CHEMISTRY FOR MUSEUMS
A MANUAL OF CHEMISTRY DEMONSTRATIONS
DEVELOPED BY THE CENTER OF SCIENCE AND INDUSTRY
280 EAST BROAD STREET COLUMBUS, OHIO 43215

funded by a grant from:
THE NATIONAL SCIENCE FOUNDATION 1976
INTRODUCTION

This manual contains the scripts for live chemistry demonstrations which were developed and evaluated at COSI. The demonstrations are organized into twelve separate shows centering around various chemistry themes. Each show was designed to be approximately a 20-minute presentation. The material is arranged so that you may present the shows as suggested or pick and choose from individual shows to develop your own presentation. The demonstrations are presented in such a way that it is not necessary for the demonstrator to be an experienced chemist. However, it is recommended that an experienced chemist be consulted to assist with such matters as determining the best methods for disposing of residual material, etc.

We have available color slides and tape cassettes on certain demonstrations. These are available for your review on a loan basis.

At a later date we will request that you complete and return the enclosed questionnaire. We wish to know if and how you adapted the demonstrations to your needs and any revisions or additions you may suggest. This will enable us to further evaluate utilization of this project and report to other participating museums.

We have attempted to make the manual as comprehensive as possible. However, should you need any additional information, feel free to contact Mike Stanley, our Physical Science Specialist, who supervises the chemical demonstrations.

This project was funded by National Science Foundation Grant #7423549.

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* These five shows have been presented at COSI numerous times and the scripts represent tested, final products. The other seven scripts are transcripts from tapes of the original presentations.

The chemical demonstrations themselves are well tested but there has not been sufficient time to develop polished dialogue.

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GOOD DAY. I'd like to welcome you to our chemistry demonstration. What I want to talk about today is titled, "Metals and Non-Metals."

In chemistry there are a lot of materials, elements and compounds, that we deal with. We try to separate them out into general categories. Is what we use to sort metals, and to sort of sub-divide, so we can understand them better by giving them some kind of name. Metals, I think most of you are familiar with in some way, shape or form. If I ask you to describe metals, what kinds of properties would you say metals have?

What does a metal look like? (Hard) It is usually fairly hard. (Heavy) Many of them are heavy; heavy compared with most. These are relative terms, right. (Solid) Many metals are solid; any metals that are not solid? (Mercury) Yes, mercury is a liquid, so most of them are solid; mercury is an unusual metal, a liquid.

What do we use metals for? (Cars and bridges) These are some of the construction uses of metals. What makes the light here? (Electricity) And how does that electricity get to us? (Wire) And what is the wire made out of? (Metal) It is a metal, copper. That's one of the properties of metal I will demonstrate, if I don't get electrocuted. If I do get electrocuted, well, that is the way it is.

DEMONSTRATION #1

The conductivity apparatus consists of a light bulb and socket with two copper wires in the circuit. By connecting the wires with a conductor (metal) the device would use 110v or for safety employ a small voltage with appropriate bulb.

Samples of each metal in strip form should be available — copper, zinc, aluminum — could also have pieces of non-metals, and show they don't conduct — sulfur, carbon.

This is a strip of zinc, which is very shiny. Zinc is a metal. Metals are used, because they are conductors; and copper is the metal that we use most, because it is one of the best conductors. Actually, there is a better conductor than copper, and that is silver. Unfortunately silver is too expensive to use to make wires. Silver has other uses, such as coins, jewelry, and so on. Aluminum is also a very good conductor. You probably are aware of this, but if you aren't, I will mention it. I found it out when the plumber came to fix my dishwasher not too long ago; he told me that the windings in the motor were made of aluminum. Aluminum is a good enough conductor that it can be used for that kind of purpose. It is not quite as tough as some metals. You can see that the aluminum is not quite as hard as copper; it is not the same thickness, but the aluminum is not as tough as copper as a metal. Aluminum has one other advantage over copper, and that is that it is so light. In fact we use aluminum for that property in construction of airplanes. So metals are good conductors.

Another property that metals have is that they are shiny. That is one way that we identify them. Here are some non-metals.

DEMONSTRATION #2

Show samples of the metals and non-metals and samples of ores, if possible.

This one is sulfur ore found in its natural state, and this is sulfur that is ground up; it is very dull. Most of the non-metals are pretty dull. They don't shine like metals do. This is carbon black; you've seen charcoal, which is carbon black; again it is very dull. This is iodine; this turns out to be the exception that proves the rule. Iodine is somewhat shiny, and in that sense is different than most of the non-metals. When we find these materials in nature, usually they are combined with each other and not pure. That is one very interesting thing about metals and non-metals; they do combine to form materials.

This is a metal -- non-metal combination called galena, lead sulfide. Is lead a light metal like aluminum? (No) It is a very heavy metal, and if you come up here after the demonstration, you'll find this a hell of a way to put the it has that lead in it along with the sulfur to make this lead sulfide. The one here is not quite as easy to see, but it is more spectacular if you can see it explode, and that's gold. There are very small stripes and pieces of gold in this particular ore.

DEMONSTRATION #3

A burner is necessary along with a metal spatula (wooden handle), steel wool and iron powder. After heating the spatula in the flame, obtain a portion (1cm x 8cm) of steel wool and lower it vertically into the flame, using tongs. Sprinkle the iron powder from above the flame to obtain a sparking effect.

This is a piece of iron, mostly iron at least, that I am holding in the flame. Another thing about metals is that iron is a good heat conductor. If I were to touch it to the flame as I am doing now, and then touch it to my skin, I would find that it has picked up the heat. Or if I hold my fingers up here and heated it in the flames a little while, that heat would work its way up to my fingers, due to the conductivity of the metal. We use this property in cooking utensils; it is one of the interesting and functional properties of metals. Metals do not burn if they are in the bulk state. If I take this metal, this is iron, steel wool, and I put it in the flame, when it is a little bit more finely divided, it burns nicely. In fact if I take the iron metal in a very fine dust form and sprinkle it in the flame, we see a little 4th of July effect. So, if you take something and divide it finely enough, it burns more and more rapidly.

The ultimate of that would be if I get something to burn so rapidly... What happens when something burns so rapidly as it possibly can? (An explosion) Right.

DEMONSTRATION #4

An explosive can be constructed by using a 1lb, coffee can, a small funnel with right angle bend on its tip, a stopper, hose and rubber bulb. The use of lycopodium powder assures explosions, although other materials (dry flour) work. Place a small amount of powder in the funnel, light the candle and place it opposite the funnel in the can. Seal the can, and squeeze the bulb. Be careful with the lycopodium powder and candle flame, as the powder is extremely flammable.

Let's make a little explosion here. Not because it is relative to metals and non-metals, but just because I like to have explosions now and then. I have in here some powder in a little cone made from a funnel, and I'll put a candle in there. This is a model of the sort of explosion you might get in a coal mine when dust accumulated enough so that when someone lights a match it explodes. Also a flour mill is another place where this kind of explosion does indeed happen. A fine dust powder gets in the air and it burns rapidly, if someone is unfortunate enough to set off a spark or fire.

Now, what will I do to put the lid on in order to keep the powder in there. When I squeeze this little bulb, the powder will be blown into the air inside the can. It should make a little puff... (explodes) This is called lycopodium powder, and it is just a kind of finely ground bug dust. So, if we take something, like iron, that doesn't burn even in the chunk state and divide it finely enough, we can make it burn pretty well.

Metals react with air that way. When iron reacts with the moisture in air and rusts, it reacts slowly. Other metals react a little bit more rapidly with air, or sometimes they react very rapidly with water.
DEMONSTRATION #5
An overhead projector, crystallizing dish, distilled water, phenolphthalein indicator, small pieces of sodium metal (1 millimeter cubes), small sections of cardboard, a metal spatula, a 500ml flask, and a small piece of sodium. A second piece may be used, if desired, after the first has reacted.

The addition of 2 or 3 chunks of calcium results in slow reaction at first as the surface coating dissolves, but more rapid reaction and bubbling later.

I have here a dish with some water in it and just a very tiny amount of an indicator, phenolphthalein. I use the indicator in there so that when the metal reacts with the water, it will form hydrogen and will also form a little bit of lye at that point where it reacts. So, as the sodium metal eats on the surface and reacts with the water, it will dance around and make a little path. I think you can see the path being traced out. Wherever the metal has been, it traces out a little pink path. Now, this metal is sodium, a very active metal, meaning it reacts very strongly, very quickly with water. Sometimes it even does so with a little bang. Sometimes it just kind of keeps going for a while.

As I mentioned, sodium is a very reactive metal. There are other metals that I could put in here, but it would take days for something to happen. We don't want to sit here that long. This is another metal, which is not nearly as active as sodium, it is calcium. Calcium is the metal found in lime. I will put a few pieces of calcium in here. You notice that I use big chunks of calcium, so I don't worry so much. Calcium reacts relatively slowly; it doesn't dance around the surface. One thing that I might tell you happens here. When the sodium was moving around on the surface, did you notice that it was a little ball? The fact that it is a ball is a result of the water-sodium reaction, which is so hot that it melts the sodium. When melted, the sodium takes on that little ball shape and still dances around the surface on the little hydrogen atmosphere that is generated. You can see that the calcium does percolate pretty well, when it reacts with water. The red color is due to the base that is formed when the calcium reacts with the water.

It is unfortunate that I can't really do much with the non-metals for you, because they are so reactive and they are also relatively poisonous.

DEMONSTRATION #6
A small amount of iodine in a 500ml flask with cork stopper and a flame. Heat the solid carefully and note the cloud of iodine formed — also, the crystals on the upper portions of the flask.

This is iodine; I can heat it just a little bit. Iodine is one of the few materials, which goes directly from the solid to the gas state. What is iodine used for? (Tincture of iodine) The tincture of iodine that you buy to kill germs. Iodine goes directly from the solid to the gas, as I said. It doesn't form any liquid state. Iodine is a poison and like many things that are poisonous, if we use them in small amounts for cuts and so on, the effect of the poison is to kill the bacteria, which would infect you. So, tincture of iodine is not very pleasant to put on; mercuric and other treatments are more pleasant, because they don't hurt. Tincture of iodine has been used for that purpose a long time. It is called tincture of iodine because it is made from iodine, which doesn't dissolve in water. It dissolves in alcohol, and it is the alcohol that stings on cuts.

One other demonstration that I want to do for you does involve the non-metals.

DEMONSTRATION #7
Crystallizing dish, sodium thiosulfate solution (45g/500ml water), very dilute HCl (15ml concentrated HCl/500ml water) — use equal amounts in dish placed on projector over a cardboard, which has a 3" hole for light to pass through.

As I said, one problem with the non-metals is that I can't make a very good demonstration with them. But there is one demonstration which is sort of like the last scene in the old western movies, where the hero, having conquered all the evil in town, gets on his horse and rides off into the sunset. I haven't got a horse, but I think I can make a sunset with a chemical reaction. What I have done is mix a little hydrochloric acid and sodium thiosulfate solution. If you watch the image on the overhead projector, you'll see a little white color developing. Now, the color is becoming less and less white and more red, just like a sunset. It works for the same reason we have sunsets. The light that comes from the sun is a mixture of colors, which is white light. The light that can come to you is bent and is red. Red in bent better and makes its way through the atmosphere. Red light waves are bent more, and the color that we see on the screen, the sunset that we get, is due to those red light waves.

Sometimes people get all concerned that if we know all about some natural phenomenon, that it is going to make it less pretty or enjoyable. All I can say is that in my own experience I still find tremendous beauty in sunsets, even though I understand the physical principles of why sunsets have the colors they do. It is just an attractive anyway. Now, the reaction has gone to the gray state, where there is almost no light coming through.

Thank you very much for your attention. If you have any questions, I will try to answer them.

EQUIPMENT, SUPPLIES & CHEMICALS REQUIRED FOR THIS DEMONSTRATION (Note: Quantities of expendables are estimates based on 10 shows)

Show Title: METALS AND NON-METALS
Show Number: One

DEMONSTRATION #1
Light Bulb & Socket
2 Copper wires
Samples — Copper, zinc, aluminum, sulfur, carbon

DEMONSTRATION #2
Samples of metals & non-metals

DEMONSTRATION #3
Burner
Metal Spatula (Wood Handle)
Steel Wool (10 cm x 8 cm portions) 8-oz. pkg
Iron Powder (.4 lb.)

DEMONSTRATION #4
3-lb. Coffee Can — with lid
Funnel with right angle bend at tip
Stopper, Hose & Rubber Bulb
Lycopodium Powder (10 gram)

Candle

DEMONSTRATION #5
Overhead Projector
Crystallizing Dish
Distilled H₂O
Phenolphthalein
Sodium Metal (20-mm³ cubes)
Calicum Metal (20-30 chunks)

DEMONSTRATION #6
Iodine (10g)
500ml Flask with cork stopper
Flame/Propane Burner

DEMONSTRATION #7
Crystallizing Dish (6" Diameter)
Sodium Thiosulfate Solution (45g/500ml water) — use equal
Dilute HCl (15ml concentrated HCl/500ml H₂O) — portions
Overhead Projector
Cardboard with 3" hole to cover projector surface
Good morning, and welcome to our chemistry demonstration. Among other things, chemistry entails the examination of the physical properties of various substances, and of primary concern is the physical state of whatever we are examining: the sample is a solid, a liquid, or a gas? How can I be sure, know what these terms mean, but let's try to more exactly define and differentiate them.

What are some of the characteristics of solids? (Definite shape, definite volume, usually hard) By contrast, how would you describe a liquid? (Flow, no definite shape, takes the shape of whatever container it is in, still has definite volume) Finally, what properties does a gas have? (No definite shape, no definite volume, expands easily) Okay, we can see that each of the three states of matter has different characteristics.

Familiarity with them and everything around us is either a solid, a liquid, or a gas. There is one substance, though, that we commonly see in all three states. What is it? (Water) Right, water.

DEMONSTRATION 1

Display some ice, a jar of water. Start the gallon of water heating on the hot plate with around 100ml water inside.

We know it as a solid, which we call ice. I have some here. We know it as a liquid, which we call water. Finally, we know it as a gas, which happens to be constant, vapor. I am heating some water up in this can and making it change into a gas; we’ll come back to that later on. It is important to note that, whatever state it happens to be in, water does not change shape that is, a molecule of water, made up of two atoms of hydrogen and one atom of oxygen, H2O in chemical notation, is identical to any other molecule of water, regardless of the state it is in; whether ice, water, or steam. This is generally true of most substances.

Since water to us is so common, all around us, we do not realize it is a rather unusual compound. For example, most liquids when changed to solids, get slightly smaller. Water, by contrast, expands slightly when it freezes, when it solidifies into ice. Furthermore, water is just about the most effective solvent known. You can dissolve all sorts of things in water.

DEMONSTRATION 2

Use solids in vials (hygroscopic) - potassium thiocyanate and cobalt chloride. Two vials of each, half filled. First, add water to one vial of each, cap, shake and pour the liquids together in a test tube. Second, add two solids together in test tube, shake.

Here I have two vials of chemicals. The white material is potassium thiocyanate, and the purple one is cobalt chloride. I will add water to each of them, shake them up to dissolve them and then mix them together. You can see the color change occurring indicating the chemical reaction. The water, by contrast, expands slightly when it freezes, when it solidifies into ice. Furthermore, water is just about the most effective solvent known. You can dissolve all sorts of things in water.

DEMONSTRATION 3

Prepare a super-saturated solution of sodium acetate by adding small amounts of water to 200g of sodium acetate and heating until just dissolved. Use a Florence flask. Plug with cotton and allow to cool slowly. Should yield liquid. If not, reheat carefully and add a little more water. If the liquid is available, then demonstrate crystallization by dropping a crystal of sodium acetate into the super-saturated solution. Notice, however, that if I mix the two solids together without water and shake them up well, there is still a reaction; you can see some blue coloring. The solids rub against one another, and the pressure they exert is nowhere near as strong as when water is added. Liquids, or solutions, mix much more readily than solids.

Now, suppose I take a solid and put it in water.

I can only put so much solid in there. If I dissolve, for example, common table salt, sodium chloride, in the water, you know what it is, the salt will dissolve, before the saturation point is reached. If I now want to increase the amount of salt in the water, how can I do that? (Heat) Right, heat the water and the water will dissolve more salt. We call this a saturated solution. If I now want to increase it further, I have a super-saturated solution of salt, called sodium acetate. I obtained this type of solution by heating the water to a very high temperature, sulphur, adding as much sodium acetate as the water would hold at this high temperature, that is, temperature. The resulting solution could, excess salt would start to solidify. But, in fact, if the temperature is lowered slowly and carefully, without getting too much, it starts to crystallize. Then, by adding a crystal, or a few crystals, of the sodium acetate to the solution, all the excess salt immediately starts to come out of solution to crystallize, growing on those few crystals I added.

As we have noted, liquids are different from solids in that they are not as good at preserving the identities of the substances making them.

