

*FUSION SCIENCE THEATER presents*

## *The Boiling Point*

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### **NOTE:**

We invite you to perform *The Boiling Point* whenever and wherever you wish, but we remind you it is the copyrighted property of the authors. Therefore, you must acknowledge us and Fusion Science Theater (FST) in any promotional materials, publications, website, and social media that mention the show. We also invite you to let us know about your performances by posting on our Facebook page or contacting us through [www.FusionScienceLearning.org](http://www.FusionScienceLearning.org).

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### **Learning Objective:**

After seeing this show, the children will be able to describe what happens to water molecules when water heats up and boils.

### **Brief Description:**

The show dramatizes the steps of a scientific inquiry, including observation, hypotheses, models, and experiments. Two characters, the Scientist and actor Vinnie, present children with possible answers to the question, “What happens to water when it boils?” The children state their opinion by written vote, then participate in the inquiry at every phase, including physically acting out a dance of boiling water molecules. After the experiment and models, the children vote again, enabling the teaching team to get data about learning gains.

**Target Audience Age:** 5 – 11 years old

**Audience Attendance Range:** 10 – 50 children (up to 70 attending including adults)

### **Characters**

**THE SCIENTIST**, a science educator. His or her main function is to perform the demonstrations and lead the audience through the lesson.

**COSTUME SUGGESTION:** A lab coat.

**VINNIE the Mime**, an actor. His or her main function is to assist the **SCIENTIST**, entertain the audience and reinforce the terminology and methodology introduced by the **SCIENTIST** through physical, kinesthetic learning.

**COSTUME SUGGESTION:** A bright casual outfit

**KIDS in the audience.** The show is interactive and participatory. Kids will be asked to volunteer observations, ideas, and predictions to open-ended questions, and to chorus answers to questions asked and answered earlier in the show. We will note these interactions including Call and Response by having a “character” called “**KIDS ANSWER.**” When the audience calls out an answer, it should be acknowledged and the right answer repeated.

### Setting

**AUDIENCE SET UP:** Have chairs set up for adults, encourage children to sit in front of the adults on rugs on the floor, or in the first few rows of the theatre. A semi-circle around the front of the playing area works best.

**STAGE AREA:** You will need a round table off to one side for the demonstrations, and a large clear area to the opposite side for the Act-It-Out. The Box is upstage center, behind the immediate playing area. See page \_\_\_\_ for Box description/specs.

Following the script is the following:

- \* **Lab Equipment List – Demonstrations**
- \* **Properties List – Act-It-Out and Basic Show**
- \* **Sound List**
- \* **Music for “Science in a Box” song**
- \* **Evaluation Slips [ballots]**

**About the ballots:** They are designed for children to vote on 3 possible hypotheses.

There are two separate votes, one near the beginning and one near the end of the show. As children enter, hand them 2 ballots (on different colored paper) and golf pencils. Tell them to hang on to them until the show begins.

When indicated in the script, direct children to take out one of the ballots (designate color) and vote on what they think is the best answer to the investigation question.

Collect all the ballots immediately after they’ve been filled out.

### PRE-SHOW SET UP

- BOX set upstage center.
- SIGNS are in or around the box, easily accessible.
- ACT-IT-OUT props easily accessible.
- WATER is boiling on portable stove on the table.
- LAB equipment is on table or available.
- Children have their BALLOTS and PENCILS.
- Vinnie is holding his TEA CUP AND SAUCER and patiently waiting for a cup of tea.

## THE BOILING POINT

**VINNIE and the SCIENTIST** *sing their opening song.*

Gather 'round, we welcome your attention,  
 To this rare and curious invention,  
 Full of wonder and mysteries to unlock,  
 We think you'll find it grows your mind,  
 Our Science in a Box!  
 Science in a Box,  
 Science in a Box,  
 Our show's begun, let's have some fun,  
 With Science in a Box!

### **SCIENTIST**

[Does the following: (1) Welcomes audience. (2) Tells children to sit on their ballots. (3) Explains about filming. (4) Asks, "Do you like science? We're going to do science." (5) Introduces self and "my assistant Vinnie ..." ]

### **VINNIE**

*(Points to box.)*

... and his magic box. Today we will investigate one of the most mysterious substances know to humankind. This substance covers more than 70% of the earth surface!

