

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.

- Stuff:**
- * **insulated container (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)**
 - * **matches**

Propane Torch (*we provide – you must return!!*)

14 glass petri dishes (*we provide – you must CLEAN & return!!*)

solutions of Li, Na, K, Ca, Sr, Ba, Cu salts (*we provide – return empty containers*)

ethanol solution (*we provide – return empty container*)

35 plastic safety glasses (*we provide – you must return!!*)

8 Chemical Light Sticks (*we provide*)

24 g Mg chips (*we provide*)

Dry Ice (*we provide – but you need to bring an insulated container to put it in*)

Safety Note: 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.***

Part I: The burning of group IA (Li, Na, K), IIA (Ca, Sr, Ba) & IIB (Cu) salts:

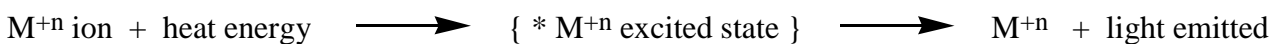
You have a solution of each salt dissolved in an ethanol/water mixture. You will need matches. For each solution, invert a petri dish lid to use as an insulator, place the dish on top of inverted lid. Into the dish, either pour or add the salt solution with a disposable pipet to about 1/8 inch depth. Using the squirt bottle, add ethanol (this is the flame source) to bring the final volume to about 1/4 inch depth. Ignite the solution, let the match stick fall into the solution. The match stick will act as a wick. ***Be very careful since ethanol is flammable.***

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.

Note:

- 1) Be careful – the ethanol flame is sometimes hard to see, so be careful not to burn your arm or hand.
- 2) Allow the dishes cool before touching or moving! Wear your safety glasses and cotton clothing.
- 3) Have several wet (but not soaking) paper towels around if you need to extinguish the flame, by placing them over the top of the petri dish.
- 4) The salt solutions may be acidic, so wash your hands and be careful while and after handling these!

General Reaction:



Li⁺ - red, Na⁺ - yellow, K⁺ - violet, Ca²⁺ - red, Sr²⁺ - red, Ba²⁺ - green

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.*

SAFETY NOTE: The Dry Ice (solid CO₂) is very cold, -78°C or -108°F. It can give anyone touching it frostbite relatively quickly. ***DO NOT LET THE STUDENTS TOUCH OR PLAY WITH THE 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 CO₂:

- 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.