DEMONSTRATION 4

Boil, burn, stand and water and a test tube. Allow water to drip slowly into the beaker forming good droplets, and synchronize the strobe light so you can "step on" the droplets and see the round shape. A bright strobe and surrounding darkness works best.

I have a very simple demonstration here; I didn't know any complicated way of doing it. If I open this little stopcock on the water, I can watch the water flow from the cylinder, which is on the side of the test tube. Right, water. Right.

I have a new way to propel boats across the ocean. You don't have to worry about using fuel any more. I have a technique that will get the boats moving. We don't have to burn any fuel; all we have to do is have a little droplet of water, which is on the side of the test tube, and it jumps pretty fast. Notice that the boat moves whenever I put the soap in that little section cut out of the boat. That is the part of the boat that will propel it. We see what happens when I put some solution into the little cutout area; it is water. It is a salt; it is not a gas. It is a little boat; the motor in my boat is this little section cut out of the boat. That is the part of the boat that will propel it. We see what happens when I put some solution into the little cutout area. I have a new way to generate power. It is a form of propulsion. This is terrific to try in the bathtub; very good for you in the bathtub. You can do that little experiment yourself.

DEMONSTRATION 5

Eterno Demonstration: Prepare saturated calcium acetate by adding 100ml water to 40g calcium acetate. Filter to obtain a clear liquid. Use 1ml of the calcium acetate as the "hard water" to test the volumes of denatured alcohol as the test solution. Pour together.

Remove a sample of the gelatinous solid and place it on an asbestos pad using a spatula. Light the solid and note the flame color. The color is blue and the flame is a little bigger than a match. What is the reason for this? What is the reason for this? It demonstrates that the alcohol does not react with the water.

So liquids can sometimes display a shape, because of the surface tension. One of the things that water has is that it is surface tension, pulls it together, the shape that it has is a sphere or a ball. This surface tension is the reason the water has that particular shape, the reason it is so sensible for a lot of interesting things. One of them is water bugs. How many of you have been camping or out by a stream and have seen the water bugs dancing on the water? Those water bugs use that surface tension; their feet are thin enough that they can go along on the top of the water. Let me show you another way to use that surface tension.

DEMONSTRATION 6

Crystallizing dish, small boats cut from lightweight cardboard, soap solution (bubble pipe type is good), dropper. Add 1" of water to the dish on an overhead projector and place a boat on the surface. Carefully add the soap solution, one drop at a time, in the bowl on the disk. This is terrific to try in the bathtub; very good for you in the bathtub. You can do that little experiment yourself.

DEMONSTRATION 7

Ester Demonstration: Prepare saturated calcium acetate by adding 100ml water to 40g calcium acetate. Filter to obtain a clear liquid. Use 1ml of the calcium acetate as the "hard water" to test volumes of denatured alcohol as the test solution. Pour together.

Remove a sample of the gelatinous solid and place it on an asbestos pad using a spatula. Light the solid and note the flame color. The color is blue and the flame is a little bigger than a match. What is the reason for this? What is the reason for this? It demonstrates that the alcohol does not react with the water.

So liquids can sometimes display a shape, because of the surface tension. One of the things that water has is that it is surface tension, pulls it together, the shape that it has is a sphere or a ball. This surface tension is the reason the water has that particular shape, the reason it is so sensible for a lot of interesting things. One of them is water bugs. How many of you have been camping or out by a stream and have seen the water bugs dancing on the water? Those water bugs use that surface tension; their feet are thin enough that they can go along on the top of the water. Let me show you another way to use that surface tension.

DEMONSTRATION 8

Crystallizing dish, small boats cut from lightweight cardboard, soap solution (bubble pipe type is good), dropper. Add 1" of water to the dish on an overhead projector and place a boat on the boat. Carefully add the soap solution, one drop at a time, in the bowl on the disk. This is terrific to try in the bathtub; very good for you in the bathtub. You can do that little experiment yourself.

DEMONSTRATION 9

Eternium Demonstration: Prepare a saturated calcium acetate solution by adding 100ml water to 40g calcium acetate. Filter to obtain a clear liquid. Use 1ml of the calcium acetate as the "hard water" to test the volumes of denatured alcohol as the test solution. Pour together.

Remove a sample of the gelatinous solid and place it on an asbestos pad using a spatula. Light the solid and note the flame color. The color is blue and the flame is a little bigger than a match. What is the reason for this? What is the reason for this? It demonstrates that the alcohol does not react with the water.

So liquids can sometimes display a shape, because of the surface tension. One of the things that water has is that it is surface tension, pulls it together, the shape that it has is a sphere or a ball. This surface tension is the reason the water has that particular shape, the reason it is so sensible for a lot of interesting things. One of them is water bugs. How many of you have been camping or out by a stream and have seen the water bugs dancing on the water? Those water bugs use that surface tension; their feet are thin enough that they can go along on the top of the water. Let me show you another way to use that surface tension.

DEMONSTRATION 10

Eternium Demonstration: Prepare a saturated calcium acetate solution by adding 100ml water to 40g calcium acetate. Filter to obtain a clear liquid. Use 1ml of the calcium acetate as the "hard water" to test the volumes of denatured alcohol as the test solution. Pour together.

Remove a sample of the gelatinous solid and place it on an asbestos pad using a spatula. Light the solid and note the flame color. The color is blue and the flame is a little bigger than a match. What is the reason for this? What is the reason for this? It demonstrates that the alcohol does not react with the water.

So liquids can sometimes display a shape, because of the surface tension. One of the things that water has is that it is surface tension, pulls it together, the shape that it has is a sphere or a ball. This surface tension is the reason the water has that particular shape, the reason it is so sensible for a lot of interesting things. One of them is water bugs. How many of you have been camping or out by a stream and have seen the water bugs dancing on the water? Those water bugs use that surface tension; their feet are thin enough that they can go along on the top of the water. Let me show you another way to use that surface tension.
The gallon can of water should be steaming well now. Remove it from the heat and cap it with a good fitting rubber stopper. Allow it to cool.

When the water boils, it pushes all the air in there out and replaces it with steam, water vapor. As we noted earlier, steam is simply water in its gaseous state. So, the steam is inside the can, resisting the pressure of the air outside. But water only exists as steam at the high temperature of 212 degrees F, or above. If I take it off the burner, the steam condenses to water and again becomes a liquid. If the can is open when the steam changes to water, the can will fill up with air, which replaces the steam. But if I plug it up and don't let the air in, what will happen when I take the can off the burner?

When the can is removed from the heat, the water inside begins to cool down. I can help it cool by placing it in the ice. The water inside is cooling down, but there is no way for the air to get inside. So as it cools down, the air is still pushing on the outside, but there isn't a balance of air or water inside pushing out. So what happens? The can is going to collapse. It is beginning to crumple now. You can see the side caving in more rapidly. That is the pressure of the atmosphere around the can pushing in and the water inside isn't pushing back anymore, because it is condensed out as water from the steam.

So, we have seen that matter exists in different states, and we have seen some of the things, which occur because of the different states of matter. All three states are part of our environment, and essential to our existence; the solid ground beneath our feet, the liquid of our oceans, lakes and rivers, the gases of our atmosphere. Thinking in terms of solids, liquids and gases is another way of looking at the world around us.

Thank you for your attention.

EQUIPMENT, SUPPLIES & CHEMICALS REQUIRED FOR THIS DEMONSTRATION
(Note: Quantities of expendables are estimates based on 10 shows)

Show Title: SOLIDS, LIQUIDS, AND GASES
Show Number: Two

DEMONSTRATION #1
- Ice
- Rectangular gallon can (10)
- Hot Plate
- 1000ml water

DEMONSTRATION #2
- Solids in vials (hygroscopic) - 20 vials each (1/2 filled)
- 1-lb. each Potassium Thiocyanate & cobalt chloride
- Test tubes
- Water

DEMONSTRATION #3
- 200g Sodium Acetate
- Florence Flask, Crystallizing Dish
- Cotton

DEMONSTRATION #4
- Beaker
- Stand and Buret
- Water (Stroboscope)

DEMONSTRATION #5
- Crystallizing Dish - (8") diameter
- Lightweight Cardboard Boats
- Soap Solution
- Dropper
- Overhead Projector

DEMONSTRATION #6
- 1-lb. Calcium Acetate
- Denatured Alcohol - 1 liter
- Asbestos Pad, Spatula
- 1000ml Water

DEMONSTRATION #7
- Rubber Stopper
- Can (No. 1)
Today I will be talking to you about electrical energy. The kind of electrical energy I am going to talk about is generated chemically. There is electrical energy that you can make with a solution in other ways and well; for example, you get that kind of energy from water power.

**Demonstration 01**

A tall form beaker is 2/3 filled with 6N sulfuric acid. I need some water. If I swirl this around just a little bit, the blue color salt gets into the solution. What I have got in solution then, giving this blue color, is copper sulfate. The copper goes out of solution, which is what we have in these sheets, but copper ions, the copper is charged. This is very important, because if I take a piece of zinc metal, now we'll see if it works. If it doesn't work, I'll try the other solution. This is a piece of zinc metal, very shiny. If I put the zinc metal down into the copper sulfate solution, what happens to it? Well, it becomes dark. The reason this happens is because copper ions go in solution and out on the zinc and zinc goes in the solution. You can see the zinc go in the solution, because the zinc doesn't have any color. It is colorless in solution. But that is a chemical reaction where electrons move. Electrical energy is produced as the copper and zinc change places.

If I dissolve this salt, which is copper sulfate (used to get rid of algae in swimming pools), I need some water. If I swirl this around just a little bit, the blue color salt gets into the solution. What I have got in solution then, giving this blue color, is copper sulfate. The copper goes out of solution, which is what we have in these sheets, but copper ions, the copper is charged. This is very important, because if I take a piece of zinc metal, now we'll see if it works. If it doesn't work, I'll try the other solution. This is a piece of zinc metal, very shiny. If I put the zinc metal down into the copper sulfate solution, what happens to it? Well, it becomes dark. The reason this happens is because copper ions go in solution and out on the zinc and zinc goes in the solution. You can see the zinc go in the solution, because the zinc doesn't have any color. It is colorless in solution. But that is a chemical reaction where electrons move. Electrical energy is produced as the copper and zinc change places.

Let's build a system, put together a little battery here, which does some work. The difference is that in order to do some work, you need to have a charge, you need to have a source of electricity. Electricity is now flowing through the system. If you take the battery out, the electricity stops. You have to have this bridge in there for the electricity to move. This is then a battery. A battery is a source of electricity, which is fixed.

**Demonstration 02**

Solid Copper sulfate, water 600ml beaker, spatula, stirring rod, zinc metal strip.

Add several grams of copper sulfate to the beaker and add water (about 400ml). Stir to yield blue color. Insert the zinc strip into the beaker and observe the black deposit. It is the copper metal. Electricity is produced as copper sulfate is produced as the copper and zinc change places. I'm not doing any work there. It is not work as I did those little leaves, lifting them up with electrical energy, because I'm not just letting it happen.

If I dissolve this salt, which is copper sulfate (used to get rid of algae in swimming pools), I need some water. If I swirl this around just a little bit, the blue color salt gets into the solution. What I have got in solution then, giving this blue color, is copper sulfate. The copper goes out of solution, which is what we have in these sheets, but copper ions, the copper is charged. This is very important, because if I take a piece of zinc metal, now we'll see if it works. If it doesn't work, I'll try the other solution. This is a piece of zinc metal, very shiny. If I put the zinc metal down into the copper sulfate solution, what happens to it? Well, it becomes dark. The reason this happens is because copper ions go in solution and out on the zinc and zinc goes in the solution. You can see the zinc go in the solution, because the zinc doesn't have any color. It is colorless in solution. But that is a chemical reaction where electrons move. Electrical energy is produced as the copper and zinc change places. I'm not doing any work there. It is not work as I did those little leaves, lifting them up with electrical energy, because I'm not just letting it happen.

**Demonstration 03**

Prepare solutions of copper sulfate (250g/l) and zinc sulfate (250g/l) and add 500ml of each to 600ml beakers. Place a copper strip in the copper sulfate solution and a zinc strip in the zinc sulfate solution. Connect to a voltmeter and show that it is difference in voltage.

There is work involved in those in and out of the water? Nothing. That is good, otherwise I can't do any work. You can see a change happening, but there is no way I can do any work. The only difference is that I just did.

**Demonstration 04**

Cut a 1.5 volt cell (D cell) and a 9 volt cell to expose the inner elements. The presence of a 2 or 3 cell flashlight might emphasize the point of getting more voltege by adding more cells. If a 3 cell flashlight is available, the effect of first one, then two, and finally three cells could be demonstrated.

Batteries that are made this way use up the metal, the copper goes out of solution, the zinc goes into solution; that's why we have the solutions and metals. But they run down. You've got examples of that in flashlight batteries. This is a typical flashlight battery. It has got a zinc can, that is one of the electrodes, one of the parts of the battery. It's got some manganese dioxide and a carbon electrode in the center. You can come up and look at them after the demonstration. I cut one apart this morning (I wasn't too wasteful, I hope), but you can look in and see carbon electrode in the center. That is where one of the electrodes is and the zinc can is the other electrode. That is a simple battery that you can use in a flashlight. It generates about 1.5 volts. Most flashlights, as you know, have about two batteries in them. Sometimes you want more than 3 volts; well, where you get that is by putting the two batteries end to end, right? That is what happens in a flashlight; you just hook them up one after the other. You can take the positive end of this one and put it against the negative end of the other. So now you have three volts at these ends. So you've added them together by putting the batteries end to end.

We do that same thing if we make a little 9 volt battery as is used in radios. If you look at this 9 volt transistor battery here, I don't have that. But you know you can make one, you can do work by putting it together. If I take this one apart today with a little pair of wire cutters), you'll see there are six layers; six little batteries which are layed end to end. Each one gives you 1.5 volts and six of them give 9 volts. That is how you can build up as much voltage as you want by putting a lot of these batteries end to end.

One of the problems with a battery like this is that it can't be recharged. Another problem is that with this kind of battery I can get only 1.5 volts, because this kind of battery depends on the two materials in there and how much energy they can give. This is only one kind of a battery that you use. What other types of batteries do you have that you have used around the house in flashlights, radios and so on? (C batteries, D cell and 9 volt cell) Well, there are a number of different ones, no? (Show C, 9A batteries) This is the same battery as this, the difference is how big you make it. This won't give energy as long as this one will, but it has the same voltage, 1.5 volts. So the C and D, those are all rechargeable batteries.

Some of you have seen mercury cells, nickle cadumum cells. You can buy those heavy duty batteries. What they have in them are essentially different materials, different metals to give you a different voltage. One difference between them and this kind of batteries is that you can recharge those batteries. I can show you a charging experiment in a few minutes. But you can recharge those. Have you ever tried recharging these with a battery charger? Do they charge up? (Yes) A little bit; they are not quite as good as they were the first time, are they? They run down more rapidly and don't hold a charge well. That's a real problem we have with these batteries. If we put a different voltage in and reuse them, we need a battery that can charge up well.

**Demonstration 05**

A tall form beaker is 2/3 filled with 6N sulfuric acid. The special apparatus consists of a 1.5 volt light bulb soldered to two alligator clips. The clips hold on a piece of copper wire and a coil of magnesium ribbon. When the apparatus is lowered to the inner elements, the presence of a 2 or 3 cell flashlight might emphasize the point of getting more voltage by adding more cells. If a 3 cell flashlight is available, the effect of first one, then two, and finally three cells could be demonstrated.

Let me show you a different way of making electrical energy. This is some sulfuric acid. I am going to hook on to the flashlight here 1.5 volt light bulb connected to a coil of magnesium wire, and touch it to my hands and observe it. I don't think this into the sulfuric acid, it will generate electricity and it should make the light bulb light. You can see it because I am behind and I can't hold it out. Does it light? Okay. Well, that's not too bad, but it is not dramatic enough for me.

So, let's go on and do something else. Let's take a coil again. This little gadget came apart, but I'll hold it together and see if it will work anyway. The only difference is that instead of a flashlight bulb, I have a flash cube.
CHEMISTRY FOR MUSEUMS

DEMONSTRATION #6
The beaker and acid from Demo 5 are used. The flashbulb holder is an enlarger purchased at a camera shop where two alligator clips have been soldered. A flash cube is inserted in the upper end and colls of copper wire and magnesium ribbon attached via the alligator clips. Inserting the colls into the acid causes the bulb to flash.

If this works, it should cause a blinding sensation. It works so well, let's do it again. I just turned the flash cube around. If it got enough of the battery left in there to flash it once more. Oh, yes. I'd take your picture, but I don't have any film. So this is a way of getting electricity very quickly. I also get a lot of hydrogen, that is the gas that is bubble off of charge. but those and materials that are being used to generate electricity, but once they are used up, they are gone and they really don't recharge very well.