### **VINNIE**

*(Mimes "investigation")*

### **SCIENTIST**

And makes up more than 70% of our own bodies.

### **VINNIE**

*(Mimes drinking water)*

### **SCIENTIST**

Do you know what this chemical substance is?

### **KIDS ANSWER:**

Water!

### **SCIENTIST**

That's right... Water.

### **VINNIE**

*(Water gesture)*

**SCIENTIST**

*(Observing VINNIE's gesture)* Yes, today we're going to investigate the substance of water. *(Observes VINNIE as he mimes "water" again.)* Vinnie, what are you doing?

**VINNIE**

*(Mimes: "I'm an actor.")*

**SCIENTIST**

Oh, you're an actor so . . . you're going to act things out.

**VINNIE**

*(Mimes: "You got it.")*

**SCIENTIST**

But this is a science show. We're going to do science. And we'll be talking about things that we can't even see.

**VINNIE**

*(Mimes: "Exactly, that's going to make it easier.")*

**SCIENTIST**

*(Interpreting)* That's why you're going to act things out. OK. Water does many mysterious things. In fact, here's some water that is doing something that is very mysterious. *(To kids)* Have you ever seen anything like that? *(Indicates boiling water in tea pot.)*

**VINNIE**

*(Mimes: holding up binoculars)*

**KIDS ANSWER**

It's boiling water

**SCIENTIST**

It's boiling? How do you know it's boiling?

**KIDS ANSWER**

[Bubbles, steam, shaking, colors, waves]

**VINNIE**

*(Hands imaginary binoculars to SCIENTIST)*

**SCIENTIST**

The first step of doing science is generally making observations.

**VINNIE**

*(Rings bell. Pulls out OBSERVATIONS sign, shows to audience and hangs it on the Box.)*

*NOTE: When anyone takes something out of the Box, there is a sound and flashing lights.*

**SCIENTIST**

Do you know what scientists do after they make observations?

**VINNIE**

*(Mimes: Hmm... I don't know? Ask Questions?)*

**SCIENTIST**

That's right, Vinnie. They ask questions. (*"Questions" gesture.*) About something they observed. (*"Observations" gesture.*)

**VINNIE**

*(Rings bell. Pulls out the QUESTIONS sign and hangs on Box, then pulls out the What Happens To Water When It Boils? sign and hands it to SCIENTIST.)*

**SCIENTIST**

You have a question, Vinnie? What's your question?

**VINNIE**

*(Indicates the What Happens to Water When It Boils? sign)*

**SCIENTIST**

*(Reading)* Let's read this question all together. What happens to water when it boils? Great, but tough question. Because to answer it, we need to think about what water is made of. And water is made of tiny particles, so tiny that we can't see them.

**VINNIE**

*(Holds out hand, for piece of water. )*

**SCIENTIST**

And that's a problem because if we can't see them, it's hard to understand what they are like or what they're doing. Vinnie, do you want something? What do you want?

**VINNIE**

*(Points to the boiling water.)*

**SCIENTIST**

You want a piece of water? Vinnie, I told you, they're so small no one can see them.

**VINNIE**

*(Gives up and pinches the steam to get a particle. Carefully carries the "particle" to the Box. Lights flash on Box. VINNIE comes out of the Box with foam molecule.)*

**SCIENTIST**

What do you have? Oh, a model!

**VINNIE**

*(Rings bell. Gets "Model" sign.)*

**SCIENTIST**

A model is a physical thing we create to represent something that we can't see. In this model you have three different pieces. These pieces are the smallest bits of matter. Do you know what they're called? If you think you know just yell it out.

**KIDS ANSWER**

Atom!

**SCIENTIST**

Right, atom. When you put atoms together it's called what?

**KIDS ANSWER**

Molecule!

**SCIENTIST**

Yes, a molecule. This is a model of the smallest bit of water which is called a molecule. What is it called?  
*(Call and response with kids.)*

[Explain what the parts of the water molecule are; include the fact that it's two hydrogen and one oxygen atoms.] Do you know what the formula is?

