once the core where the Mg chips used to be cools down, the dry ice and carbon can be dumped in a trash container – preferably a big outside trash can. The dry ice will evaporate away. The carbon is non-toxic.