Now, I am far from a battery, I assure. At least you have seen one, if you haven't played around with it, that you can recharge. What battery is that? (Car) An automobile battery can be charged up. If it discharges you can take it away and have it charged up. You should charge it slowly, because if you charge it slowly, you put back the materials very evenly on the surface. If you charge it rapidly, the stuff goes back on the surface unevenly, and it won't last as long. It will burn the battery out more quickly. That is the reason you not to give it a quick charging, if you can help it. Well, let's build a little battery here over.

DEMONSTRATION #7
Use a 1 liter beaker, 6N sulfuric acid, two large thick sheets of lead, a battery charger or power supply set to 6 volts, and the 1.5 volt bulb with alligator clips from Demo 5 will still the materials 2/3 full of acid plates in the beaker at opposite sides. Connect them by the bulb to show no charge exists on the plates. Remove one alligator clip, attach the battery charger leads to the plates and turn the charger on. Note the evolution of hydrogen. I have a balloon here with some hydrogen in it, and if I am not quick, I also get a lot of hydrogen, that is the gas that is explosively, and I might get a charge out of that.

I've got my two lead plates. This is the same kind of thing that you would find in a car battery. And I've got my sulfuric acid. I'll put it in the automobile battery, the same kind of acid that is in most car batteries at least, sulfuric acid. I'll hook up the battery and hope it doesn't work, because if it doesn't work, I've done something very strange. So right now there is no energy available between these two pieces of metal, right? Let's take this one off, so I won't have to move both of them all the time. And we'll hook this up, and we'll give a quick charge. Now, don't let it go, but a quick charge. Now you can see it, if you see it that closely, that I am generating gas. That same thing happens when you charge a car battery. When you charge a car battery, hydrogen is given off. And don't tell you not to do around your battery when you are charging it? Smoke, right? Caution. If you smoke, if I lit a cigarette up right now, for example, there might be a very interesting chemical reaction where the hydrogen that is bubbling off would be recombined and form water explosively, and I might get a charge out of that in a different way.

Now, I am charging up the battery. I am putting on the two surfaces the material necessary to make the battery run. If I charge it long enough, I can get it to run a long time, but I'll try to answer questions, has to do with nuclear batteries. These are very special batteries for space exploration where you can't have a place to go and mine and get your metals you need. You have to have something that in very light-weight and gives a lot of power. That is a whole special area for batteries.

DEMONSTRATION #8
Fill a balloon with hydrogen and attach it via thumb to the end of the table. Using a 3 foot dowel on which a birthday candle has been taped, ignite the balloon.

Hydrogen combines with oxygen with a lot of energy. We don't have a battery that goes off like that, that would be kind of nice. If you throw the balloon light in the house, and it goes "paw, paw, pow, pow." That is not a very efficient way of doing it anyway. But we do have batteries that use hydrogen and oxygen. I have to do the same thing in those batteries as before, but we both operate the batteries. As I did with the zinc and copper, I have to separate the hydrogen on one side and the oxygen on the other, and I bubble them over the electrodes, and I can generate electricity. And these are called fuel cells. You use a blend with fuel cell, a gas that will burn in air. You have probably seen articles about these fuel cell operated cars. That is something they are working on. They have a long way to go to make them efficient to run well enough and fast enough. But fuel cells are one place where batteries can make energy very efficiently with relatively little pollution.

Another whole idea, which I am not going to discuss very much, but I think to answer questions, has to do with nuclear batteries. These are very special batteries for space exploration where you can't have a place to go and mine and get your metals you need. You have to have something that can store up that energy. That is a whole special area for batteries.

DEMONSTRATION #9
Glass or Rubber Rod
Cat's Fur
Static Electricity Apparatus (leaves)

DEMONSTRATION #10
Solid Copper Sulfate 1-lb.
Water
600ml Beaker
Spatula
Stirring Rod
Zinc Metal Strips 1-lb.

DEMONSTRATION #11
Coil of Copper Wire
1/5 Volt Light Bulb Soldered to two Alligator Clip's

DEMONSTRATION #12
Battery Charger or Power Supply - 6 volts
Battery
Flashbulb Holder
Coil of Copper Wire
Flashcube (10)
Magnesium Ribbon (100g)

DEMONSTRATION #13
Flashbulb Holder
Coil of Copper Wire

DEMONSTRATION #14
Flashbulb Holder
Coil of Copper Wire

DEMONSTRATION #15
Brush and Acid From #5

DEMONSTRATION #16
Flashbulb Holder
Flashcube (10)
Magnesium Ribbon (100g)
Coil of Copper Wire

DEMONSTRATION #17
Magnet
Hydrogen Cylinder

DEMONSTRATION #18
1 Liter Beaker
Sulfuric Acid
2 Large Thick Lead Sheets (2" x 8" x 1")
Battery Charger or Power Supply - 6 volts

DEMONSTRATION #19
7.5g Potassium Chloride/100ml water (75g)
Filter Paper

DEMONSTRATION #20
1.5 Volt Cell (0)
9 Volt Cell
2 or 3 Cell Flashlight

DEMONSTRATION #21
Tall Form Beaker

DEMONSTRATION #22
Batteries then have a lot of potential long range and a lot more remaining to be done.

If you have any questions on the demonstration, I will be happy to try to answer them. Thank you very much.

EQUIPMENT, SUPPLIES & CHEMICALS RECOMMENDED FOR THIS DEMONSTRATION (Note: Quantities of expendables are estimates based on 10 shows)

Show Number: Three

DEMONSTRATION TITLE: ELECTRICAL ENERGY

Show Number: Three
I would like to welcome you to our chemistry demonstration. I often find that when chemistry is made tangible, people think of things like test tubes full of colored powders, bubbling solutions, explosions, and the like. You mix things together, and something happens. Well, this is the case here, but another very important part of any chemical reaction is the release of a kind of energy, or perhaps several kinds. One of these is light.

We use light and we find light important in many chemical reactions. For example, there is one that gets to be very famous during the summer when people are going on vacation. Can you think of a way that you use light when you are on a trip to help you remember it later? (Camera) The first thing that I want to talk to you about is photography, which is one place that light is very important. In photography we capture light by making the light do a chemical reaction.

**Demonstration #1**

Use three beakers (50ml), three petri dishes, filter paper, tongs, solutions of silver nitrate (1.7 g AgNO₃ / 100 ml H₂O) and sodium bromide (1.0 g NaBr / 100 ml H₂O), and an overhead projector.

Pour 10 ml of silver nitrate solution into one petri dish and sufficient bromide to cover the bottom of a second petri dish. Take a piece of filter paper and drop it into the bromide solution, remove, allowing excess liquid to run off, and dip the paper into the silver solution. Place the paper, dampened, on the third petri dish and invert onto a familiar object, such as a key. Leave the paper until late in the program.

I have some silver nitrate solution here; all it is is some silver salt in water, and it is a very clear liquid. I will add to it another salt in water. It could be sodium chloride, but for this demonstration let us use silver bromide, which is very similar. When I pour these two together, I get this yellow-white, almost pure white, solid, silver bromide, which is photosensitive. That means that it changes character when light strikes it. If I put this on the overhead projector, for example, it would turn black. That is what happens in photography. You get light changing the silver salt into the silver metal. Well, I am going to do that.

I am going to make a very crude piece of photographic paper, using filter paper. I will bend the edge up, so I can get a grip on it with the tongs, because if I touch silver salt my hands will turn black, and would stick that way for a long time until the skin dies and wears off. What I am going to do is wet this paper with the silver bromide solution. And now that it is wet with the bromide solution, if I wet it now with the silver salt solution on the surface of this paper as silver bromide. This is the same solid I got before when we poured the two solutions together. Now it is coating this piece of filter paper. What I will do is put this paper here in this dish just as a place to hold it. I have a piece of filter paper, which I have made photosensitive. That means that if the light shines on it, it will turn dark. It takes quite a bit of light, because it is not very good paper; it is not the quality of photographic paper. I will take the filter paper, swirl it around in the mixture so it gets coated with that material, and again I have some photosensitive paper that should change color with the light.

Let's check on the silver coated paper we prepared earlier. You can see the key imprint on there. It is not too bright, because I don't have the exact mix of materials that I would if I were making photographic film. It is a very rough experiment, but it is designed to show you that the light sensitive silver salt is on there. Let's allow this blueprint paper to sit for just a minute. We can see that the light is causing the chemical reaction to take place. This is another very important part of any chemical transformation of these particular materials.

Let's talk a little bit about some other color changes, other things, that happen with light. One thing that we can do with light is change the color of some material. This is similar to the sun bleaching clothes. This solution is sensitive to light in the opposite way that those photographic papers are. Those are sensitive in that they become very darkly colored when light strikes them. This material also will change in light, but in a very different manner.

**Demonstration #2**

Stock solutions:
- 6 N sulfuric acid: Add 84 ml of concentrated sulfuric acid (H₂SO₄) to 416 ml of distilled water. ADD ACID TO WATER. CAUTION: THIS SOLUTION BECOMES VERY HOT.
- 0.001 N thionine solution: Add 0.115 g of thionine to 500 ml of distilled water. Thionine can be dissolved (this will take some time). Adjust to pH 3.5 with concentrated H₂SO₄, adding a drop at a time. Keep in a glass-stoppered Pyrex bottle.

Preparation of demonstration solution: ThorOUGHLY mix 15 ml of the stock thionine solution, 15 ml of the 6 N H₂SO₄, and 720 ml of distilled water. Add 3 g of ferric sulfate and mix thoroughly again.

To perform the demonstration place the solution in bright light from a floodlight or overhead projector — remove to restore the color.

See how dark it is in the room light. Watch what happens when I set this up on the tablecloth. What is happening to it? It is getting lighter and lighter. The projector isn't quite bright enough to make it vanish completely. If I take it outdoors in the bright sunlight, it will turn clear in an instant, because it is light-sensitive. The compound in this solution changes back in darkness, but as soon as I put it in the light, you can see the color practically disappears. Again we have a chemical reaction being caused by the light. But it is a reversible one, meaning that it will not be as soon as I take the light away. So light can cause very useful chemical reactions and some just interesting reactions. This is not one that has any particular use, but it is just kind of fun to do. Another way that light is used is by burning various substances. We all know of lots of things that burn and give off light, such things as paper, wood, coal, oil, gas, last night's dinner, and so on. All these things contain carbon, which burns nicely in air, giving heat and light. Also, some metals will burn. Iron, for example, if finely divided into a powder, will burn nicely. Here I have another metal that burns...
Show Title: LIGHT IN CHEMISTRY

DON'T LOOK DIRECTLY AT THE LIGHT. WHAT METAL IS IT THAT I AM BURNING? (MAGNESIUM) MAGNESIUM BURNS WITH A VERY BRIGHT LIGHT AND GIVES OFF LOTS OF HEAT. IT IS THE SAME METAL THAT IS IN OLDER FLASH CUBES AND WAS USED BEFORE THAT IN THE FLASH POWDER, WHICH WAS USED BY EARLY PHOTOGRAPHERS.

Let's dim the lights. The light that I am now going to make by mixing these two solutions doesn't have any heat associated with it. When the magnesium burned, you'll recall, it was very bright but it also gave off a lot of heat. This is quite different.

DEMONSTRATION 05

Prepare the luminol solutions fresh. Solution "A" contains 0.4 g luminol (a complex organic compound of which there are several varieties) and 1.0 g sodium hydroxide (NaOH) in 1 liter water. Solution "B" contains 40 ml 3% hydrogen peroxide (H2O2) and 1.0 g potassium ferricyanide (K3Fe(CN)6) in 1 liter of water.

One effective demonstration involves pouring the solutions together into a funnel supported over the edge of the table with a long glass tube attached, which is over a 1 liter beaker. In a darkened room the column of light formed is dramatic.

Can anyone tell me where you might see that kind of light in nature? It is a cold light and doesn't have any heat with it. I'll give you a clue. It is something you see at night when you go outside in the summer. (Lightning bugs) The chemicals that I was mixing are the same kind of chemicals that are important to lightning bugs. We don't know now the lightning bug does it as a matter of fact. We know what some of the chemicals are, but how that little bug gets out there and sparks on and off with that bright light, and he pulses, he goes on and off, we don't understand exactly how he does that. But we do know an awful lot about the materials that he uses and some of the same materials are used here.

Let's take a look at our blueprint paper. We can see that the paper is, indeed, turning blue, except where the light did not hit it, where the key was. So, as a result, we see an image of the key on the paper. Again, the light is an important part of the chemical reaction.

That concludes my talk on light in chemistry. I hope I have shown some important uses of light in chemistry. If you have any questions, I will be happy to try to answer them. Thank you for your attention.

EQUIPMENT, SUPPLIES & CHEMICALS REQUIRED FOR THIS DEMONSTRATION
(Note: Quantities of expendables are estimated based on 10 shows)

Show Title: LIGHT IN CHEMISTRY

Equipment and Supplies

DEMONSTRATION 01

3 Beakers - 50ml
3 Petri Dishes
Filter Paper, tongs
Silver Nitrate (1.7g/100ml water) 4-oz. silver nitrate
Sodium bromide (1g/100ml water) 4-oz. sodium bromide

DEMONSTRATION 02

4 Petri Dishes
Ferric Ammonium Sulfate (2g/20ml water) 20g
Potassium Ferricyanide (2g/20ml water) 20g
Ferrous Sulfate (2g/20ml water) 20g
Overhead Projector

DEMONSTRATION 03

Concentrated Sulfuric Acid 1000ml
Thionine 1.150g
Ferrous Sulfate 30g
1 liter Flask
Distilled Water

DEMONSTRATION 04

Magnesium Ribbon 40"
Butane Gas Flame
Tongs

DEMONSTRATION 05

1g Luminol (3 amino-phthal-hydrozide)
2.5g NaOH (25g NaOH)
100ml 3% Hydrogen Peroxide (1 liter 3% H2O2)
2.5g Potassium Ferricyanide (25g)
Funnel, long glass tube
1 liter Beaker
DEMONSTRATION #1

The liquid nitrogen supply should be in a 5 liter container and smaller flasks used for the demos. Dewar flasks are fragile and must be handled carefully. Use a 1 liter flask for most demos.

The first demo shows the liquid nitrogen - pour some from the storage container into the Dewar to show its water-like character. Pour a small amount into a large (1 liter) beaker or onto the floor (not too near the audience).

I'll begin to pour it. I haven't got any liquid coming out yet, but the streamer running down is just water vapor. Water in the air forms this vapor. Water isn't the nitrogen. Let's see the nitrogen. If I pour a little bit out, first of all you can see that I still have a little bit of water in there, but there is a little bit of nitrogen in the bottom of the beaker. If I pour just a little bit, it will or not. I'll toss it around a little bit. That clear liquid is liquid nitrogen. It is a very, very cold, very cold material, and it can be used to cool things. That is one of the ways we can use liquid nitrogen.

DEMONSTRATION #2

Use a small, metal ice cube tray. Fill less than ½ full and pour LN (liquid nitrogen) over the tray in small batches. The water will freeze to ice.

I can make some instant ice cubes, for example. If you come up to the time just before the party, and you don't have any ice cubes ready, you can run next door and borrow some liquid nitrogen (if you can't borrow ice cubes). You pour it on top and the liquid nitrogen on the surface of the water evaporates, takes the heat out of the water, cools down the water, and we should get some solid ice in there, if I am not too chintzy with the liquid nitrogen anyway. It takes the heat away, cools it down, but it probably won't freeze solid. I put too much water in there to do that. It takes an awful lot of liquid nitrogen to cool all that down. Well, we'll just let it percolate away for a few minutes. The thing that we can then do is to cool liquid down and make them into solids.

Cooling water is no big deal; you've seen water cooled down every winter. Here is some alcohol; the real kind of alcohol, denatured so I can't drink it, and neither can you.

DEMONSTRATION #3

Place 20 ml ethyl alcohol in a 100 ml beaker and add LN slowly with stirring. Be careful not to freeze solid and you can create a short-lived "alcohol-stickle".

I'll take that alcohol, not too much of it, because I don't want to use too much of the nitrogen. I want to stir this while adding the nitrogen to it. And I am cooling the alcohol down now. (Cauldren, cauldron, boil and bubble - my witch's brew, here.) All of that vapor like steam is just water from this cold. It is a little of it is alcohol freezing out actually. It takes some time and a little liquid nitrogen to cool the alcohol down far enough. I don't want to get it too cold, because you will find that the LN won't go in and I won't get it. But if I cool it just right - and I used to be experienced at this in my job as a bartender, in a chemistry lab, of course - if I stir it just right, it starts to thicken up a little; it gets the kind of pasty solid and it can't go in. This is one way to cool the Celsius scale at which the alcohol freezes. So if you put pure alcohol in your radiator and went down to minus 60 Celsius, it would freeze. I could have some hard liquor or a hard liquor population if I could find it. No. You can cool a lot of materials that you think of as being liquid, because of the very low temperatures you can get with liquid nitrogen. I did make some ice in here, just a thin layer. You can come up and look at it afterwards if you wish. I have to use a little bit less water in there, because I had to use too much of my liquid nitrogen to cool it down.