**VINNIE**

*(Holds up  $H_2O$  sign behind Scientist's back.)*

**KIDS ANSWER**

$H_2O$ !

**SCIENTIST**

That's right! How did you know?

**VINNIE**

*(Hang up  $H_2O$  sign. Then tug on SCIENTIST's sleeve, points to the What happens to water when it boils? sign)*

**SCIENTIST**

Would you like to know what happens to water when it boils?

**VINNIE**

*(Mimes: You betcha)*

**SCIENTIST T**

Well I'm not going to tell you! Because science isn't about giving answers, it's about figuring them out! But let me give you some possible answers to the question. Each of these possible answers are called "hypotheses". . .

**VINNIE**

*(Ring bell. Hypothesis gesture; pulls out the HYPOTHESIS sign and posts it.)*

**SCIENTIST**

Hypothesis is our best guess about what happens to water when it boils. *(Holds up a water molecule)*

**VINNIE**

*(Picks up a water molecule)*

**SCIENTIST**

Option 1: maybe the water molecules disappear when water boils.

*(SCIENTIST and VINNIE put the foam molecules behind their backs. Then VINNIE goes to the Box and pulls out the DISAPPEARS sign and posts it.)*

**SCIENTIST**

Option 2: maybe the water molecules spread apart.

*(SCIENTIST and VINNIE, each with a molecule, run in different directions and then wave to each other. Then VINNIE goes to the Box and pulls out the SPREADS OUT sign and posts it.)*

**SCIENTIST**

Option 3: remember the bonds that hold together the hydrogen and oxygen atoms? Maybe, when water boils, the water molecules break apart into hydrogen and oxygen atoms.

*(SCIENTIST and VINNIE tear the water molecules apart. Then VINNIE goes to the Box and pulls out the BREAKS APART sign and posts it.)*

**SCIENTIST**

Option 4: or maybe you just don't know. In science, it's always OK to say, "I don't know."

*(VINNIE goes to the Box and pulls out the I DON'T KNOW YET! Sign and posts it.)*

**SCIENTIST**

I'd like each of you to think about these four options and decide which one makes the most sense to you. And then I want to know what you think.

**VINNIE**

*(Pulls out ballots from pocket, hand to SCIENTIST.)*

**SCIENTIST**

The election's over, Vinnie. Oh! They can vote!

[Direct the children to vote on one of the ballots. Indicate which color they should use.]

*(VINNIE and/or volunteers should collect all the ballots in a box.)*

**VINNIE**

*(Tugging on SCIENTIST's sleeve. Point to question. Hypothesis gesture, then Question gesture.)*

**SCIENTIST**

You want to know the answer? *(To audience)* Do you want to know the answer? I'm not going to tell you. Because in science, (running thru signs – words & gestures), after we make Observations, ask Questions, look at Models and make a Hypothesis, if we want to figure out which of our options is the best one, we do X-periments!

**VINNIE**

*(Rings bell. "X" for Experiment gesture. Pulls out EXPERIMENT sign, post on box.)*

**SCIENTIST**

*(Puts on safety goggles.)*

[Asks the children why it is important to wear safety goggles while doing chemical experiments.

Talks through first experiment: Purpose is to test Hypothesis #3, that water molecules break down into hydrogen and oxygen atoms which will, in turn, form hydrogen and oxygen gas.]

I have some hydrogen and oxygen gas right here in this tube.

**VINNIE**

*(Lights candle during speech.)*

**SCIENTIST (cont.)**

*(Presents a stoppered, inverted tube of hydrogen and oxygen gas--2:1 ratio by volume-- prepared just before the show. Instructions following script.)*

Let's see what happens when we take this mixture of hydrogen and oxygen gas and put it by the flame of this candle.

*(Tests combustibility of mixture by holding the mouth of the tube to a lit candle, producing the characteristic bark.)*

[Asks children what they heard and saw. Calls on KIDS.]

**KIDS ANSWER**

[Observe the characteristic bark.]

**SCIENTIST**

Now let's see what happens when we do the same thing to the gas coming out of the teapot while the water is boiling. Are you ready?

