

Kool Colors

Learning Objectives: Students learn how different factors affect the rate of chemical reactions.

GRADE LEVEL

2-8

SCIENCE TOPICS

Solutions and Mixtures
Techniques
Chemical Reactions

PROCESS SKILLS

Describing and Defining
Hypothesizing
Controlling Variables
Evaluating

GROUP SIZE

2-4

TIME REQUIRED

SNEAK PEAK inside ...

ACTIVITY

Students add steel wool to various types of Kool-Aid™ and watch for the color to fade.

STUDENT SUPPLIES

see next page for more supplies

steel wool
Kool-Aid
plastic cups
classroom clock or watch ...

ADVANCE PREPARATION

see next page for more details

Cut up steel wool
Mix Kool-Aid solutions ...

OPTIONAL EXTRAS

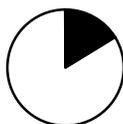
DEMONSTRATION

Liquid Bleach and Kool-Aid (p. E - 5)

EXTENSIONS

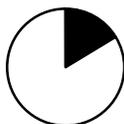
Inquiry Opportunity—Surface Area and Reaction Rate (p. E - 11)
Inquiry Opportunity—Concentration and Reaction Rate (p. E - 12)

Advance Preparation



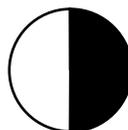
10 minutes

Set Up



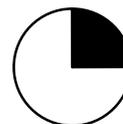
10 minutes

Activity



30 minutes

Clean Up



10 minutes

SUPPLIES

Supplies Note:

The table below lists supplies for testing one color of Kool-Aid at three different temperatures.

For older students, make multiple colors of Kool-Aid for students to repeat the experiment. Multiply the supply needs by the number of colors you are testing.

Item	Amount Needed
fine grade (#000 or #0000) steel wool	3 small clumps, 1 tablespoon each, per group
unsweetened Kool-Aid™ (grape, black cherry, cherry, strawberry, watermelon-cherry, and orange all work)	1 cup per group (1–3 packets total per class)
clear plastic cups, 4 oz. or larger	4 per group
spoons, plastic	1 per group
stopwatch or line of sight to a clock with a second hand	1 per group
masking tape	1 roll for teacher
access to hot water (from the tap, from a microwave, etc.)	
access to fridge	
pop-top squeeze bottles (e.g., water or sports drink)	3 per group
paint color strips from paint store (optional) * See Notes and Hints in Advance Preparation	1 or more per group

For Extension or Demonstration supplies, see the corresponding section.

ADVANCE PREPARATION

Supplies Preparation

Kool-Aid:

- ❑ If you are using multiple colors of Kool-Aid, repeat the directions below for each color of Kool-Aid.
- ❑ Don't buy sugarless or "sugar already added" Kool-Aid. Look for the small packets with the concentrated flavor powder alone.
- ❑ Use the package directions to add the appropriate amount of water to the Kool-Aid powder. Do not add sugar.
- ❑ Fill pop-top squeeze bottles with $\frac{1}{4}$ – $\frac{1}{2}$ cup of Kool-Aid solution.
- ❑ Label the bottles with the color of Kool-Aid.

- ❑ Put one third of the bottles in a refrigerator overnight. Label these “cold.”
- ❑ Keep one third of the bottles at room temperature. Label these “room.”
- ❑ The final third of the bottles are for hot Kool-Aid solution. Label these bottles “hot.” You can put these in a hot water bath to warm them up just before class starts.

CAUTION: Never put lab supplies in your mouth. Even if lab supplies are foods, they may be contaminated by other items in the lab.

Steel Wool:

- ❑ Use scissors to cut the steel wool into portions equal in size to a cotton ball (about 1 tablespoon or 1 gram each).
- ❑ Choose the finest possible grade of steel wool (Grade: #000 or #0000); fine steel wool reacts with the colors in Kool-Aid faster than coarse steel wool.
- ❑ Use only pure steel wool, not the kind with soap on the surface (e.g., SOS Pads).