DEMONSTRATION #4

Use a chrysanthemum, carnation or other fluffy flower. Show how squeezing the flower at room temperature gives a resilient response. Then immerse in LN until the heavy bubbling ceases and remove and squeeze quickly. Don't hold the petals, but squeeze and release to avoid frost bite.

Liquid nitrogen also changes the character of a lot of materials. We use it sometimes to freeze things. I have a flower here. Some of you recognize it. I don't see flowers too often in the lab. But it is a nice soft, tender flower. And if I stick it in the liquid nitrogen, it doesn't take very long before it loses that soft, tender character, and it becomes very hard, very brittle and I can shatter it. This is one way to de-petal the flower. So we can change the way things behave by freezing them.

DEMONSTRATION #5

Use a 26" length of rubber hose - immerse one end in LN - the end freezes and gas spouts from the upper end due to the pressure generated. Remove and tap against the table to show its rigidity. Allow to warm up.

Here is a piece of rubber hose. I can do an interesting demonstration with this, because there are two ends to watch. This is one end of liquid nitrogen in being kicked out the other end, because of the pressure I am getting inside a little bit anyway. Now (ping, ping, ping) the rubber is hard, brittle material. If I had a hammer I could shatter that. It will come back to the rubber character, that is it will have the stretch that it had before, fairly quickly. So things that have stretch and give to them like the flower and the rubber hose, lose that when they are cooled. They become more rigid, much harder.

DEMONSTRATION #6

Use two pieces of coiled solder. Test ahead of time to obtain the correct weight which the frozen coil can support. Place the weight on the room temperature coil and note that it stretches. Immerse the second coil in LN and then remove and quickly add the weight. It will be supported at first, but then stretch out as the coil warms up.

De we can see another way of using that characteristic of making things harder by looking at some metal here. This is some solder that I made up into little springlike fashion. If I hang a piece of lead from the solder, what is going to happen? Not too good. So the solder is a very soft metal. That is why we use it as solder, because it melts easily, and we use it to seal materials together. If I take that same solder, and I cool it down quickly, it will have the usual strength to it. My big problem is getting the piece of lead on there before it gets too cold. Otherwise it is going to stick, and when it warms up, it loses the strength that it had, because it was cool, and it stretches out. So as long as it is really cold, it will have that strength to it. Metals which are soft normally at room temperature can be made harder.

DEMONSTRATION #7

A piece of heavy lead sheet on a string with a striker is required. Strike at room temperature (thud), then immerse in LN and strike again - a metallic clang.

We can see another way of using that fact if I take this bell. This is a bell made of lead. But if I cool it down in liquid nitrogen, it will take a couple of minutes, because the lead is very heavy, it takes a lot of cooling. Fortunately the shank that I am holding on to doesn't conduct too well, or I would have my fingers frozen. As I cool it down, it becomes more metallic, just as the spring becomes more metal like, harder. You can see that it has a much more normal ring to it as a metal. I can show you that same effect with another piece of lead, and it will have that ring to it that a metal has. And it will have that resilience, that strength to it that it has in fact. If I had a hammer I could shatter that. It will come back to the metal character, that is it will have the stretch that it had when it was cool, it will have some resilience, that's it. Metals which are soft normally at room temperature can be made harder.
DEMONSTRATION 010
Use a thin-wall rubber ball, which fits into the Dewar flask. Bounce it to show normal behavior, then immerse in LN, remove with tongs and toss hard (Don't grab, hold loosely) onto floor - ball shatters.

Let me show you an example of something made out of rubber that can be cooled. We have here a little more liquid nitrogen; I just happened to bring along a supply, just a small supply, 25 or 30 liters. Now we are going to cool this paddle ball or racket ball, depending upon what you want to call it, in the 3 liter Dewar flask, which is going to contain the ball when I cool it in the liquid nitrogen? Is it going to be a bouncing ball any more? Will, if I threw it down, what is going to happen to it? It will have lost its bounce. Let's try it and see. Let's try it once more: done was bring my winter gloves. This time I’ll take a quick grab and thrust it onto the ground. And it shatters. Don’t grab it if you see a piece, because it will be very cold, and it might stick to your hands and give you a little frost bite.

The properties that I am demonstrating here, where I take something soft and flexible and make it hard, has a good use in the industry, when they want to use the leads for seals and gaskets, one of the things that they have a problem with is that these rubber rugs have little pieces of rubber on the outside, and they need to trim this off. So what they do is take these up till the light comes on it takes about 6 volts. This is because I have the electricity going through this little coil and through a 3 volt bulb to the other lead. If I take it away, it will warm up very quickly, because it is a good conductor and the light will go back out (I hope). All you have to do is cool it down, and it loses about 85% of the resistance it had while at liquid nitrogen temperature. So the bulbs, this is a very important area for the super cooled liquids, because we can transmit power without losing all of the power due to resistance that is in the line.

DEMONSTRATION 011
Before the demo fill a small balloon with helium and attach to the demo table via a thread. Hold the balloon in a large beaker and pour LN over it - it shrinks and collapses - can't rise. Allow it to warm up, and it fills out and rises again.

This is a balloon with some helium in it. You can tell that it is a gas that is at least lighter than air, because the balloon rises. What I am going to do is cool it down, and the effect of cooling down will be to take the volume of the helium and reduce it. I am not liquefying the helium, all I am doing is cooling it so it isn't occupying as much volume, so it can't hold the balloon up any more. But as it warms up, it expands and eventually gets to the point where it can rise again. It takes a little while.

That concludes the demonstration. If you have any questions, I will be happy to try to answer them. Thank you.

DEMONSTRATION 02
Metal Ice Cube Tray
Water
Liquid Nitrogen

DEMONSTRATION 03
20ml Ethyl Alcohol (200ml)
100ml Beaker
Liquid Nitrogen

DEMONSTRATION 04
Chrysanthemum or Carnation (10)
Liquid Nitrogen

DEMONSTRATION 05
24" length Rubber Hose (20")
Liquid Nitrogen

DEMONSTRATION 06
2 pieces Coiled Solder
String with Striker

DEMONSTRATION 07
Heavy Lead Sheet Piece
Thin-wall Rubber Ball (10)
Tongs

DEMONSTRATION 08
Ball and Ring (Ball larger than ring)

DEMONSTRATION 09
18 ft. #39 Coated Copper Wire
Steel Wool or Sand Paper - small piece
Heavy Copper Wires in Rubber Stopper
Power Supply or Battery pack - 3 volts DC
3-volt Bulb
2 clip
Solder Copper to Heavy Copper Wires

DEMONSTRATION 10
Helium Balloon
Thread
Good heavens, what I want to talk to you about today is gases, some of the things that gases are used for, some of the properties of gases, and maybe you show some unusual, but interesting ways in which gases behave. A lot of what I am going to do is not at all unusual if you think about it. But maybe you haven't had the opportunity to see gases do just what I am going to do with them. I have gases here in these cylinders. I have a cylinder of helium and a cylinder of hydrogen. Helium and hydrogen are two of the gases that normally come in contact with the air. Since we are in a gas, nitrogen and oxygen mostly, a little bit of carbon dioxide. Then there are the gases that you are probably most familiar with. Another gas that you might be familiar with that we will talk about is propane, which you can buy in a variety of cylinder types and sizes. Let’s talk about hydrogen and helium for a few minutes. One of the properties of hydrogen and helium that makes them very useful is that these gases are so light compared with air. They have a lot of lift to them, hydrogen especially.

**DEMONSTRATION 01**

Fill a balloon with hydrogen and attach it via a thread to the dosen bench. Use a 3 foot dowel to which a candle is attached to light the balloon.

Hydrogen was used in early dirigibles. Does anyone know the name of a dirigible in which hydrogen was found? (Hindenberg) Hindenberg is very familiar with it, it was the last of the big dirigibles. Does anyone know why? (It burned) Yes, it burned and sort of wiped out the whole dirigible industry. I recently saw a paperback book with the details about the Hindenberg, but all the sizes and so forth, it was very helpful. Interestingly enough, the Hindenberg didn’t really explode. Hydrogen doesn’t always explode. And one of the reasons is that with hydrogen, it must have just the right mix of air, which has oxygen in it. If you have just the right mix, that right mix, won’t explode, it will just burn. I have a balloon over here, which I am going to light. It is filled with pure hydrogen, and you can see that it has lift. And when I light it, (poof) it makes a real sharp bang, instead of just a little pop. I can also make bubbles ignite, if I am lucky and careful. I have a cylinder of helium and I am going to do this, although it may not exactly be the same thing. I can make bubbles ignite if I don’t get just the right amount of soap solution in there, my bubbles won’t rise.

**DEMONSTRATION 02**

Use a bubble pipe (toy) and bubble solution. Add only a small amount of soap so it bubbles over. Attach the pipe via a hose to a hydrogen cylinder and control the flow of hydrogen to produce bubbles. Ignite the bubbles after they rise, using the candle/dowel lighter from Demo 1.

Hydrogen, then, can be used for lift, but it isn’t used in balloons anymore because it is so dangerous. Since there was a good mix of air with the hydrogen in the bubble, the hydrogen exploded in a puff like that.

We now use helium in balloons. What is the name of a famous big balloon that has helium in it? (Goodyear blimp) Helium doesn’t have quite the lifting power of hydrogen, but it doesn’t burn, so it is safe. Helium and hydrogen have their lifting power because they are lighter than air. Just as something that is lighter than water floats to the surface, hydrogen and helium rise to the surface of the air. If I fill a balloon with helium what is going to happen? (It rises)

**DEMONSTRATION 03**

Fill a balloon with helium using the tank during the demo.

Another interesting property of helium can be demonstrated if I just breathe the helium. My voice will get higher, because something is happening in my lungs, they will be filled with helium, which will give a different tone to my voice. And you’ll just have to take my word that I am not changing my voice. I just hope that I don’t get too much helium, because if I don’t get enough, my voice really changes way over and over and over and over, and I will just continue to talk, and we’ll see what happens.

**DEMONSTRATION 04**

Use the balloon from Demo 3 as follows: breathe deeply for two or three times. Then breathe out. Hold the balloon in your mouth snugly while breathing in and talk naturally. This procedure is less wasteful of helium than breathing from the tank.

And now I am talking exactly as before, but my voice is pitched up, because my lungs are filled with helium. But as I talk, I am breathing air and so the air replaces the pure helium and my voice comes back down. I think it is coming down; at least I certainly hope so, I don’t want to go home like this. Well, you might say, that is interesting, but no so. We have used helium sometimes when we didn’t want to use nitrogen, because nitrogen in a high pressure gets into the blood and diverts. When divers breathe air, they get the bends from having nitrogen bubbles in their blood. So divers frequently mix helium with oxygen and breathe that instead of air, which contains nitrogen. The helium doesn’t dissolve very well in the blood. The helium and oxygen mix, and we know that had a group of men in a helium-oxygen filled cylinder deep in the ocean. When they talked to each other they sounded just as I did a moment ago, though maybe a little more high, because they had a lot of oxygen in there. They had a high pitch to their voices when they talked to each other and when they talked to the people on the surface. So helium is used, because it has the particular lift properties and for special reasons in diving.

There is one problem with helium that is not a problem with hydrogen, and that in that there is a limited supply of helium. Helium has to be made. Does anyone know where helium comes from? It comes out of the ground as a small part of the gases that are in with natural gas. The reason it is found under the ground is that it is more positive than air and so rises right up through the atmosphere to the top of the atmosphere and drifts away. So we lose it; every time I open up this bottle, some helium is lost forever. It was made underground, because a gas that is lighter than air and not radioactive, and it got captured in the rock. It got captured along with the natural gas; but once it is released, it is lost.

Hydrogen comes from water, and we can decompose water. We have a, a gas that is also used, but that we don’t have an unlimited source of hydrogen. These two gases are lighter than air, but they are only two of a whole bunch of different gases that we talk about. Next, I will talk about a gas that is heavier than air. This is one that should be familiar to you, does anyone know what it is? (Carbon dioxide) Okay, I am going to make some carbon dioxide.

**DEMONSTRATION 05**

Use two 1 liter beakers. Place a small lighted candle in one beaker. Add a layer of vinegar into the second beaker and add a generous amount of baking soda to the vinegar; after 3 seconds pour the invisible carbon dioxide into the beaker with the candle. It is snuffed out.

Can everyone see the fire? I am going to make some carbon dioxide by pouring vinegar, which contains the weak acid, acetic acid. I will make carbon dioxide with this baking powder. I get a lot of foaming and bubbling and carbon dioxide is generated. You should see the carbon dioxide generated; pouring out, can’t you? No one can see it? That’s good, because it is a gas and it is invisible. How do you know it is there? Well, you can believe me, or I can do a little demonstration to prove that it is really there. I am going to pour the invisible carbon dioxide into the flame. What does the carbon dioxide do? It puts the flame out, because the carbon dioxide can’t support combustion. It puts the fire out by taking away the oxygen. It is a gas heavier than air.

I have another gas here that is heavier than air. It is a gas with which you might associate a certain gas company - propane gas. This is a small propane gas cylinder. Propane also burns. It doesn’t burn quite as rapidly as hydrogen, but it burns pretty well. Let’s try a little experiment here. I developed this very carefully, tasted it, and it works 100 percent of the time. Well, that one didn’t work at all. What I am going to do is fill this “home”. This is someone’s home; the best one I could build. I wanted a home that could fill with this gas. I am going to fill with the gas, so if I fill it, I want the gas to flow out. If I tip the can up straight, which is what I did when I drilled the hole in there… I thought I would be very clever, and I drilled the holes in the can, then thought to put the can out in the sun the gas in and tried to light the top, and nothing happened. The reason nothing happened was the hole was up, and the gas was all drifting out the bottom, because the gas is heavier than air. So I had to get it smart and lay the can on its side, so that it just drifted a little while to fill it up. This is your house, and you have loft the gas on. Somehow the pilot light went out, and the gas kept running and is filling up your house slowly, but surely. You folks at the front of the room went out to find their feet. One strange phenomenon about this little filler can that am I using is that it doesn’t stop instantly; it just keeps going, so I have to set it over here at the edge. And I’ll light this. (bong)
DEMONSTRATION #6

A special can with a removable lid and with two holes is required - one hole in the bottom center and the other in the top edge. Support the can so that the second hole is up and fill the can with gas (propane, butane, natural gas). Allow 15-20 seconds of flow at least - practice this ahead of time. Remove the gas supply and ignite the can by holding the dowel/candle near the hole in the center of the can. It may explode quickly or burn a short time prior to exploding.

If you were at home, you would have been awakened by the sound. It probably would have gotten you out of bed more rapidly than you ever did before in your life. One thing I was trying to demonstrate there was that it burns just for an instant with the gas at the nozzle where I lit it, and then it very quickly forms a mixture inside the can. As that gas was used up, the air was pulled in and it formed an explosive mixture. Every flammable gas has that mixture between gas and air which is explosive. If I had all gas in there it would not explode; it would simply burn. The balloon of hydrogen mostly burned; it didn’t really explode sharply, because it was all hydrogen. But if I mixed air and hydrogen together, it would have exploded just as the can did when it reached that particular point, that explosive mixture. And that is what you have to be careful about. As soon as it reaches that explosive mixture, then it will take off very rapidly.

DEMONSTRATION #7

A series of tubes containing various gases and a Tesla coil are required. Support the tubes from an insulating rod and turn the coil on. Bring it near each tube as you discuss the glow produced by the gas present.

One final demonstration I am going to do is a quiet one, just to end up with a quiet note, since I started out loud. This is a demonstration of one way in which we use some gases. There are gases in these tubes. I won’t tell you what they are; I’ll see if you can figure out what they are. I have a Tesla coil, which is a spark to give us a high voltage. When I bring it near these tubes the spark passes through the tubes. Does that look like a familiar light? This is what a mercury vapor light looks like. It has a small amount of mercury and a lot of electricity. That is one that is familiar...neon light. This is one you probably won’t know...carbon dioxide. Each gas has its own color, its own spectrum that it generates. And we use them both in terms of lasers, which is a very special use for gas, as well as for decorations and artificial lights and signs.

I hope this has given you some different views, perhaps a little information, on some other ideas about gases. If you have any questions, I would be happy to try to answer them for you. Thank you very much.