*(Put a candle to the spout of the teapot while VINNIE is poised to use the fire extinguisher. Flame of candle goes out!)*

**SCIENTIST**

Did you hear anything? Did you see anything? *(Calls on KIDS.)*

**KIDS ANSWER**

No, the candle just went out.

**SCIENTIST**

I didn't see anything either. Well, that wasn't too exciting but it certainly gave us an important clue about what happens to water when it boils. Let's do another experiment.

*(Experiment #2: SCIENTIST describes what she is doing as she puts balloon on spout of teapot and return pot to flame. As water boils, balloon inflates.)*

[Asks KIDS what they see. Asks KIDS when she should take the teapot off the burner.]

**KIDS ANSWER**

They shout out answers and advice.

*(SCIENTIST plays the audience and finally removes pot with fully inflated balloon from flame and plunges it into ice water, describing her actions as performed. Balloon shrinks and pops inside of the glass pot).*

**SCIENTIST**

What happened? OR I thought you said the balloon was getting smaller. It doesn't look very small to me.

**KIDS ANSWER**

The balloon went inside.

**VINNIE**

*(Tugs at SCIENTIST's sleeve and Mimes: Why? Holding up the teapot.)*

**SCIENTIST**

Why did it happen? Would you like to know why that happened?

**VINNIE**

*(Hands SCIENTIST the foam model)*

**SCIENTIST**

Yes, that's a great model for a water molecule. But boiling is an action, we really need a model that's bigger and that can move.

**VINNIE**

*(Mimes: I have an idea! Goes to the Box.  
Box sound, flashing lights in Box.  
Comes back dressed like a water molecule.)*

**SCIENTIST**

[Explains about the parts of this model. Explains that to model what happens to water when it boils, we'll need a group of molecules.]

**ACT-IT-OUT** - Ask for volunteers. 5 kids to be "water molecules" and 2 kids and 2 adults to act as the teapot. Tea pot volunteers are arranged in a square and all 4 hold a rope that encloses 3 sides of the "tea pot." 6 "water molecules" go into the enclosed space of the teapot.

Please see show video for demonstration.

**SCIENTIST**

Have I mentioned the part about the dancing?!?

[Talk through the movement of water molecules – vibrating, rotating, moving short distances. Ask kids in audience, how the dancing will change as the water heats up]

**KIDS ANSWER**

Molecules will dance faster as the water heats up.

**SCIENTIST**

Guide the volunteer water molecules through a "practice," dancing practice faster and faster as water heats up – until they are dancing so fast they have reached: the **BOILING POINT!**

**SCIENTIST and VINNIE**

*On Kazoos: Da Da Daaaa!*

**SCIENTIST**

[Explains that the molecules leave the pot one by one to model as they are boiling and directs kids out of the "pot" accordingly.]

**VINNIE**

*(Holds up balloon and gives it to SCIENTIST)*

**SCIENTIST**

Oh, that's right, we need a balloon in our model. What should we use?

**VINNIE**

*(Points to the Box)*

**SCIENTIST**

Me? In There? OK!

*(Go into the Box  
Box sound, flashing lights in Box.  
Brings out a Reel of barrier tape on a music stand.)*

Hey! Look what I found in the box! This will be our model of the balloon.

*(Hands the reel part of the tape to one adult at the “mouth” of the “pot” with the warning to hold on TIGHTLY. Pulls the tape out and hand the end to the other adult at the “mouth.”)*

**VINNIE**

*(Mimes: giving SCIENTIST a “microphone.”)*

**SCIENTIST**

Everyone ready!?! Ready, Box? *(Box sound, flashing lights.)* Start the music please!

*(Cue music: Blue Danube for dancing—it should gradually speed up in the first 30 seconds. The Can Can for boiling. MP3 recording of each song available from Fusion Science Theater.)*

*(Narrates the ACT-IT-OUT in a mock broadcaster voice)* Ladies and Gentlemen, welcome to the “Dance of the Water Molecule.”

*(Directs the volunteers to follow the narrated script—dancing faster, reaching the boiling point (with Da-Da-Daaaa!), leaving the pot one by one until space inside barrier tape encroaches on the seated audience.)*

**VINNIE**

*(Actually yelling!!)* STOP!!!!