Notes and Hints

Paint Color Strips:

This activity requires students to have some way to evaluate color changes. Here are two options:

- ❑ The procedure tells students to start with four cups with Kool-Aid, but they only add steel wool to three of them. In the fourth cup, the solution will remain the same color and not fade, so students can compare their reaction cups to it.
- ❑ Bring a sample of Kool-Aid solution to a paint store and look for sample color strips that match. With luck, the Kool-Aid will start as one of the darkest colors on the strip. Then it will fade through the lighter versions of the color. This gives the students a way to quantify the color of the solution as it changes.

Kool-Aid:

- ❑ Watermelon-cherry, cherry, and orange Kool-Aid fade to colorless. Black cherry and grape change from purple to blue.
- ❑ Try to select flavors that include different combinations of dyes (the dyes are listed in the ingredients).

Flavor	Dyes
Black Cherry	Red 40 Blue 1
Cherry	Red 40 Blue 1
Grape	Red 40 Blue 1
Orange	Red 40 Red 40 Lake Yellow 5
Watermelon-Cherry	Red 40

SETUP



For each group

Set out these supplies for each color of Kool-Aid.

- 4 clear plastic cups
- 3 clumps of steel wool
- $\frac{1}{4}$ – $\frac{1}{2}$ cup of Kool-Aid solution in a pop-top squeeze bottle at **each** temperature you will measure:
 - room temperature
 - refrigerated
 - hot (as hot as possible from the tap)
- 1 plastic spoon
- 1 stopwatch or line of sight to a clock with second hand
- paint color strips (optional)

At a central location (or with the teacher)

- towels and sponges for clean up

INTRODUCING THE ACTIVITY

Let the students speculate before offering answers to any questions. The answers at right are provided for the teacher.

Choose questions that are appropriate for your classroom.

This activity has a carefully designed procedure. Take some time to discuss with students why the activity is designed the way it is.

For more information about experimental design, see the **Science Inquiry** section at the beginning of the Guide.

Today we are going to investigate how to make chemical reactions go faster or slower. Can anyone name a very fast chemical reaction? How about a slow one?

Examples of fast reactions are explosions, acid-base reactions like vinegar and baking soda, rocket launches, forest fires, etc.

Examples of relatively slower reactions are rusting, photosynthesis, bread rising (yeast reaction), digestion, food going bad, etc.

All of these reactions can be sped up or slowed down by changing the temperature. For instance, food goes bad much more slowly when it is stored in the fridge, and bread rises much faster in a warm location than a cold one.

In order to investigate the effect of temperature more, I've brought in a very interesting problem for us to work on.

Show students the back to one of the Kool-Aid packets and point out that the last line in the directions says "Do not store in a metal container."

Why do you think that direction is there? What do you think will happen if we mix metal and Kool-Aid?

Answers will vary. Encourage the class to form some hypotheses.

Will what we do be affected by temperature? Why or why not?

Yes it will be affected, because temperature affects the rate of all chemical reactions.

TEACHER DEMONSTRATION

Bleach with Kool-Aid

In this demonstration, the instructor adds a tiny amount of bleach to solutions of Kool-Aid to watch the color fade. You can do this demonstration as an introduction before the activity or as a follow up after the activity.

This demonstration is similar in structure to the activity **Color Me Blue**. For more information on the chemistry of bleach, see that activity.

Supplies

- about 1 cup of any color Kool-Aid solution in a clear plastic cup, include as many other colors of Kool-Aid as desired
- 1 spoonful diluted bleach solution for each cup of Kool-Aid to be tested
 - prepare diluted bleach solution by adding 5 drops of bleach to 2 cups water

CAUTION: Full strength bleach is a corrosive and hazardous substance. Wear gloves and use care when handling.

Demonstration

- Point out the colored Kool-Aid cups and ask students to guess which colors are present in each (e.g., students might guess that red and blue colors are in purple Kool-Aid).
- Point out the bleach and discuss how it works. Ask students whether it bleaches all colors equally. Solicit stories of hair coloring or artificial tanning solution to establish the potentially mysterious results of adding color-changing chemicals together.
- If time permits, collect student hypotheses on what the bleach will do to each Kool-Aid solution. Ask students to provide reasons behind their hypotheses, if they have them.
- Add 1 spoonful of dilute bleach solution to each Kool-Aid solution. Observe for any changes.