EQUIPMENT, SUPPLIES & CHEMICALS REQUIRED FOR THIS DEMONSTRATION
(Note: Quantities of expendables are estimates based on 10 shows)

Show Title: GASES
Show Number: Six

DEMONSTRATION #1
Balloon (10) - light thread
Hydrogen Cylinder
3' Dowel with Candle Attached

DEMONSTRATION #2
Toy Bubble Pipe
Bubble Solution
Hydrogen Cylinder
None
Candle/Dowel Lighter (#1)

DEMONSTRATION #3
Balloon
Helium Cylinder

DEMONSTRATION #4
Helium Balloon (#3)

DEMONSTRATION #5
2 - 1 liter Beakers
Small Candle
Vinegar - 1 quart
Baking Soda (1 box)

DEMONSTRATION #6
Can with Removable Lid & 2 holes
Gas (Propane/butane/Natural Gas)
Dowel/Candle

DEMONSTRATION #7
Tubes containing various gases
Tesla Coil
Insulating Rod
Good morning, today I would like to talk with you about combustion. What do you mean, anything? Well, it is another name for burning. The most obvious and familiar example of combustion is fire. Man has been using fire since the days of the cave man. Can you tell me where fire came from? (Lighting!) The belief is that man first got fire by collecting burning trees that had been struck by lightning. He found that fire would do certain things, such as keep him warm, cook his food, and keep wild animals away. I am going to duplicate that prehistoric feat in my own small way with electricity.

**DEMONSTRATION #1**

Take a coil of copper wire in a tree shape and cover with a kleenex or tissue paper on an asbestos square. Using a tesla coil turned to full discharge, cause a spark to jump through the paper to the coil. The heat will start the paper burning.

If I discharge this tesla coil next to this "tree"... it makes the tree burn. So the static electricity is like the electricity in lightning. It hits the paper and burns. I put the copper in the center to make it attract. This is the same thing that happens when lightning strikes trees. The lightning strikes the tree and generates enough heat to get the tree burning. That is one way to get fire.

If you examine the process of combustion, you will find that you need three things in order for combustion to occur. First, you need some sort of fuel, anything to burn. For example, paper. Second, you must have a source of oxygen, for combustion may also be described as very rapid oxidation. Finally, you need heat. Without all three components combustion cannot occur.

Combustion can be initiated in a variety of ways. You just saw me do it with our man-made lightning. You can, of course, use a match. But there is another process known as spontaneous combustion, which is responsible for many fires. Has anyone ever seen what happens when a pile of oily rags is left around? It is possible for them to start burning all by themselves, and the same for that burning is spontaneous combustion. Imagine a big pile of oily rags. Oxidation is slowly taking place down at the bottom, and that builds up heat. The heat can't get out, because it is insulated by the rags, so it builds up higher and higher, until it gets so hot that the rags burst into flames. I don't have any oily rags, but I will show you something similar to that.

**DEMONSTRATION #2**

Place a small pile of potassium permanganate (KMnO4) on an asbestos pad. Make a slight depression in the top. Add five (5) drops of glycerine to the depression and move back. The reaction starts slowly, but soon gives off heat into the flame.

This is a pile of a very strong oxidizing agent. It has a lot of oxygen in it, and it will release that oxygen, if it is in contact with something that will burn. This liquid is glycerine. (Don't get too close.) I will put three or four drops onto a piece of steel wool, very slowly at first. But once sufficient heat has been built up, it takes off just like the oily rags, it flares up, it flashes and burns rapidly. That is an example of spontaneous combustion.

As mentioned earlier, one of the necessary ingredients for fire is some sort of fuel. This, of course, brings to mind such things as paper, wood, coal, oil, natural gas, and so on. But we can also burn other things; for example, metals. Of course, I don't expect to take a solid piece of metal and hold it in a flame and have it burn. But if the metal is finely divided, allowing maximum exposure to the air, it can burn. Did anyone ever burn steel wool?

**DEMONSTRATION #3**

Using steel wool obtained at a grocery store and a gas flame for burning, take a length of steel wool 1-2 inches by 1-2 inches from the roll. Hold it with tongs and lower it into the flame slowly.

Steel wool is just iron in a very fine wire-like condition; and it does burn. It burns in air and sparkles just like a sparkler. But it doesn't burn too well. The problem with the steel wool is that the air around it doesn't have enough oxygen in it.

Does anyone know the percentage of oxygen in the air? (about 21%) Only 21%, about 1/5 of the air, is oxygen. It seems reasonable that if we increase the available oxygen, we increase the rate of combustion.

**DEMONSTRATION #4**

Similar to Demon 3, but prepare a large (1000ml) beaker filled with oxygen from a cylinder. Ignite burning steel wool by placing the tip in the burner flame, and then thrust it vertically into the beaker. (The beaker can be cleaned with hydrochloric acid.)

So I am going to put a little oxygen in this beaker. Oxygen is denser than air, so it will sit in the beaker. Then I will take another piece of steel wool, ignite it, and let's see what it does in the oxygen. What is going to happen when I put that into pure oxygen? It is going to go a little faster. Give it a little more oxygen and it goes a little faster still. Notice how little of it is oxygen in there as it melts. Iron will burn, in fact iron will burn pretty fast, particularly when it is very finely divided.

One of the problems we have with combustion is that we don't want too much of it. We want some control; keep it within bounds. Sometimes we would like to put fire out with some device.

**DEMONSTRATION #5**

Use two large (1 liter) beakers, a small candle, vinegar, and baking soda. Place the candle in one beaker and light it. Put some baking soda in the bottom of the second beaker, then add sufficient vinegar to cover the bottom well. Allow the generation of CO2 to proceed for 15-20 seconds, and then pour the invisible gas into the beaker containing the candle.

I will light this candle, which is going to represent a fire. If I am a fireman, I will have to put the fire out. Now how do I need to do that? (Indigo,) Pull a length of magnesium held by tongs. Lower the magnesium in the CO2, It continues to burn. I don't have any water, but I do have baking soda, so let's make a fire extinguisher. When you combine vinegar with the baking soda, a chemical reaction occurs, and one of the products of the reaction is carbon dioxide, a combination of carbon and oxygen. Again, as in the case of oxygen, carbon dioxide is an invisible gas, heavier than air, so it sits in the beaker. Unlike oxygen, however, carbon dioxide will not support combustion, but will suffocate a flame. Watch as I pour the carbon dioxide into the beaker with the candle, and as you can see, the fire is extinguished. Now, that sounds good, sounds like I have made a fire extinguisher. But carbon dioxide will not work on all types of fires.

**DEMONSTRATION #6**

Repeat the preparation of a beaker of CO2 gas as in Demon 5 and light a strip of magnesium held by tongs. Lower the burning magnesium into the CO2, it continues to burn. For example, this strip of metal, made of magnesium, will burn quite intensely. Be careful not to look directly at it. Notice when that stick in the carbon dioxide fire extinguisher, it doesn't go out. Magnesium in fact splatters and spouts and keeps on going. By the time the magnesium burns at such a high temperature that it breaks down the carbon dioxide, and uses the oxygen thus liberated to support the combustion of the magnesium, so, while carbon dioxide in a very good fire extinguisher for some kinds of fires, it doesn't work for everything. There is a special dry powder chemical used to put out fire involving metals, such as magnesium.

A few minutes ago you saw me make that paper burn, right? I claim that I can put a piece of paper in the flame and not have it burn. I won't put anything special on it; in fact, I will just use one of these little paper dishes.

**DEMONSTRATION #7**

Use a round bottomed cup or bowl as those with ridges will burn quite slowly. Half fill with water and heat using a gas burner. Be careful to heat only areas where water is in contact with the paper and use a moderate flame. An embellishment might be the use of a bowl and a cup-a-soup packet to prepare hot soup. Or you could have a member of the audience use a finger to test the water temperature before and after.

If you are ever camping out, and you want a cup of soup, and you have a paper dish, you can just take some water and heat it. You can heat the water directly at the source.

Let's look at the principle upon which this is based. Normally, when the flame hits the paper, it will make the paper burn. But the water takes the heat away from the paper just as the water does when it comes out of the water heater. The paper won't burn as long as I don't heat it too fast or with too much heat. By using a reasonable flame, I can heat this up and make the water hot, but not the paper. If I start heating the edge and get it where there isn't any water, what is going to happen? There is nothing there to take that heat away from the flame, so it could ignite or sear badly. That is what we are doing, basically, in preventing the paper from reaching its ignition temperature.

Another demonstration I would like to do for you is the non-burning towel demonstration. If I am not too good at it, it may be the burning demonstrator demonstration.
**Chemistry for Museums**

**Show Title:** COMBUSTION

**Show Number:** Seven

**DEMONSTRATION #8**

A 1000ml beaker, 100ml of a solution with 50-50 water and isopropyl (rubbing) alcohol, a cloth towel, tongs and a match or flame are required. Soak the towel in the solution, squeeze slightly, but keep quite wet. Light while holding with tongs. Keep away from beaker.

This beaker contains a solution of water and alcohol, 50-50. I’ll soak this towel in the solution, squeeze it a little, and ignite it. Now, one’s immediate impression is that the towel is on fire. On closer examination, however, it can be seen that the towel isn’t really burning. The alcohol is burning, and the water protects the towel. In a way this is similar to our last demonstration. While the alcohol burns, the water keeps the towel cool and prevents it from reaching its ignition temperature. You can see now, the fire is out, but the towel is undamaged.

Let me do a demonstration of historical interest. You all have heard about the Hindenberg.

**DEMONSTRATION #9**

Prior to the demonstration, fill a small balloon with hydrogen and tie down with thread. A suitable ignition stick can be prepared from a 6" dowel about 30" long to which is taped a birthday candle. Light the candle and hold its flame below the balloon to cause it to explode.

Sometimes combustion takes place at an extremely rapid rate. What do we call such a rapid combustion? (An explosion) The fuel that underwent combustion in this case was a gas.

Anyone know what it was? (Hydrogen) If you have ever seen films of the destruction of the Hindenberg, you know why hydrogen is no longer used in airships.

One of the things we don’t know much about is why some kinds of burning happen the way they do.

**DEMONSTRATION #10**

Have two sugar cubes, cigarette ashes, tongs, and a flame available. Hold one sugar cube in the edge of the flame, and show that it won’t burn, just melt. Rub the second cube in the cigarette ashes thoroughly, and then hold in the edge of the flame. It will continue to burn some time after removal from the flame.

This is a cube of sugar. I am going to waste this cube of sugar, in a sense, but I am going to show you that if I heat this cube of sugar in the flame, all that happens is that it melts and drips. Sugar melts, but does not burn. Now, there are cigarette ashes, and I am going to rub this sugar cube in the ashes. All I am trying to do is get a little bit of the ashes into the surface of the cube, and for some reason, and this is one of the many things we don’t understand, when I heat this in the flame now, it will burn. We call that a catalytic reaction, and the sugar burning is catalyzed by the cigarette ashes. So now, in some way, the ashes have to be there to help that reaction go, even though they are not a direct part of the reaction. If they aren’t there, the sugar cube would melt just as it did before, but if they are there, it will burn.

So there are some things we still do not know about. Burning, even though fire is one of man’s earliest discoveries, is something we still have much to learn about. Combustion is all around us, from the internal combustion engine of your automobile to the common match. In many ways we are still learning about the process. I hope this presentation has helped increase your understanding of combustion.

Thank you for coming.

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**Equipment, Supplies & Chemicals Required for this Demonstration**

(Note: Quantities of expendables are estimates based on 10 shows)

**Show Title:** COMBUSTION

**Show Number:** Seven

**DEMONSTRATION #1**

- Copper Wire
- Kleenex or Tissue Paper
- Asbestos Square
- Tesla Coil

**DEMONSTRATION #2**

- Potassium Permanganate (1-lb)
- Asbestos Square
- Glycerine (50 drops) 1 pint

**DEMONSTRATION #3**

- Steel Wool 10 4-6" by 1-2" portions (1 8-oz. package)
- Gas Flame
- Tongs

**DEMONSTRATION #4**

- 800-1000ml Beaker
- Oxygen Cylinder
- Steel Wool & Gas Flame (above) (1 8-oz. package)

**DEMONSTRATION #5**

- 2 Beakers, 1 liter
- Candle
- Vinegar - 1 quart
- Baking Soda (1 package)

**DEMONSTRATION #6**

- All same equipment as above – #5
- Magnesium Strip – 40"
- Tongs

**DEMONSTRATION #7**

- Round bottomed cup or bowl (paper) 10
- Gas Burner
- Water

**DEMONSTRATION #8**

- 1000ml Beaker
- 100ml 50-50 Water Isopropanol Solution (500ml Isopropanol)
- Cloth Towel
- Tongs, flame or match

**DEMONSTRATION #9**

- Balloon (10)
- Hydrogen Cylinder
- 6" Dowel – 30" long with birthday candle taped on

**DEMONSTRATION #10**

- 20 Sugar Cubes
- Cigarette Ashes
- Tongs
- Flame
Today I would like to share a particular area of chemistry to show you how it touches our lives. The chemistry we share is not intended to be a secret thing, something else does off in a laboratory somewhere. This morning I want to talk about heat and chemistry. You have seen a lot of experiments about making heat and light. So you don't have to worry if you don't have any. You may have a little mound, just like a real volcano. It gives off light and heat — not lava fortunately, and then it dies off and everything is back the way it was. That is a model of one way in which we see nature making heat and light.

There are many ways in which man makes heat and light. Some of these, atomic bombs and other types of explosive devices, are dramatic. I have a demonstration of an old way in which we made heat and light. There is a chemical reaction which makes hot iron on the spot. What we do is to mix some aluminum powder with iron oxide.

**Demonstration 1**

To prepare the volcano drill a V hole in a small metal dish or crucible. Place a piece of paper over the hole, and add the desired amount of ammonium dichromate. It is difficult to specify the amount, but a pile of about 3/4" height should suffice. Add sand carefully to keep the dish centered on the floor, and fill to level. Cover with a piece of asbestos board and invert in a larger dish or pan. Add sand until it is over the top of the inverted dish. Use a short length of iron tubing and cover the iron tubing support to initiate the volcano. A V right angle bend in the top of the iron tubing allows easier ignition. Try this ahead of time to determine the area covered by the green chromium oxide produced.

It is not really a volcano. I have a chemical in here, which gives off light and heat, and it gives off green oxide material. It is down inside this dish. You may want to stand up to see it, I can't lift it up, and I am afraid to set it down. It is dangerous. Use a short length of iron tubing and cover the iron tubing support to initiate the volcano. This is a good example of where nature makes heat, ways in which we can't yet duplicate, at least safely. Lighting is a bad way of doing it. The amount of energy that is taken out by the red color generated as the metal forms sodium hydroxide and hydrogen and the indicator reacts with the sodium hydroxide.

It is not a circle of around it. It reacts with the water. It gives off heat and light and spews off some. But we do it in the way, so you can see it, it is really thin. The sodium molten at it absorbs the heat and then usually at the end it goes pop. It gets about 3 people right down here in front. It should trace out a line forming that color where the sodium travels. You can see it forming around and the color does come out somewhat. As the sodium gets tired at the end, it pops. That time it didn't have enough pop. So we put it up. The dye that I use is phenolphthalein, and I have most of you had much experience with it. It is the main ingredient in Exem. So if you are at home and do not have your chemistry set and want to make some phenolphthalein solution, just use an Exem tablet. I did this and it worked. Just grab it up with water and it will be an indicator, when you put it in sodium bicarbonate or some other base.

Not all reactions occur where energy is given off. Occasionally they absorb heat or energy. I have a block of wood here. I will put a little water on top. It hasn't worked perfectly, but I keep trying. I don't know the word of giving up. This is gas called. Ammonium nitrate was the compound, for those of you who are old enough to remember, on the ships in the harbor in Texas City that blew up. The ships caught on fire. The chemical doesn't catch on fire itself but because it is a compound that dissolves in water and takes heat to dissolve in the water, it so cools down. When you pour some water in there, you see that it is up there, but I can ask the room. The reaction, the epitome, if I can get it to work, it is ever would work, and it hasn't yet worked, but we are going to keep trying, because we don't know when to quit.

**Demonstration 2**

To me produce a white light and it gives off energy. I have a chemical in the water, and add the water while stirring. The cooling action due to the heat produced is none for five. The beaker of ammonium nitrate on the block in contact with the water and add the water while stirring. The cooling action due to the dissolution of the uteute should cause the water between the beaker and block to freeze into ice. My experience with this demonstration has been not so perfect.

If it ever works, it picks up so much heat, it takes heat from the water between the box and the glass beaker to the extent that it freezes and forms ice. That is what is supposed to happen and when I stop et this and pick up the beaker, the box is supposed to stick to it because of the ice formed there. It has never happened yet. It is one of those experiments I read about in books and decide to try. No, it didn't work. Let me have a volunteer. Just take a little water and put it there. How cold is it, can't you? I haven't figured out the right mixture of ingredients to make it make ice. Maybe I have too much water. But it is an example of a chemical reaction, simple solution reaction, where a lot of heat is taken out of the water, because they take energy up rather than give energy off. We really have those two types of reactions.