**SCIENTIST**

What is it?

**VINNIE**

*(Quietly)* We’re going to blow!

**SCIENTIST**

Let’s think about what happened in the experiment, when the balloon got so large some of you thought it was going to blow. Then what did I do?

**KIDS ANSWER**

Put the teapot in ice water.

**SCIENTIST**

Let’s say we put our whole bit teapot in ice water. What would happen?

**KIDS ANSWER**

Balloon got smaller, etc.

**SCIENTIST**

And what would our water molecules do? What about their dancing if we put the pot in ice water?

**KIDS ANSWER**

Water molecules would dance slower/go back into teapot.

**SCIENTIST**

OK! Let's model that. And for this we'll run the heating-up music BACKWARDS!

*(Music goes backward. SCIENTIST narrates the rest of the ACT-It-Out and guides the kids back into the teapot, making sure to point out that the balloon actually inflates into the pot. Directs everyone take a bow to get a round of applause.)*

**VINNIE**

*(Tug on SCIENTIST's sleeve, whisper "I changed my mind" and give her ballots.)*

**SCIENTIST**

Oh, you changed your mind about the options? That happens a lot after an experiment.

**VINNIE**

*(Holding up another ballot.)*

**SCIENTIST**

Did anyone else change their mind? Let's take another vote.

[Talks them through the options and encourages them to vote whatever they think, even if they don't know.]

Thank you for sharing your thoughts with us.

**VINNIE**

*(Takes "I don't know" sign, indicates: "But I still don't know")*

**SCIENTIST**

Let's look at our hypotheses.

[Puts away option #4 ("I don't know") because we are about to figure it out.]

Option #3: breaking up. What do you think? Did the water molecule break up with the water boiled?

**KIDS ANSWER**

No, and why.

**SCIENTIST**

[Repeats answers and reminds kids of the results of lighting the tube of hydrogen and oxygen compared to lighting the steam from the teapot]

Option #1: What do you think? Did the water molecules disappear?

**KIDS ANSWER**

No, and why.

**SCIENTIST**

[Repeats answers and reminds them that the kids in the model didn't disappear when they boiled and left the pot; mention of "Law of conservation of matter" if appropriate.]

That leaves option #2: water molecules spread out. This is the one that best fits what happened in our experiments and what we acted out in our model. The others were good ideas, smart ideas, but the data supports option #2 the best. This is how scientists think through things and come up with explanations.

**VINNIE**

*(Mimes: Experiment gesture "X" and points to EXPERIMENT sign.)*

**SCIENTIST**

You want to do another experiment? Do you (ask audience) want to see another experiment?

**KIDS ANSWER**

Yes! Yeah!

**SCIENTIST**

Hmmm. What experiment should I do?

**VINNIE**

*(Goes to Box and returns with metal can and cork as well as the PREDICTION sign.)*

**SCIENTIST**

What do we have here? A can and a cork and a sign that says: Prediction. Hmm.

[Explain that when scientists think they understand why something happens, they use that model to predict will happen in a different experiment.]

**VINNIE**

*(Ring bell. Sticks the PREDICTION SIGN on Box)*

**SCIENTIST**

[Final Experiment: collapsing can. SCIENTIST narrates as she performs experiment—pouring a little water in the can, setting it on a lit burner. While waiting for it to boil, she tells the audience what she will do once it boils—seal the mouth with a rubber stopper and plunge the can into ice water—And asks the audience what they predict will happen.]

**Ask kids to not raise their hand if they've seen this experiment before. If they've seen it, they know what will happen. It's not a prediction, it's an observation.]**

**KIDS ANSWER**

Give predictions.

**SCIENTIST**

[Listens and repeats predictions. When water in can boils she does as she promised. Can collapses.]

**VINNIE**

*(Acts surprised; not what he would have predicted.)*

**SCIENTIST**

Wouldn't you like to know why that happened? Well, it has to do with pressure. If you go to our website you'll find a bunch of experiments you can do. And our website is ... is ...

