CheMagic Demonstration Notes©

Acidic Oxide - AKA Acid Anhydride; AKA Acid Rain

Materials

800-mL fleaker; fleaker top with a drilled hole that allows a snug fit for a #1 rubber stopper; #1 rubber stopper; two strike on box stick matches; butane grill lighter; adhesive tape

NOTE: Fleakers are hard to come by these days. A 1000-mL Erlenmeyer flask can be substituted for the fleaker. The #9 or #10 stopper for the Erlenmeyer is sufficiently large for drilling a hole for a #1 stopper. The Erlenmeyer does provide more of a problem for tilting the flask while the grill lighter is lit, however.

Chemicals

phenolphthalein solution (1% w/v) [e.g. 1 g phenolphthalein in 100 mL ethanol solution]; potassium hydroxide solution (2 M) [e.g. 28 g KOH in 250 mL solution]; DI water

Abstract

To 350 ml of water in the 800-mL fleaker, add 1 mL of 1% phenolphthalein solution and 1 drop of 2 M KOH. Place the specially drilled fleaker top on the fleaker. Prepare the butane grill lighter by taping two strike on the box stick matches to the end of the lighter so that the flame of the lighter will ignite the matches. See the video of this demonstration to check this set-up.

Tilt the fleaker and insert the butane lighter in the hole drilled in the fleaker top. Using the lighter trigger, ignite the butane flame. The flame will ignite the matches. If the base of the butane lighter is pressed snuggly against the hole in the top of the fleaker, the flame inside the flask will self extinguish.

After the flame is extinguished, withdraw the lighter and place the #1 rubber stopper in the hole in the fleaker. Make sure the system is tightly closed and give the fleaker a good shake. The red phenolphthalein color will disappear quickly.

Obligatory but Very Important Note

Please check the demonstration video for details on the above abstract. Are there possible hazards and risks in this demonstration? Yes, absolutely. The fleaker could crack during ignition of the matches or grill lighter. The demonstration involves fire that could get out of hand. Butane lighters have been known to explode. We have not experienced specific problems in our use of the demonstration, but potential problems are there. This video demonstration manual is distributed to chemists and chemistry teachers, and the assumption is made that professionals using the manual are knowledgeable about materials, chemicals, demonstration procedure, and demonstration risks. If there is any doubt about risk, then please show your students the video rather than doing the demonstration.

Demonstration Note

This demonstration is part of our *light hearted* approach to some foundation chemical reactions on the planet that we call "Earth:"

Chemistry Planet Earth

- Planet Earth has stuff.
- There is metal stuff and there is non-metal stuff - also some borderline stuff.
- There is quite a bit of non-metal stuff called oxygen which causes other stuff to burn.
- Stuff burns.
- There is quite a bit of stuff called hydrogen which burns to form water.
- Metal stuff that burns produces other stuff that tends to react with water to produce chemical bases.
- Non-metal stuff that burns produces other stuff that tends to react with water to produce chemical acids.
- Most stuff is already all burned up.

The demonstration illustrates the following general reaction sequence:

General	**Sulfur**
Non-metal + O_2 → Non-metal Oxide	$S + O_2 \rightarrow SO_2$
Non-metal Oxide + H_2O → Acid	$SO_2 + H_2O \rightarrow H_2SO_3$

In the case of the burning match heads, sulfur and some antimony (III) sulfide in the match head burn to produce sulfur dioxide. The sulfur dioxide (SO_2) then reacts with water to produce sulfurous acid (H_2SO_3). This latter hydration of SO_2 is rapid, and hence the disappearance of the red basic phenolphthalein color is also rapid. See the Hydration of Carbon Dioxide video for an interesting and important kinetic difference between carbon dioxide hydration and sulfur dioxide hydration.

A rather more complex demonstration of the acid rain component of this demonstration has been published in the Journal of Chemical education [Driscoll, Jerry A., *J.Chem.Educ*., **74**, 1424(1997)]. An interesting periodic table approach to presenting the chemistry of acidic and basic oxides is also available in this journal [Rich, Ronald L., *J.Chem.Educ*., **62**, 44(1985)]. Finally, a general discussion of acidic, basic, and amphoteric oxides is suggested as relevant background for this demonstration [Smith, Derek W., *J.Chem.Educ.*, **64**, 480(1987)].

The chemical demonstration described above is suggested for use by chemical educators and other chemical professionals interested in the instructional use of chemical magic. It is assumed that qualified chemical professionals using this manual are familiar with the properties of the chemicals and with the characteristics of the materials involved in all of the demonstrations. Any attempts to repeat the demonstrations in this manual MUST be carried out under the supervision of a qualified chemical professional.