The next demonstration shows that energy is given off when water is used in some way. The sodium reaction to the water gave off energy; this is a reaction of sugar. This is sugar. I hate to waste it, but it is sugar, and I'll waste it to show you the reaction. Anything, there is some powdered sugar in there. Don't ask me how much a pound it is, because I don't shop anymore. Don't eat too much. Sugar is a carbohydrate (write on a board). I like to write on blackboards, so I'll write carbohydrate. I'm a chemist, and when a chemist talks, that is the short word for carbon is "C", and shorthand for hydrate is "H2O". That means water. The basic formula for sugar is the way it is put together. There is carbon and a lot of water with that carbon. If I add something to that, it is going to go and it is going to give off energy. Sugar, if I add it, it is going to give off energy. And that energy is making water into steam, and there it comes out of the beaker as water vapor, much thicker and it is growing more and more. The record is five (5) feet, I think. I have never done that. This is one reason that concentrated sulfuric acid is so dangerous. If you spill it on yourself, and nimce you are BOX water, it doesn't know the difference. It doesn't say, "Oh, I shouldn't take the water away from the person." It just goes "glop", and glums onto the water and does a real job on you. If you ever handled concentrated sulfuric acid, be careful, it is very dangerous. I avoid it whenever possible.
DEMONSTRATION #5

Write: \( \text{C(H}_2\text{O)}_x \rightarrow \text{C} + \text{H}_2\text{O} \)

To a tall form beaker add 3/4" of powdered (confectionary) sugar. Add 30ml of concentrated sulfuric acid to the sugar and discuss the reaction as it proceeds. It will start slowly and then grow into a tall black column. The cleanup is simple but the materials should be handled with care since the acid remains active.

Not all chemical reactions give off heat and light together. Can you think of a chemical reaction that gives off light, but no heat? You can buy gadgets today that do that. Well, there is one that you can think of if you go out at night in the summer. What do you see? (Lightning bugs) They have light without heat, at least we think they do. They don't complain about heat at all. There is a reaction that is supposed to work when you pour these two chemicals together. This one is called luminol and this one has an oxidizing agent in it. There is a beaker underneath that glass rod, isn't there? Every once in a while I make a mistake. That's kind of keen stuff and fireflies do it without beakers and flasks, they just kind of go zap. I don't know what kind of sound they make, but they make this luminol reaction. You can buy these little things, for use as safety flares. I saw a dance program where a little girl had a baton with one of these things on each end twirling it around. So they are kind of a fun thing. It is an example of getting light without heat.

DEMONSTRATION #6

To prepare the phosphorus in olive oil add several small 4” chunks of phosphorus to 200ml olive oil. The phosphorus dissolves slowly (several days) to give a solution which glows in very dim light (darkness is better). I prefer rubber gloves although it is safe to use your hands if immediate cleanup is possible using strong soap.

My final demonstration I saved for last, because it is a kind of dangerous one, and I don't survive very long if I don't do it last. I put on rubber gloves. This is only for cowards. People who know what they are doing don't put on gloves. They just do this straight out. I am a coward, but I am not afraid of saying I am a coward. This is a solution of white phosphorus, which was used in World War II. You may have read about phosphorous materials being dropped on houses to get them to burn. If you want a real freaky thing to do on Halloween, you can get some of this. Ask the kids in my neighborhood, I do this kind of freaky thing all the time. And if the light is dim enough you might be able to see it glow.

Thank you for your attention. I enjoyed talking with you.

EQUIPMENT, SUPPLIES & CHEMICALS REQUIRED FOR THIS DEMONSTRATION
(Note: Quantities of expendables are estimates based on 10 shows)

Show Title: HEAT AND LIGHT
Show Number: Eight

DEMONSTRATION #1
- Small Metal Dish or Crucible with ½” hole
- Ammonium Dichromate 1-lb.
- Sand
- Asbestos Board
- Larger Dish or Pan
- Magnesium Ribbon 20”
- Paper

DEMONSTRATION #2
- Iron Crucible with ½” hole
- 55g Aluminum Powder
- 160g Ferric Oxide (Fe\(\text{O}_3\))
- Pan with sand & water, Iron triangle or ring
- Magnesium Ribbon with 4” right angle bend (40”)

DEMONSTRATION #3
- Crystallizing Dish
- Distilled Water
- Phenolphthalein 10 ml
- 5/8” cube Sodium Metal (10g)

DEMONSTRATION #4
- 250ml Beaker
- Ammonium Nitrate (3 lbs.)
- Wooden block 2" x 4” x 4”
- 500ml Water

DEMONSTRATION #5
- Tall Form Beaker
- Powdered Sugar (1 lb.)
- 300ml Concentrated Sulfuric Acid

DEMONSTRATION #6
- Phosphorus (40 4” chunks)
- 2000ml Olive Oil
- Beaker
- Rubber Gloves
Good morning, and welcome to the chemistry demonstration. Today's show will explore chemistry and how it relates to the sense of smell and taste. As you are no doubt aware, the sense of smell is something that is not very highly developed in human beings; it is much more sensitive in insects and animals. I will talk more about that later.

DEMONSTRATION 1

Open a bottle of ammonia and blow over the top toward the audience.

Nonetheless, the human sense of smell can pick up and distinguish a great many different odors, and I would like to put your sense of smell to the test with this chemical. I won't tell you what it is, although there are several different techniques a chemist could use to figure it out. In this instance there is a very simple test to use. Just try to smell it as I blow some of the chemical's vapor out toward you. What is it? (Ammonia)

Ammonia is right. And your ability to sense that ammonia is pretty strong, because it is a very strong smell, and there need be only a very few particles of ammonia vapor in the air for human beings to detect it. The odor of ammonia is so strong that it can be used, for example, as a way of reviving people who have fainted. Of course, your ability to pick up the scent of that ammonia was speeded up because I blew it at you, but you would have picked it up anyway. If I had just opened up the bottle and let it drift over to you, you would have known it was there.

DEMONSTRATION 2

Prepare four boxes with tissue paper in them. Mark them A, B, C and D. Cut a 1” hole for smelling the contents in the top of each box. In two boxes place cut up fruit (banana, apple, etc.) and in the other two place a generous amount of artificial flavorings (pineapple, banana, etc.) Pass these around and ask for audience reaction, identification.

Let’s put your sense of smell to work again. I will hand out these boxes and let you smell them. You can take a deep whiff; they contain nothing poisonous, nothing dangerous. Try to remember which box you had and what it smelled like. Just kind of pass these around. They all contain smells that are probably familiar to you. Some of the boxes contain fruit which I have cut up and placed inside each box with some padding so they won’t rattle around. Some of the boxes contain artificial flavorings that man has made to mimic the smells of nature. We use these flavorings routinely to make things tastier. I have some examples of them here...imitation pineapple...imitation banana, and for those in a fairly good mood, imitation brandy.

These flavorings are used primarily in food preparation to make things smell and taste better, and this smell and taste comes from chemical compounds, called esters. I mention this to you because that is what we are going to talk about and what I am going to demonstrate next.

DEMONSTRATION 3

Use a prepared slide to write the reaction:

ALCOHOL + ACID → ESTER + WATER

e.g.: METHYL ALCOHOL + SALICYLIC ACID → METHYL SALICYLATE + WATER

Prepare the ester by adding 10 drops of the alcohol, 10 drops of the acid, and 10 drops of concentrated sulfuric acid to a beaker, heating the mixture, and then pouring the resulting solution into a small vial with a hole drilled in the cap.

A. Methyl alcohol, salicylic acid (small amount of solid), plus sulfuric acid. Heat on a hot plate for 30 seconds. (Oil of wintergreen)

B. Amyl alcohol, plus acetic acid... (Banana)

C. Ethanol alcohol, plus acetic acid... (Nail polish remover)

D. Methyl alcohol, plus butyric acid (Cone: this acid is foul smelling)

Pass the vials around after they have cooled slightly, and ask members of the audience if they can identify the different aromas.

We can make these esters fairly simply, by combining an alcohol and an acid. I will write out the general equation and a specific equation to help explain what is occurring. Combining an alcohol and an acid produces an ester, plus water. What I have done is to make the ester go right away, and tell you in the case when I simply mix the alcohol and the acid and the beaker the reaction won’t go very well. I can push it by heating it on a hot plate and I can also pull it a little bit by taking away the water by adding concentrated sulfuric acid. When I make these, I will hand them around in vials, but be careful because they will contain a little concentrated acid. You can smell them. Let me make sure that is familiar to you. This will be methyl alcohol and salicylic acid, and you will see what we get. I carefully measure out just the right amount of material, a chemist does everything in the right order, and I look around for some methyl alcohol - this is not the drinking kind - a little methyl alcohol, a little salicylic acid, a little sulfuric acid to kind of speed things up a little bit.

By the way, if you get sulfuric acid on your hand, it is time to speed up the sink and clean your hand off.

Now, I will warn that gently, just to kind of perk things up. To name what I get, when I make an ester from an alcohol and an acid, I use the alcohol name and the acid name with an "ate" on the end; so, the name of this one is "Methyl salicylate". I am not going to bore you with a lot of names, I will just set this one down. I will be the first one to smell it to make sure it is all right. If I pass out, carry me to the hospital. We will let that cool just a little bit. That was methyl salicylate.

Let's make another one you are familiar with - ethyl alcohol and acetic acid - what I have made here is ethyl acetate. I am not writing these names up here to try to give you any gibberish about chemistry, but I want to point out that the names we write up here are the same names that you will find in a lot of products. (Write: ETHYL ALCOHOL + ACETIC ACID → ETHYL ACETATE + WATER)

While I prepare this ester, you can pass around the methyl salicylate and try to identify the odor. I am sure you know that I find it familiar to you. There are many esters identifying their names and passing around the vials as they cool. Caution the audience about not getting the solution on their skin or clothing. Also, pass around the bottles of artificial flavorings and have the audience find the names of the esters on the labels.

These smells are useful. They make life a little more pleasant, because we use them as flavorings. But there are some other uses of something that man is getting into. What other smells are you familiar with? Think about smells man uses for other purposes. For example, we use air fresheners, sprays or solids, to give rooms a more pleasant fragrance, or to cover up unpleasant odors from animals, cooking and so on. Another example would be things like cologne, after shave, and perfume. Why do we use perfumes? (Mask, attractant?) We use them to make us more attractive to the opposite sex. Animals also have scents and the function of those attractants are to bring two animals of the same species together. Not too far from perfume, is it? This happens to be particularly important in the lower forms of animals, especially down into the insect range. There is an area of chemistry that deals with a series of compounds, and I will write the name, because I don't like to say words without writing them. These are pheromones. (Write: PHEROMONES)

These pheromones are very much like perfume. They are very much like perfumes among the insects, and man has recently begun to work with these pheromones, because we have had a lot of trouble with HDT and other pest control materials. So, what would you like to do is get something that is biodegradable, but something that would help to get the insects incapacitated in some way. And there are two ways that these pheromones work. One is to lure the insects into traps.
This has been done with gypsy moths. What they do is put the sex attractant chemical into the trap. It's a pretty dirty trick when you stop to think about it. We put this "perfume" into a trap with sticky walls. The insect gets in there and buzzes around trying to find the source of this attractant and gets stuck in the walls. And that's it — it's like fly paper.

Another way we use them would be the same as if a man went into a room blindfolded and there were 20 jars of perfume and one girl with perfume on. He would be attracted to different perfumes but could not find the girl. The same notion applies here. Strips of paper, which are biodegradable so they don't stay around very long, are coated with insect pheromones. The papers are spread around a certain area, which is insect infested. One experiment in Pennsylvania used about 300,000 papers. The insects keep buzzing around trying to find the source of the attractant, but they can't find it because there is no bug there. They get worn out and die, and there is no continuation of that species.

These are two ways in which pheromones are used. And there is a lot more being learned about pheromones. Many insects use them, for example, ants. An ant leaves the nest to find food. He doesn't leave a trail as he goes out, because he may not find food until he wanders around. If he finds food, on his trek back (I'm not going to worry about how he finds his way back) to the nest he deposits some pheromones along the trail. As he gets near the nest, other ants see him coming and follow his trail back to the food. If there is a lot of food there, ants keep coming in and the trail gets heavy and more ants keep coming in, causing the trail to get heavier and getting more ants on the trail. If the food wears out, the ants start coming back empty-handed and the trail fades away, because the scent doesn't last very long. All of this knowledge, if we figure out what the attractants are. They are very complicated chemicals, but we can use the correct ones for ants to lure them into traps.

I have talked briefly about how man uses chemically created tastes and smells in a number of ways, from giving flavor to foods to controlling insects. I am sure you can think of many other examples. I hope you enjoyed the program, and if there are any questions, please feel free to ask. Thank you.

EQUIPMENT, SUPPLIES & CHEMICALS REQUIRED FOR THIS DEMONSTRATION
(Note: Quantities of expendables are estimates based on 10 shows)
Show Title: SMELL AND TASTE
Show Number: Nine

DEMONSTRATION #1
Ammonia

DEMONSTRATION #2
4 boxes with Tissue Paper with 1" hole
Cut-up Fruit (Banana, apples...)
Artificial Flavorings (Imitation banana, pineapple, brandy, etc.)

DEMONSTRATION #3
Small Vials with holes in cap (4)
Hot Plate
Methyl Alcohol - 25ml
Salicylic Acid - 25ml
Sulfuric Acid - 25ml
Amyl Alcohol - 25ml
Acetic Acid - 25ml
Ethyl Alcohol - 25ml
Butyric Acid - 25ml
Good morning, and welcome to our chemistry demonstration. I'd like to start by asking you to imagine that you are holding a little phenolphthalein in your hand. But, some things about that substance are immediately apparent. You can see its size, and its shape. You can hold it in your hand and get a fairly good idea of its weight, and its density. What other property of the substance is immediately noticeable?

(Answer: color) Yes, its color, and that is what we'll be discussing in this program. Colors play an important role in chemistry, for colors not only help determine the identity of a substance, they can help to determine a substance's characteristics, such as whether or not something is an acid, or a base. Some of the experiences I do, you can duplicate at home.

This is about five girls who were sitting around one night in their sorority house, and they were trying to figure out how they would spend their evening. Their boyfriends were off playing basketball, there was nothing on TV, and the girls had finished their studying. So they decided to get themselves a bottle of wine, and spend the evening talking and drinking the wine. The only trouble was, they only had enough money for one bottle, and not only was it only a bottle of one kind of wine, but it was a second girl who wanted red wine, and the rest liked pink wine. They didn't know what to do until one of the girls mentioned that she knew where to get a very special wine, which turned both pink and white from the same bottle. I have a bottle of that same wine here in this flask.

**DEMONSTRATION #1**

I'll pour the wine glasses by adding 2ml concentrated (36%) H$_2$SO$_4$ to the first, 2ml (6N)H$_2$SO$_4$ (26g/100ml H$_2$O) to the second and fourth, leave the third and fifth empty.

The 'wine' is water with 1ml of phenolphthalein indicator added. Adding this wine to the glasses yields clear, red, clear, red, and clear respectively for the five glasses.

The addition of the five glasses to the original decanter gives a clear solution, because the acid outweighs the base, and the phenolphthalein remains colorless.

Addition of the wine to the milk pitcher (containing 5ml of concentrated (12N) HCL saturated with antimony trichloride) gives a clear solution, because the acid outweighs the base, and thus the phenolphthalein remains colorless.

Does anyone know what the primary colors are? (Red, yellow, and blue) Green isn't a primary color, is it? How would you make green? (Mix blue and yellow) If I made this green by putting blue and yellow together, there ought to be some way I can get those two colors apart. That is what my next demonstration is about. We'll see if we can do that, with a process called Chromatography. I'll use a piece of filter paper, but you can do the same thing with a piece of paper towel, if you want to try this kind of thing at home. I will make a little dot of green color on here, not too big. Now, in this beaker is a 50-50 mixture of water and alcohol. I'm using rubbing alcohol, but if you don't have any at home, you can use your dad's gin supply. I am salt, only they happen to have different metals other than sodium in them. This one has copper; it is a blue solution. Here is iron, it's very strongly colored, but it's a yellowish color. This is cobalt, a sort of red. Next, nickel, which is green, and vanadium, which is yellow.

These are colors, which you can see, for example, if you ever go into caves, such as Mammoth Cave, or Ohio Caverns or Lechster Caves, where there are beautiful formations of stalactites and stalagmites. They are not pure white materials, but often have colors. These colors come from different metal ions, which are caught when the stalactites and stalagmites are formed. Or, just pick up a handful of rocks along a stream bed and you can see many different colors from those metal ions. Many metals exist like this as one color, but a few metals may have several colors. They have different "States," and we can change the color by changing the state. This involves some complex chemistry that I won't get into in too much detail.

The first girl asked for white wine, and when it was poured, sure enough, it was white wine. The second girl said, "I'd rather have red wine," and when the wine was poured in her glass, it was red. The third girl said, "I'll have white, please," so when it was poured, she got white wine. The next girl wanted red wine, and red wine was poured.