**VINNIE**

*(Pulls out website sign and posts it.)*

**SCIENTIST**

www (cluck) fusion science theatre (cluck) org. *(Call and response)*

**VINNIE**

*(Pours himself that cup of tea he's been waiting for.)*

**SCIENTIST**

Thanks for coming. We had a great time doing science with you today. Vinnie! We don't have time for tea now! We've got to wrap up the show. Let's sing the song!

*(SCIENTIST and VINNIE sing the final song with CODA:  
"the show is done, we've gotta run!")*

**BALLOTS USED IN SHOW (printed twice, on different colored paper)**

--first vote--  <b>1</b>  <b>DISAPPEAR</b>  --first vote--	--first vote--  <b>2</b>  <b>SPREAD OUT</b>  --first vote--	--first vote-  <b>3</b>  <b>BREAK UP</b>  --first vote-	--first vote-  <b>4</b>  <b>I DON'T KNOW</b>  --first vote-	<p><b>Circle one:</b></p> <table border="1" style="width: 100%;"> <tr> <td style="width: 50%; text-align: center;">Boy</td> <td style="width: 50%; text-align: center;">Girl</td> </tr> </table> <p style="text-align: center;">Age:</p> <div style="border: 1px solid black; width: 100px; height: 30px; margin: 0 auto;"></div>	Boy	Girl
Boy	Girl					

--second vote--  <b>1</b>  <b>DISAPPEAR</b>  --second vote--	--second vote-  <b>2</b>  <b>SPREAD OUT</b>  --second vote-	--second vote-  <b>3</b>  <b>BREAK UP</b>  --second vote-	--second vote-  <b>4</b>  <b>I DON'T KNOW</b>  --second vote-	<p><b>Circle one:</b></p> <table border="1" style="width: 100%;"> <tr> <td style="width: 50%; text-align: center;">Boy</td> <td style="width: 50%; text-align: center;">Girl</td> </tr> </table> <p style="text-align: center;">Age:</p> <div style="border: 1px solid black; width: 100px; height: 30px; margin: 0 auto;"></div>	Boy	Girl
Boy	Girl					

**LAB EQUIPMENT LIST**

- Glass Tea Pot
- Stove (portable)
- Matches
- Water in Measuring Container
- Ice Water
- Balloons
- Tongs
- Can
- Cork
- Test tubes with hydrogen and oxygen mix, prepared in advance.
- SAFETY EQUIPMENT
  - Goggles
  - Hot Pad
  - Mitt
  - Fire Extinguisher

**BOX SUGGESTION**

The box can be of the design of your choice. We suggest a structure large enough to hold the signs, lights and props used in the show as well as large enough to make an impression on the children. It should be a box of the imagination as much as a physical container. The box should have hooks or Velcro on it, or have strings running from it to the walls – something to hang the signs on.

**PROPERTIES LIST**

- SIGNS
  - “What Happens To Water When It Boils?”
  - “H<sub>2</sub>O”
  - “OBSERVATIONS”
  - “QUESTIONS”
  - “DISAPEARS”
  - “SPREAD OUT”
  - “BREAKS APART”
- Second Molecule
- Green Foam Circle
- Blue Foam Circle
- Tape Measure
- Teacup & Saucer
- Kazoos
- H’s and O’s Rope
- Ballots
- Golf Pencils
- “I DON’T KNOW YET!”
- “HYPOTHESIS”
- “EXPERIMENT”
- “MODEL”
- “PREDICTION”

**SOUND LIST**

- Bell
- Slide Whistle
- Music [sound system or sung]
- Song sung
- Kazoo playing

Music for Show Theme Song:

"Science in a Box" theme song

Holly Walter Kerby

Ga-ther round, we wel-come your at-ten-tion To this rare and cu-ri-ous in-ven- tion



Full of won-ders and mys'tries to un-lock, We think you'll find it grows your mind, Our



Sci-ence in a Box. Sci-ence in a Box, Sci-ence in a Box. Our



(first time) show's be-gun, let's have some fun with Sci-ence in a Box!

(second) show is done, we've got - ta run with Sci-ence in a Box!