Explanation

Full strength bleach reacts with many dyes in clothes and food. The reaction can destroy the dye. Dilute bleach reacts with only certain types of dyes. In this demonstration, you may see that some of the Kool-Aid colors fade and others do not.

CLASSROOM ACTIVITY

Have students follow the Scientific Procedure on page E - 15, working in groups of 2–4. The following are suggestions to help the teacher facilitate the activity.

NOTES

This handout is
on p. E - 15.

Kool Colors

SCIENTIFIC PROCEDURE

1. Label four cups "Cold," "Room Temp," "Hot," and "No Steel Wool."
2. Add 4 spoonfuls of cold Kool-Aid into the cup labeled "No Steel Wool."
 - Record: Write the flavor of Kool-Aid at the top of the Data Table.
 - Record: Write the initial color of the Kool-Aid on the Data Table.
3. Look at the pieces of steel wool.



Running Suggestions

- Groups of three students work well, then each student can test the reaction at a different temperature.
- Discuss with students how they will decide when the Kool-Aid has finished changing color. Brainstorm and have the class arrive at a method that they will consistently use.
- Have students place their clear plastic cups over a white piece of paper so they can see the color changes better.
- Have groups of students analyze all three temperatures or give different temperatures to different groups and collect all class data to discuss at the end.
- If you are testing different colors of Kool-Aid, students should complete all the tests with one color first. Then they can repeat the experiment with another color.
- Show students the ingredients lists on the back of the original drink packets. Students can see and record the particular dyes they are investigating.
- Use paint color test strips so students can compare the color of the Kool-Aid solutions during the reaction.

Ongoing Assessment

- ❑ What colors are you seeing? Has the Kool-Aid changed at all? *(Answers will vary.)*
- ❑ How can you tell when the reaction is finished? *(This is important for students to answer, have them compare their solutions with each other or with the original Kool-Aid.)*
- ❑ What is happening to the steel wool? How is it changing, if at all? *(Students might see it turning dark in color; small clumps may be visible on its surface.)*

Safety and Disposal

- ❑ Kool-Aid solutions may be poured down the sink.
- ❑ Steel wool should be thrown away in the trash.

CAUTION: Never put lab supplies in your mouth. Even if lab supplies are foods, they may be contaminated from other items in the lab.

CLASSROOM DISCUSSION

Ask for student observations and explanations. Let the students guide the discussion and present their hypotheses before discussing explanations.

Choose questions that are appropriate for your classroom.

Upon carefully observing the color changes in each batch of Kool-Aid, students should be able to notice patterns in how the colors changed. For instance, if steel wool turned a cup of Kool-Aid with Red 40 clear, students might notice that other Kool-Aid solutions with Red 40 also changed color.

Create a chart with the data from each group.

What happened to the Kool-Aid solutions? What happened to the steel wool?

The color changed/dissappeared. When the steel wool was removed from the Kool-Aid solutions, it was black rusty.

What does your data show? Which colors of Kool-Aid reacted with the steel wool?

Answers will vary based on the Kool-Aid chosen.

Did the color change happen faster in warm water, room temperature water, or cold water?

Hot water changed the color the fastest, room temperature the next fastest, and cold water changed the slowest.

Why do you think hot water changed the color faster?

The mixture with hot water had more energy (heat) in the system, so the reactions were able to happen faster, causing the color change to occur earlier.

Which chemical was left over after the reaction: the Kool-Aid color or the steel wool? How do you know?

The steel wool is left over. We know because we can see it!

Discuss with students the design of the experiment they conducted.

For detailed information about experimental design, see **Science Inquiry** in the beginning of the guide.

EXPLANATION

This background information is for teachers. Modify and communicate to students as necessary.

Students learn how they can change the speed of a chemical reaction by changing the temperature of the ingredients.