Finally, she poured a glass of white wine for herself. The group was sitting around ready to start drinking the wine when they heard the housemother coming. They decided to pour the wine back into the wine bottle, and when they did, the wine became one color. Since it was still wine, they decided the only thing they could do to save themselves was to turn it into milk. So they grabbed a milk pitcher and poured the wine in and it turned into milk.

This little demonstration has been done as part of a magic act, but I would quickly point out that it did not involve magic but simply a series of basic chemical reactions.

What I am using here is not wine and not milk, but simply water with a little phenolphthalein in it. Phenolphthalein is a chemical indicator and it makes this change in color when I change the acidity and basicity of the solution.

The first glass contained a little sulfuric acid and remained clear, while the second phenolphthalein red contained a little base, (sodium hydroxide). When I poured them back into the decanter, the sulfuric acid neutralized the base to make the phenolphthalein clear. So that we see that a chemist can use certain chemicals which, due to color changes, can tell him something about the make-up of an unknown material.

Now, you may not know it, but most of you are chemists, too. Every time you cook something, you are involved in chemical reactions, and you use color, too. What kind of colors do you use in the kitchen? (Food colors) Right, and I have a set right here, red, yellow, green, and blue.
DEMONSTRATION #4

The zinc amalgam may be prepared by adding $2g$ mercuric chloride to $10g$ of freshly squeezed lemon juice (1M) HCl. Add 300g to 30mL of $3g$ zinc. Stir for 5-10 minutes and decant the solution. Wash solid 3 times with 100mL portions of water and store under water.

The reaction demonstrated involves addition of vanadium (V) solution to the reductor (Amalgam). To prepare the vanadium solution add 10g ammonium metavanadate to 200mL of 1M NaOH (18g NaOH/200mL H$_2$O). Warm, if necessary, to dissolve. Add 500mL (MO=90, 8 volumes water) and dilute to 1 liter.

To show the color changes add 20g of zinc amalgam (prepared as above) to a 1 liter flask; pour in 200mL of the vanadium solution carefully and stopper the flask. Shake gently to give the first change (yellow to green), more to give the second change (green to blue) and very vigorously to give the final color change (blue to violet). (Choose the speed on the flask frequently to relieve pressure of gas build-up.)

Reference: Teachers manual to accompany Chemical Systems by Campbell, P 24 and P 171 of Tested Demonstrations, Section 6. 

I have here a mixture of zinc and mercury in the bottom, called zinc amalgam, which is a good reducing agent. Here is a good reducing agent. Here is a solution of ammonium vanadate. Vanadium is the yellow. You'll recall one of the tests tubes we just showed you was this same solution. Vanadium, when it is yellow, is in its highest state, plus 5. Just to give you a reference point, you have some red cabbage in this tube. You'll notice that the vanadium becomes a light green color. Let me shake it once and help it down the first rung, which is toward that green color. All I have to do is shake it once and it goes from 5, which is what I had already done, to 2, which is green. Then the color I get is when I go from 4, green, to 3, which is blue. If I shake it just the right amount I get blue, the 3 state or vanadium. Those changes aren't too hard. You can get easily to 4; to get to 3 was a little bit harder. Now I want to go all the way to 2, which is very hard, because each state is progressively less stable, so I have to shake it a lot more than I have to shake the other states. You can see I got evenly to 4; to get to 3 was a little bit harder. Also it is good exercise, and I need to lose weight. Now when I get to 2, I'll be going from the blue, which I have, to a violet. We are not there yet. It really takes a lot of work. Still has a lot of blue. There, now it is violet. Vanadium is a very interesting metal, because it exists in those different states. (Alternatively, have a volunteer from the audience shake the flask for you.)

By the way, some of you may be wondering what this is I'm cooking over here. (Demonstration #7) I haven't had lunch yet, and I thought I'd cook up some red cabbage to eat after this show. By the way, some of you may be wondering what this is I'm going to show you. It is red cabbage in it. Now, it has a purple color. Red cabbage is very interesting material; in plain water it is purple, oxidized, is what it is with vanadium in the colorized state. When I add the sodium hydroxide, it will give a color change and it turns a definite green color. So the purple goes to green in a base, that is very important. Let's try a little sulfuric acid. You can see the drop color change very well. If I added sulfuric acid, it turns to a red color. So an acid solution in that cabbage extract becomes a red color. We can use this liquid to tell us when something is an acid or a base, when we put them in water. Let's try a few home products. I guess you might be curious at home sometime to know if something that you bought is an acid or a base. I use the plunger glasses because they are plastic and I can buy them cheap, and the colors come out nicely. Here is lemon juice. What color should I get if I put the lemon juice into this neutral solution? (Red) And by George, no matter what it is, it is a definite red. Here is some baking soda, what will it do to the solution? (Green) Okay, let's see how much of an alkali it is. Well, it went blue. If I had a whole range of things, which were weak and strong, what I would find is that blue is sort of half way between the purple and the green. So this is a base, but not a base as strong as the alkali, sodium hydroxide. Here is vinegar. What color will it be? Take a chance, you have a 50-50 chance. (Red) Okay, well, it is kind of a red, isn't it? But not as red as the strong acid. So it is a weak acid, it turns out. Let's try one more. This is baking powder, also used in acid solutions. Baking powder has to settle out, that's one problem with putting a solid in the extract. It is not quite as good as an acid, but it will work. One of the ads you've seen on TV is a Alka Seltzer ad. It says if you have stomach upset you have an acid stomach. Vinegar is acid, right? We certified that before. So here is my acid test. They say if I have an acid stomach, I should buy Alka Seltzer. So let's check it out. Sometimes they don't show you the color change very well and you don't know what is going on anyway, but I'll try to help you out of it. Look at that: it is not a very strong acid. What happens to the acid when the Alka Seltzer hits? Well, as it neutralizes it, it will either go toward a lighter red, or maybe even an orange or to the violet. And sure looks like it is violet, doesn't it? I am not selling Alka Seltzer but I am saying that they are not lying when they say that the Alka Seltzer will neutralize excess stomach acid. You should see that. Find that out. It is a very good test. If you are not sure, can you buy a box of Alka Seltzer?
Time has an influence or characteristic of chemical reactions. Chemical reactions are not the same thing when we mix materials together. In some cases, we can see a chemical change occur. Most of the chemical reactions that I am going to do here are pretty complicated, but they are interesting because we do strange things that start with a demonstration that you may have seen. This is a reaction where a change happens in what is contained in this bottle.

DEMONSTRATION 1
Blue Bottle - A 1 liter flask and stopper. The solution is prepared by adding 8g potassium hydroxide in 300ml water. Add 20g cool and 2g dried. Add 2ml methyl blue solution (25g/1000ml water) and shake to give color. Avoid shaking too much as the disappearance will take too long.

If I shake this solution, it becomes blue. There is a chemical change that goes on that gives it that blue color, because of a coloring agent, methylene blue dye that I put in the solution. But if I let a while, the chemicals I put in the liquid before, the potassium hydroxide and the sugar, change that blue back to colorless. Also you will note that some of the little solid pieces that haven't dissolved yet give you streamers, an interesting party effect — if you like that sort of thing.

You can make it a fairly intense blue by shaking it. The reason it turns blue is that the oxygen in the air above this solution dissolves in the solution to give that color change. If I keep shaking it and I don't stop, after a while I use up oxygen and I can't make it go any more. But if I take the stopper out and pump some oxygen in, it will work again. It will keep changing back and forth; it will change as many times as I want it to, basically on a lot of light, but it doesn't do it by itself spontaneously. It has to be shaken to get the oxygen to dissolve enough in the liquid to give you that color change. Well, we can come back to that later on.

Now this one kind of chemical reaction that changes with time. Time is what we really want to talk about in terms of these materials. Another kind of chemical reaction involves burning. And burning in something is a lot of different ways. This is a liquid, which is methanol, not the drinking kind, but the kind that wipes out your vision if you do happen to drink it. Methyl alcohol will burn. I am not going to light the match just to prove that, you'll just have to take my word for that. You might see it burn, if the chain reaction doesn't go quite the way I have planned it. But that is why I have this asbestos pad here, just in case. It is nice to have a chainsaw in each room.

DEMONSTRATION 2
A small crystallizing dish, asbestos pad, coil of platinum wire and methyl alcohol are needed. Add about 1/8 of methyl alcohol in a beaker and the dioxide. When I heat this platinum wire, just get it warm and make the surface active enough so that it will help to catalyze the methyl alcohol burning, I'll heat this up and get it hot and then I'll put it over the methyl alcohol. The vapor trail will come from the platinum that is washed out hear where the water condenses.

There are other catalysts, things that make chemical reactions work in one way, but as I saw, I am having a little trouble with it today. This is a reaction that is light sensitive. This is a solution which has an iron salt and some thionine, which is the colored material in there. You can see the color it has. If I take this outdoors, the light catalyzes or brings about that particular chemical reaction. It is not a permanent change though — just a temporary change caused by the light. The light is another kind of catalyst and we use it in some chemical reactions. Just to keep the blue bottle honest, I'll make it every once in a while.

There are a whole bunch of reactions which we call clock reactions because within a certain time period, you will notice that I have very careful chemical techniques that I developed in my early days. This is just some water to help slow down the reaction so it doesn't go too fast for you to observe. I'll take two solutions which can be referred to as Solution A and Solution B. I'll pour A, stir and pour in B. And nothing happens, naturally, because it is a timed reaction. We'll just have to wait until it is ready. Now I can change the chemistry just a little bit. I used A and B then. If I throw in a little bit of Solution C, well see what happens. We'll put some water in to slow down the reaction. Remember, we have just A and B, so we add C, and C. First the A, remember I added A. If I start to add A again tell me. B. And this time I'll throw in a little C. What is going to happen this time? Anyone want to guess? Well, let's take the stirring rod. I get a chemical change, then I get another color change if you are patient and wait a bit. That worked so well. Let's do it again. First, I have to have the water. If I run out of distilled water, I'll just use tap water. This is called a double clock reaction, because it has two color changes. A. Then I'll get both B and C ready. Stirring rod ready, Add C. And another stirring experience in chemistry. Well, that's an interesting reaction. We get one color; we can get two colors.

DEMONSTRATION 3
Clock reactions - Solutions required:
A. 1g Potassium iodide in 1000ml water (dissolves slowly)
B. To 4g starch add small amount of water
Form a paste, then add this paste to 500ml boiling water.
With stirring, add 15g sodium bisulfite to 500ml water and combine these solutions when the starch solution has cooled.
C. 3g mercuric chloride/1000ml water
To perform reaction one, add 150ml water and 50ml of A, then B to a 400ml beaker or pilsner glass. This can be repeated if desired.

Reaction two is performed by adding 100ml water, plus 50ml B then 50ml A and 50ml C rapidly. The time of change can be altered by using more or less water in a suitable container. The volumes were chosen for use with a pilsner glass.

DEMONSTRATION 4
The solutions involved are:
A. 2g sodium bisulfite and 3g sodium sulfite in 1000ml water.
B. 90ml formalin (33 formaldehyde) dilute to 1liter.
C. Indicator - May use phenolphthalein for red, rhymophtha-lein for blue or universal indicator for two color changes.
Add 150ml water to pilsner glass, then 50ml A, 1 ml of C and 50ml of B.
I'll pour it in.

There are a whole bunch of reactions which we call clock reactions because within a certain time period, you will notice that I have very careful chemical techniques that I developed in my early days. This is just some water to help slow down the reaction so it doesn't go too fast for you to observe. I'll take two solutions which can be referred to as Solution A and Solution B. I'll pour A, stir and pour in B. And nothing happens, naturally, because it is a timed reaction. We'll just have to wait until it is ready. Now I can change the chemistry just a little bit. I used A and B then. If I throw in a little bit of Solution C, well see what happens. We'll put some water in to slow down the reaction. Remember, we have just A and B, so we add C, and C. First the A, remember I added A. If I start to add A again tell me. B. And this time I'll throw in a little C. What is going to happen this time? Anyone want to guess? Well, let's take the stirring rod. I get a chemical change, then I get another color change if you are patient and wait a bit. That worked so well. Let's do it again. First, I have to have the water. If I run out of distilled water, I'll just use tap water. This is called a double clock reaction, because it has two color changes. A. Then I'll get both B and C ready. Stirring rod ready, Add C. And another stirring experience in chemistry. Well, that's an interesting reaction. We get one color; we can get two colors.
DEMONSTRATION #8

Prepare the three solutions as follows:
A. Indicator solution - Ferric chloride 2.7g/200ml H₂O
B. Red coloring - Potassium thiocyanate 0.4g/200ml H₂O
C. Blue coloring - Potassium ferrocyanide 0.8g/200ml H₂O

Make an outline of heavy paper, which covers the blue field and white stripes. Cover with saran wrap to protect - spray the red coloring lightly through exposed portions. Make an outline which masks all but the blue field and cover with saran wrap - spray the blue portion. Allow the flag to dry - should be essentially white - scotch tape to a 1/4" dowel and set in a 1 liter flask.

To bring out the colors spray the flag with the indicator solution using sufficient spray to obtain the full color.

An alternative to preparing the masks is to use a 1" paint brush for each color. CAUTION: The sprays are hazardous and must not be inhaled.

My final demonstration is in honor of the United States (and the Bicentennial). This is an American Flag, although it may not look like one. The addition of a little of this chemical, Ferric chloride, combines with other chemicals already painted on to bring out the familiar red, white, and blue. This concludes the show and thank you for coming.
DEMONSTRATION #5

The solutions for the oscillating reaction are as follows:

A. 3ml concentrated sulfuric acid, plus 21.4g potassium iodate per 500ml water — very slow dissolution.
B. 180ml 30% H$_2$O$_2$ (be careful) and 320ml water — make fresh.
C. 1.9g Manganese sulfate dehydrate (MnSO$_4$·2H$_2$O) plus 7.8g malonic acid added to 500ml water.
D. 0.5g starch — add small amount of water to give paste, then add to 100ml boiling water. Cool.

To carry out the reaction add 90ml A, 90ml B, 90ml C and 8ml D. Oscillates for 5 minutes or longer.

Not all chemical reactions go this way. I have one that goes by itself, just keeps going and going. I'll get everything poured out here first. This one has four components. This is called an oscillating reaction because it changes back and forth, very much like that blue reaction I had up here, except this one takes a little help. I have to shake it up to make it work. This one provides its own help. Within itself, that is within the chemical reaction, are materials that change back and forth. And we need a little catalyst here. So we put some A, B, C, and D, and a little stirring. And the reaction turns blue, no big surprise, except the reaction now is going all by itself; it will just keep changing back and forth. It will go blue, then it will go yellow or clear, then back to blue again. Just keeps oscillating back and forth, an automatic reaction. I don't have to do anything to it to get it started. (How long?) Oh, about four or five minutes. If I stir it, it will go a little bit more uniformly. If I don't stir it, it will take its own way and it does some strange things. Sometimes it creeps up from the bottom, depending upon where the reaction is happening. This is another fairly complicated reaction that is going on here as far as what is happening in chemistry.

Well, these are just a few samples of chemical reactions where time and the changes in things with time is very important. And we can make that happen according to our own schedule. I can slow these down, as I did. I can make them go faster by mixing them in the correct proportions. As I say, this is one of the more interesting reactions because it is an oscillating reaction. It changes back and forth. There are only a few of those reactions that have been investigated and are well known. Even if you know how to make them go, you still know much less about what is happening as they go. If you have any questions, be sure and come up to ask me. Thank you for your attention.

EQUIPMENT, SUPPLIES & CHEMICALS REQUIRED FOR THIS DEMONSTRATION
(Note:Quantities of expendables are estimates based on 10 shows)

Show Title: TIME IN CHEMISTRY
Show Number: Eleven

DEMONSTRATION #1
1 liter Flask & Stopper
80g Potassium Hydroxide
100g Dextrose
20ml Methylene Blue (.250g/1000 ml water)
3000ml H$_2$O

DEMONSTRATION #2
Crystallizing Dish
Asbestos Pad
Coil of Platinum Wire
Methyl Alcohol

DEMONSTRATION #3
40g Starch
3000ml Boiling Water
15g Sodium Bisulfite
5g Potassium Iodate/1000ml Water
3g Mercuric Chloride/1000ml Water
Pilsner Glasses (8)

DEMONSTRATION #4
200g Sodium Bisulfite
30g Sodium Sulfite
900ml Formalin (37% formaldehyde)
1ml Indicator (Phenolphthalein (red), Thymolphthalein (blue), or universal indicator (multi color)
Pilsner Glasses (3)

DEMONSTRATION #5
30ml Concentrated H$_2$SO$_4$
21.4g Potassium Iodate/500ml H$_2$O
1800ml 30% H$_2$O$_2$
19g HgSO$_4$, 2H$_2$O
78g Malonic Acid
5g Starch
I would like to talk to you about polymers and plastics. Nature uses polymers in a lot of ways. In most of the vegetables and animals, including ourselves, basic components of parts that hold living matter together are really polymers, and these are things that we can make in the laboratory. We have used natural polymers in some form for a long time, for example wool for fabrics in making thread. Wool and cotton are examples of natural polymers that man has found useful. Silk is a particularly interesting one because of its strength and light weight. Scientists have extensive knowledge of what makes polymers work or how they were built together to begin to try to duplicate what nature was doing in fiber formation in their laboratories. Specifically, scientists at DuPont were beginning to carry out research where they tried to make these polymers. What they learned was what occurred in nature, in plants in the building of cotton, as silk worms made silk, or sheep in the formation of wool, and so on. We have a number of molecules that are one and one of another molecule. It turned out that one end they were working with was on an end that had an acid on it, and the end of the molecule to which it was being linked had a base. What they then tried to do was to duplicate that process in the laboratory. They wanted to make a man-made fiber with specific chemical properties, so that they could use this and not have to worry about nature in an arbitrary way to make it for them. What they had was a material that had the same acid group on both ends and another material that had the same base group on both ends. The two base groups could not link up and the two acid groups couldn't link up.