## Materials and Methods for Science in a Box: The Boiling Point

Created and prepared by Fusion Science Theater ©2008

### Experiment #1: Balloon on Kettle of Boiling Water

#### Materials:

- DI water
- Glass Water Kettle— available for \$34 from Adagio Teas at [http://www.adagio.com/teaware/water\\_kettle.html](http://www.adagio.com/teaware/water_kettle.html)
- A small, lightweight, camping stove that runs on a butane cartridge (available through Coleman, Gaz, Stansport, etc.)
- Round 9” balloons

#### Procedure:

1. Seal the stainless steel top of the teapot to the glass body with rubber cement.
2. Add about 60 mL of DI water to the teapot through the spout.
3. Light the camp stove with a match and adjust flame to heat the water.
4. When the water is boiling, remove from the stove with a potholder and, while one person holds the pot to keep from slipping, slip a balloon over the spout of the teapot.
5. Return the teapot to the camp stove burner.
6. Wait until the balloon has inflated and children scream, thinking will blow up.
7. Remove the teapot from the burner and plunge the teapot into a clear container of ice water.
8. The balloon will shrink—when it is fully deflated, flick the balloon up so that it can inflate (inside out) inside the teapot.
9. Later in the show, the balloon can be removed and the water used to “make tea.”

## Experiment #2: Testing Combustibility of a Mixture of H<sub>2</sub>/O<sub>2</sub>

### Materials: (for each performance)

- 9 M Hydrogen Peroxide
- 3 M Hydrochloric Acid
- Mossy zinc
- Manganese dioxide
- Large test tube rack
- 6 large thick-walled PETE test tubes (called Soda Bottle Preforms) available from Educational Innovation at <http://www.teachersource.com/Chemistry/PreformsAndSodaBottles/SodaBottlePreformsandCaps30pk.aspx>
- 5 solid rubber stoppers (#4 )
- 2 one-holed rubber stopper (#4 ) with a short (~4 cm) piece of glass tubing through the hole
- A length (20-30 cm) of Tygon tubing should be attached to the glass tubing in the one-holed stopper.
- A large plastic basin
- A candle
- Tap water

NOTE: We wanted to collect and light the mixture of hydrogen and oxygen in a plastic tube or bottle for fear a glass bottle would shatter with the explosion of the gases. Unfortunately, commonly used polymers like soda bottles (PETE), high density polyethylene (HDPE), polypropylene (PP), and polyvinyl chloride (PVC) were so permeable to hydrogen that the gas diffused through the containers in a matter of a few minutes. We finally solved the problem with the discovery of the “Soda Bottle Preforms,” large PETE test tubes thick enough to hold the hydrogen for 30 minutes or more. The volume of these tubes is enough to allow a clearly audible “bark” from the hydrogen/oxygen mixture.

### Procedure:

#### 1) Preparation—

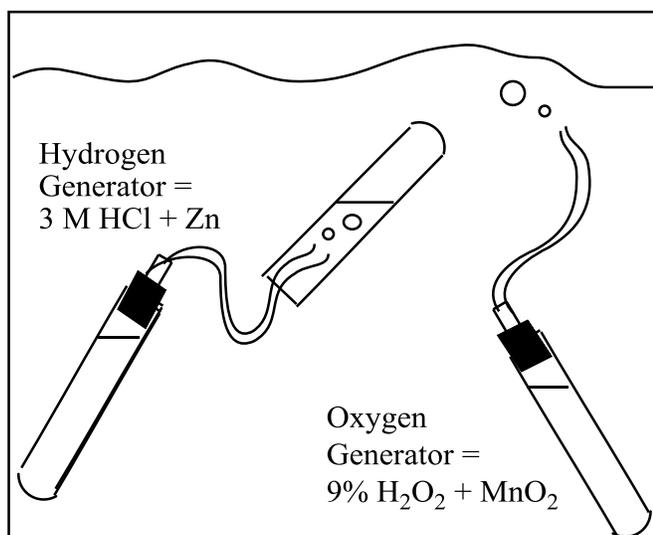
The following preparations can be made well in advance of the show and safely transported to the performance venue the day of the show:

- a) Fill one PETE tube nearly full with 9% hydrogen peroxide. Stopper and store upright in the large test tube rack.
- b) Fill one PETE tube nearly full with 3 M hydrochloric acid. Stopper and store upright in the large test tube rack.
- c) Estimate and mark thirds on the side of each remaining PETE tube with a permanent marker. Stopper tubes.
- d) The following can be loaded inside the empty plastic basin for transport to the performance site:
  - i) All PETE tubes in the test tube holder.
  - ii) Plastic container of MnO<sub>2</sub> powder
  - iii) Plastic container of mossy zinc
  - iv) One-holed stoppers with glass tubing and tygon tubing
  - v) Extra PETE tubes and stoppers (optional)

#### 2) Generation of hydrogen and oxygen gas mixture—

NOTE: This step can be done by the science teacher in any public bathroom up to 15 minutes before the start of the performance. It is helpful, but not absolutely necessary, to have another person to assist with this step. Needless to say, the people directly involved with the gas generation should wear goggles and precautions should be taken to make sure other people using the facility are not exposed to reagents.

- Fill the plastic basin with water.
- Open the tube filled with 9% hydrogen peroxide and add a small scoop of manganese dioxide. Stopper the tube (now bubbling  $O_2$ ) with a one-holed stopper connected to the length of Tygon tubing. This will act as the oxygen generator.
- Open the tube filled with 3 M hydrochloric acid and add a few pieces of mossy zinc. Stopper the tube (now bubbling  $H_2$ ) with a one-holed stopper connected to the length of Tygon tubing. This will act as the hydrogen generator.
- Submerge both generators in the basin taking care to keep them relatively upright.
- Submerge the empty PETE tubes, filling them with water.
- Fill each of the empty PETE tubes with a mixture of  $2/3^{rd}$ s hydrogen and  $1/3^{rd}$  oxygen in the following manner:
  - Put the hose connected to the hydrogen generator inside the tube until the gas displaces approximately  $2/3^{rd}$ s of the volume of water. Remove the hose from the tube.
  - Put the hose connected to the oxygen generator inside the tube until gas begins to bubble out of the tube.
  - Seal the tube with a solid rubber stopper and place it upside down in the test tube holder.
- The hydrogen and oxygen generator can be left bubbling in the basin of water during the performance. When the generators are no longer bubbling (after about 5 minutes), the aqueous reagents can be disposed of down the sink of a public bathroom with copious amounts of water following. The solid reagents can be transported by to the laboratory for further clean-up.



"Pre-form" tube being filled with approximately  $2/3^{rd}$ s  $H_2$ : $1/3^{rd}$   $O_2$  by water displacement

- Testing the mixture of hydrogen and oxygen for combustibility
  - Light a candle and place it on the table used for the demonstrations.
  - We had a fire extinguisher on hand and had the assistant character point it at the flame while the demonstration was performed for comic effect.
  - Remove the stopper from a still-inverted tube of  $H_2/O_2$ . Taking care to keep the tube inverted, pass the mouth of the tube over the flame. This should produce the characteristic "bark" of the reaction.

- d) Three remaining tubes of gas mixture can be used to repeat the experiment, especially if the demonstration was not sufficiently loud the first try.
- 4) Testing the steam for combustibility.
- a) To test whether the steam coming from the boiling water was similarly combustible, a candle can be held to the spout of the steaming tea kettle.

### **Experiment #3: Collapsing Can**

#### Materials:

- Lightweight, camping stove used for Experiment #2
- 20 mL water
- 1-gallon steel F-Style Oblong can available from Cal-Pak at [www.calpakusa.com/Products.htm](http://www.calpakusa.com/Products.htm)
- Rubber stopper to fit in steel
- Tongs
- A transparent, plastic basin of ice water.

#### Procedure:

NOTE: This is the traditional “collapsing can” demonstration.

- 1) Add about 20 mL of water to the paint can.
- 2) Set the can on the lit camp stove. Wait until the water is boiling as evidenced by steam coming out of the mouth of the can.
- 3) Remove the can from the heat and place the rubber stopper firmly in the mouth of the can.
- 4) Plunge the can into ice water. It should collapse.