BACKGROUND FOR ALL GRADES**Chemical Reactions**

In **chemical reactions**, substances interact and transform each other. In this experiment, the steel wool (which is mostly iron but with small amounts of other metals) reacts with the dyes in the Kool-Aid to remove the color of the solution. This color change is evidence of some kind of chemical reaction. This chemical reaction can be sped up or slowed down by changing the temperature of the Kool-Aid.

Color Change

As shown by the ingredient lists on the back of the package, each flavor of Kool-Aid contains different combinations of food dyes, including FD&C Red 40, FD&C Blue 1, or FD&C Yellow 5. The red and yellow dyes will react with steel wool and lose color, while the blue dye will not. This means that flavors that use only red and yellow dyes will fade completely. A flavor of Kool-Aid that uses a combination of blue with red or yellow dyes will fade so that only the blue color is left behind.

Effect of Temperature on Reaction Rate

The speed of a chemical reaction is called the **reaction rate**. By altering the conditions in a chemical reaction, scientists can speed up or slow down the reaction rate. In this experiment, hot Kool-Aid solutions reacted faster than cold ones because the increased energy in hot solutions causes the steel wool and

Kool-Aid colors to collide together more quickly and effectively (see below for more info on this).

Experimental Design

Scientists often want to know what will happen if they change something about an experiment. To investigate this, they carry out their tests while changing only one factor at a time. Each factor that can change in an experiment is called a **variable**.

For more information about experimental design, see the section **Science Inquiry** in the beginning of the Guide.

In this experiment, students conduct the same experiment three times but at different **temperatures**. All the reactions use the same amount of steel wool and the same amount of Kool-Aid solution at the same concentration. The only difference between the reactions is the temperature of the Kool-Aid solution. Since everything else is the same, students can be sure that any change to reaction rate is due to the difference in temperature.

If students repeat the test with different colors of Kool-Aid, they again need to keep everything the same and only change the color of the Kool-Aid. This way they can compare the reaction rate between two different colors of Kool-Aid at the same temperature. The extensions provided at the end of this experiment also suggest other variables that can be tested: **surface area** of steel wool (Extension A) and **concentration** of Kool-Aid dye (Extension B).

EXTRA BACKGROUND FOR GRADES 5–8

Dye Composition

The Red 40, Red 40 Lake, and Yellow 5 dyes in Kool-Aid react with steel wool because their **molecules** are similar. These dyes are called **azo dyes**. This means that somewhere in the dye molecule there are two nitrogen atoms with a “double bond” between them. The iron in steel wool reacts with and changes this bond. This changes the shape of the dye molecule and removes its color.

Other dyes, such as Blue 1, do not have this structural feature, and they keep their color in the presence of steel wool.

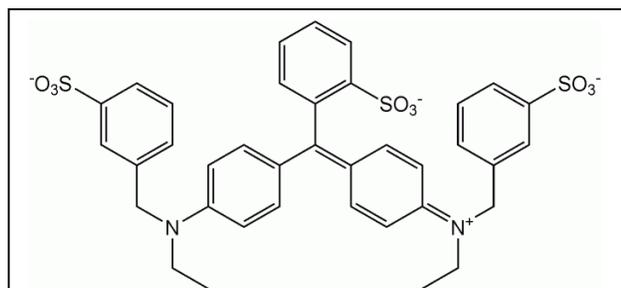


Figure 1. Dye structure for Blue 1 food coloring. Notice the lack of a nitrogen-nitrogen bond.

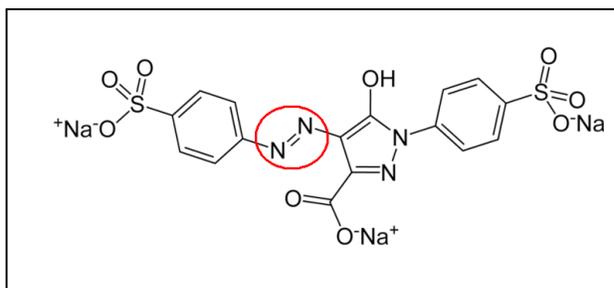


Figure 2. Dye structure for Yellow 5 food coloring with the nitrogen-nitrogen bond highlighted.