**Demonstration #1**

By using sewing snaps and 8" strips of material of two colors, one can simulate the acid and base portions of nylon. Use the two inner parts of a snap on each end of one color material (pink) and refer to it as the acid and use the outer parts of the snap on the other end of the other color material (blue) and refer to it as the base. The inability to snap the ends of the same material (e.g., pink) together parallels the fact that the acid doesn't polymerize alone.

These are just halves of snaps that I have here. I thought that was a reasonable way to try to show a model of this process. If I take the acid group and snap it to the base group, that is analogous to what chemists do in a lab, it links. If I do the same process, even though each link is pretty small, and I keep going on, millions of times, I will make a polymer. This is exactly what they did in the laboratory.

**Demonstration #2**

Prepare the solution as follows: A. 2ml of sebacyl chloride in 200ml of carbon tetrachloride and store in a glass stoppered bottle. Make fresh. B. Dissolve 6.3ml of 1,6 hexanediamine in 50ml of water. The liquids are added, first A, then B, with care to avoid mixing, to a tall form beaker. A beaker is cut from a paper clip and is used to catch the polymer formed at the interface and gently lifted to avoid breaking the fiber. The nylon can be rolled over a drum made from a can with an axle and weave it into the particular fiber. So, rayon and other artificial fibers were developed because of this process. Another way this came about was a material that had the same acid group on both ends and another material that had the same base group on both ends. The two base groups could not link up and the two acid groups couldn't link up.

I have those two parts here. This is a compound, and I'll name the compound, as a chemist would, I am not trying to confuse you but give you the facts the way they are. This is a compound called sebacyl chloride. It has six carbons, and it has those two links on the ends to help join to form a polymer. This is the other compound, hexanediamine: hexane means six, so there are six carbons in this one. And if I put these together, they will link up. I don't want them to just mix together and link up because they want very long chain molecules, which is in water, a lighter solvent, it will go on top of the carbon tetrachloride; the density is a lot less so the two liquids don't mix. When I pour these liquids together, I notice that the liquid on the left side touch, touching, then the linking up goes on and a white material forms (at the interface where the liquids touch). I'll try to pour it in carefully but you see that white material, you also see a little bit of smoke from it, reagent. The linking is going on at the place where the two liquids meet. To cause that linking up to continue and grow evenly and smoothly, I'll reach in with a little hook and grab that beginning of the formation. As I lift it out slowly, if I lift it out slowly, each time I pull one link away, the next one forms, then the next one forms. They keep forming.
DEMONSTRATION #4
Prepare the bakelite solution by adding 6.4ml of formaldehyde (37% formalin) to 10g phenol and store until ready for use. Add concentrated sulfuric acid carefully to catalyze the reaction.

This is a water solution of phenol and formaldehyde; you can see, when I pour it out, that nothing happens. It takes some sort of catalyst from some special kind of material that changes the solution, enough so that the material forms. I'll try this one. This is concentrated sulfuric acid. If I change the acidity of this mixture, I get the formaldehyde and phenol linking up to form a plastic. And that plastic will partially solidify with a nice red color when it first forms. Over a period of a few minutes it will completely solidify into a fairly solid chunk.

Bakelite was the first plastic, but not a very good one. It was the only one so it was used for a lot of purposes. As new plastics were made, they had more and varied properties. They could be thermoset, which means they could be sort of melted and molded. Some of them could be dissolved in liquids and then pushed together so the plastic pieces could be glued together. Again, plastics are designed now to do certain jobs by choosing the chemicals from which they are made.

Another plastic, which is similar to the phenol and formaldehyde plastic, is one that has resorcinol (instead of phenol), which is a very similar compound. Again, when I carry out the reaction, I dissolve the resorcinol. The phenol and resorcinol this time because I was not sure it would stay around very long without reacting, unlike the phenol-formaldehyde mixture. Now, to get this one to go I need to give it a boost, a little more energy, so I am heating it on the hot plate just for a short time to let it warm up and let the molecules of the plastic start reacting. (You notice every time I spill a chemical on myself, I rinse my hands.) In any event, we want this to get good and hot, just about to the point of boiling, because the reaction has to be catalyzed while hot. The two things that are in the percolating around don't link up. They don't form the network that has to be formed to make the plastic until I add the catalyst. The catalyst I used earlier was sulfuric acid; now I am using a base or lye, potassium hydroxide. It doesn't take very much; it percolates a little bit; I will keep swirling it; and then it sets up as a plastic. Unfortunately, I can't let you touch it because it is not only hot but it has some of that lye in it so it is not too safe to touch or handle.

I have mentioned just a few things that are done with polymers in terms of materials that we weave out of them. Plastics give up quite a range of things we can do also. There are many toys made from plastics, like squirt guns. One of the more serious or important things developed now from artificial materials are replacement parts for the human body—artificial organs made from plastic. Again, they have to have very special properties; they have to be very clean and pure and must be able to duplicate the way the body behaves. These are just a few ways we use plastics today. So, if you would like to come up and twirl the nylon, wind it gently and it will stay together; if you snap it, the threads will break and we'll have to start all over. But you can wind this up a long long time. I have never figured out how many yards of nylon of this thickness are in there but if you would like to look at any of these demonstrations, feel free to do so. Thank you.
COMPOSITE LIST OF CHEMICALS, GLASSWARE, AND APPARATUS

LIST OF APPARATUS, GLASSWARE

1. Erlenmeyer Flask - 500ml
2. Erlenmeyer Flask - 1000ml
3. Florence Flask - 500ml
4. Suction Flask - 1000ml
5. Watch Glass
6. Petri Dish
7. Crystalizing Dish
8. Test Tubes
9. Large Test Tubes
10. Vials and Cape
11. Burnet - 50ml, Replaceable Tip
12. Beakers - 100ml
13. Beakers - 250ml
14. Beakers - 500ml
15. Beakers - 1000ml
16. Tall Form Beaker - 250ml
17. Tall Form Beaker - 500ml
18. Storage Bottle - 1 liter
19. U-Tube
20. Glass Stirring Rod - 6mm
21. Iron Crucible - 3" Diameter
22. Metal Dish - 4-6" Diameter
23. Dewar Flasks - 500ml
24. Dewar Flasks - 1 liter
25. Glass Tubing (12 ft)
26. Glass Stirring Rod - 6mm
27. Glass Stirring Rod - 12" x 12"
28. Spatula
29. Rubber Stoppers
30. Corks
31. Clamp
32. Clamp Support
33. Ring Stand
34. Ring for Ring Stand
35. Tripod
36. Triangle
37. Tonga
38. Rubber Gloves
39. Filter Paper - 12cm
40. Filter Paper - 12" x 12"
41. Sand
42. Hot Plate
43. Dewar Flasks - 1 liter
44. Dewar Flasks - 500ml
45. Ice Cube Tray

LIST OF SPECIAL APPARATUS

1. Conductivity Apparatus
2. Explosive Can
3. Strobeoscope (?)
4. Electroscope
5. Large Voltmeter
6. 1.5 volt Light Bulb (or socket) with Alligator Clips
7. Flashbulb Holder with Alligator Clips
8. Power Supply (0-12 volt variable DC)
9. 3 foot Dowel/Candle
10. 18 foot Copper Wire Wire Attached to Heavy Copper Leads in Rubber Stopper
11. Special Can - Hole in bottom center
12. Tesla Coil
13. Gas Bulbs - CO2, Rg, Ne
14. Diffraction Grating
15. Spray Bottles
16. Sewing Snaps, Cloth Strips
17. Drum Apparatus
18. Large Syringe or Frosting Sprayer
19. Samples of Ores
20. Overhead Projector
21. Cardboard Boats
22. Four Boxes with Holes
23. Insect Traps
24. Glass or Rubber Rod
25. Yellow Bell
26. Ball/King Apparatus
27. Bubble Pipe
28. Gas Cylinders (?) - H2, O2, He
29. Pitcher
30. Wine Decanter
31. Cardboard with 3" hole for Projector
32. Gallon Cans
33. Burner/Flame
34. Writing Board, Pen

LIST OF STORE ITEMS

1. Steel Wool
2. Candles - Warning Type
3. Candles - Birthday
4. Scotch Tape
5. Soap (Bubble Solution)
6. Tissue Paper (Kleenex)
7. Paper Bowls (Small) or Cup (No Bottom Rim)
8. Towels
9. Plastic Wine Glasses
10. Plastic Plunger Glasses
11. Salt Shakers
12. Wood Block
13. balloons (12)
14. D-Cell Battery (Cut to show Electrode)
15. 9-Volt Battery (Opened to show Inside)
16. 3-Cell Flashlight
17. Rubber Ball - Thin-Walled, Small
18. Thread - Medium Weight
19. D" Dowsels, 24" Long
20. Artificial Flavoring - Apple, Banana, Pineapple, Apple, Banana, Red Cabbage
21. Chrzanhenium, Rum
22. Confectioners Sugar
23. Sugar Cubes
24. Vinegar
25. Sodium Bicarbonate (Bicarbonate of Soda)
26. Cup-A-Soup
27. Ammonia
28. Alka-Seltzer

LIST OF CHEMICALS

Acetic Acid
Aluminum (foil)
Ammonia
Ammonium Dichromate
Ammonium Nitrate
Ammonium Nitrate
Amyl alcohol
Antimony Trichloride
Barium Chloride
Butane
Butyric Acid
Calcium Acetate
Calcium Metal (Turnings)
Carbon Tetrachloride
Cobalt (cupric) Chloride
Copper Chloride
Copper Metal (Strip)
Copper Sulphate
Copper Wire - Heavy
Dextrose
Ethyl Alcohol
Ferric Ammonium Sulfate
Ferric Chloride
Ferric Oxide
Ferrous Sulfate
Formalin
Glycerine
Helium (Gas Cylinder)
Hydrochloric Acid
Hydrogen (Gas Cylinder)
Hydrogen Peroxide (3%) Hydrogen Peroxide (30%)
Hydrogen Sulfide
Iron (Powder)
Isopropanol
Lead Strips - Heavy
Luminal
Lycopodium Powder
Magnesium Ribbon
Malonic Acid
Manganese Sulfate
Mercuric Chloride
Methyl Alcohol
Methylene Blue
Nickel Nitrate
Nitric Acid
Oxygen (Gas Cylinder)
Phenol
Phenolphthalein
Platinum Wire
Potassium Chloride
Potassium Ferri Cyanide
Potassium Perchlorate
Potassium Hydroxide
Potassium Iodide
Potassium Permanganate
Potassium Thiocyanate
Resorcinol
Salicylic Acid
Selenium Chloride
Sebacoyl Chloride
Silver Nitrate
Sodium Acetate
Sodium Chloride
Sodium Bicarbonate
Sodium Bromide
Sodium Chloride
Sodium Metal
Sodium Sulfate
Sodium Thiosulfate
Sodium Chloride
Starch
Sulfuric Acid
Thionin
Thymolphthalein
Zinc Metal (Strip)
Zinc Chloride (20-30 mesh)
Zinc Chloride
On the following 5 pages are plans and specifications for the Chemistry Demonstration Unit pictured above. The unit is designed to contain all the necessary equipment and facilities for presentation of the CHEMISTRY FOR MUSEUMS demonstrations. The portable unit contains its own lighting, water supply and disposal system. It can be closed and secured when not in use. With the work surface folded down, the cart measures 27½" x 53" by 64" high, not including the overhead light and sign fixture. With the folding work surface in the upper position, the work surface is extended to 9'.

CHEMISTRY FOR MUSEUMS
Demonstration Unit
CHEMISTRY FOR MUSEUMS
DEMONSTRATION UNIT
SECTION B

SCALE: 9:1 | 6:1 | 2:1
REN 6/76 DRAWN BY OC

1/2" SIDES
3/4" FRONT

HANDHELD CUT-OUT ROUND ALL EDGES

DRAWER DETAIL

21/4"
17/8"
9/8"

ELECTRICAL SWITCH

HARD ASBESTOS

METAL BASE PLINT TO CATCH SCRAPINGS

TYPICAL DRAWER CHAMFER 1/4"

1/4" DRAWER BOTTOMS

TYPICAL DRAWER HARDWARE
CUT-OUT 1/4" SEE DETAIL ABOVE

TYPICAL DRAWER HARDWARE
EX: PULL EXTENSION DRAWER SLIDES & MOG

3/4" SLIDING DOORS

3/4" PLY DRAWER FRONT

3/4" DRAWER BOTTOMS

4" BOTTOM DEPENDING ON DRAWER.

NAIL INSERT TO FIT HARDWARE

3/4" DRAWER GROOSES
1. Please answer on the attached matrix all questions for shows you have done. Return completed sheet to Center of Science and Industry, 280 East Broad Street, Columbus, Ohio 43215.

2. In general, did you use the shows as written, or were they modified?

3. Please list any modifications, additions, or deletions you might suggest for the demonstrations. Use separate sheets, if necessary.

4. Please identify any areas in the scripts and directions which were difficult to understand. Use separate sheet, if necessary.

5. How much background and training in chemistry did the individual with primary responsibility for the presentation of the chemistry program have?

6. Did you construct a demonstration cart from the enclosed plans? Please describe any modifications you made.

7. Please use this space for any additional comments and suggestions not covered by your answers to the above questions.

EVALUATION NOTE: The evaluation questionnaire is not to be filled out and returned until after you have had sufficient time to implement the CHEMISTRY FOR MUSEUMS program. It is included at this time for your reference so that you can anticipate the kinds of information we would like you to submit to us.
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<th>SMELL AND TASTE</th>
<th>HEAT AND LIGHT</th>
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PRELIMINARY EVALUATION OF CHEMISTRY DEMONSTRATION

Although there has thus far been insufficient time to completely and properly evaluate the Chemistry Demonstration, initial indications are definitely positive.

The Chemistry Demonstration has been offered since November, 1975 as a regular part of our schedule of programs to any school class or other group requesting it. In the ensuing five months, the Chemistry Demonstration has been presented to groups from twenty-two schools, amounting to over 1500 students. While this is not as great an attendance as most of COSI's other demonstrations, it is a good figure for a new program and the fact that a large part of this attendance falls during the latter part of the time period being evaluated would indicate a growing interest in the demonstration as word of its existence spreads.

One indication of the Chemistry Demonstration's good reception is the fact that the entire fifth grade of the Upper Arlington School System (a Columbus suburban community) was registered to attend. The Chemistry Demonstration at the Center of Science and Industry has been instituted as part of the regular science curriculum by the school system's Elementary Science Curriculum Coordinator on the basis of his having attended one of the demonstrations.

Additionally, the Chemistry Demonstration was included on two occasions as part of COSI's renowned "Camp-In" Program in which students from various youth agencies (Girl Scouts, Camp Fire Girls, Cub Scouts, YMCA, 4-H, etc.) camp-in at COSI and actually spend the night, attend workshops, and see programs.

The "Colors in Chemistry" show was presented in late January to three groups of Girl Scout Cadettes (junior high age) of approximately 60 girls each and adapted to allow the girls to participate in a "make-it-and-take-it" workshop in Chromatography. The response of the girls and leaders attending the camp-in program was good.

In late March, 1976, the Chemistry Demonstration was presented to four groups of 4-H students camping-in at COSI, totaling over 100 students.

COSI normally requests school groups which attend programs to fill out an evaluation form for our benefit. Responses to this request vary widely and, so far, insufficient returns have mentioned the Chemistry Demonstration to allow any worthwhile conclusions to be drawn as comments have been of a very general nature. It is expected that more in-depth teacher evaluations will be forthcoming.

Demonstration Cart:

In the original design, a charcoal filter exhaust was incorporated. We found it to be unnecessary for the demonstrations given. The back of the cart is 44" high. Some of our shorter demonstrators find this a bit awkward.

The integral light box on the counter is extremely beneficial, particularly with the color-related demonstrations.

The cart includes approximately 18 square feet of counter space which has proven to be the minimal amount needed for the majority of the demonstrations.