Oxidation and Reduction

The type of reaction seen in this activity is known as an oxidation-reduction reaction. The steel wool in this activity loses electrons and is said to be **oxidized**. Students can observe this by looking at the steel wool afterward. The steel wool may turn black or may show signs of rust. Steel is primarily made from iron, and, when iron oxidizes, we call it rust.

If something loses electrons, something else must gain those electrons. In this case, the dye in the Kool-Aid solution is gaining electrons and is said to be **reduced**. When the dye reacts and becomes reduced, its color fades.

Temperature and Reaction Rate

Chemical reactions happen when **molecules** bump into each other with enough **energy** or force. In this experiment, for instance, dye molecules from the Kool-Aid must physically collide with an iron atom in the steel wool before it will react. The rate of this reaction depends on how often the molecules bump into each other and on how much energy they have when they do so.

Increasing the **temperature** increases the reaction rate because it increases both the number of collisions between molecules and the energy of those collisions. At high temperatures, molecules are shaking, twisting, and zooming around much faster than at lower temperatures. Molecules that move faster will tend to collide more forcefully, increasing the likelihood that collisions between molecules will result in a chemical reaction. In addition, molecules moving faster collide more often, and more collisions means more reactions.

Surface Area and Reaction Rate

As shown in Extension A below, the **surface area** of the steel wool is another factor in the rate of the reaction. Steel wool has a relatively large surface area compared to, say, a chunk of steel of the same weight. Along the same lines, fine grades of steel wool have more surface area exposed than coarser grades. When more steel is exposed, more collisions are possible, and the reaction rate goes up.

EXTENSIONS

Extension A: Inquiry Opportunity—Surface Area and Reaction Rate

Test different grades of steel wool to see how surface area affects the rate of reaction.

Extra Supplies

- other grades of steel wool (#3, vs. #1, vs. #00 vs. #0000, for example)

Extra Instructions

- Repeat experiment but use only one flavor of Kool-Aid and change the grade of steel wool used.
- **Note:** very coarse steel wool (e.g. #3) can take up to an hour to react.

Explanation

Finer steel wool means there is more surface area of steel wool to react with the dyes. When there is more opportunity for molecules to interact, the reaction goes faster.

Extension B: Inquiry Opportunity—Concentration and Reaction Rate

Students investigate how the rate of reaction changes when the concentration of the Kool-Aid changes.

Extra Supplies

- extra Kool-Aid to make double or triple strength solutions

Extra Instructions

- Create solutions of higher or lower concentrations of Kool-Aid for students to try out.
- If students investigate the effect of concentration on rate, they should conduct their experiments on solutions of the same temperature.

Explanation

If students use double the concentration of Kool-Aid, and the reaction goes at the same rate, they should expect the color to take twice as long to fade. If it takes less than twice as long, then the reaction is happening faster at the higher concentration. If it takes more than twice as long, then the reaction is happening slower at the higher concentration.

It is more likely that the reaction rate will increase at higher concentrations of Kool-Aid solution. This is because with more dye molecules, there are more opportunities for collisions and reactions to occur between the dye and the steel wool.

CROSS-CURRICULAR CONNECTIONS

MATHEMATICS

Graphing Reaction Rate

The relative rates of reaction at different temperatures can be measured and graphed. Use thermometers to measure the temperature of different Kool-Aid solutions and then measure how long it takes for the color to fade.

Ratios

Like other rates, the rate of reaction is a ratio. After completing Extension B, students can calculate the rate by dividing the amount of Kool-Aid divided by the time of reaction. They can compare the numbers to see which reaction has the fastest rate (the highest value).

SOCIAL STUDIES

The History of Color

Dyes and pigments were precious commodities in ancient times and their presence often indicated nobility or extreme wealth. Medieval alchemists struggled to create them and the nobility directed the efforts of nations toward acquiring them. Research into creating synthetic dyes in Germany in the 19th century gave rise to the modern chemical industry. Many books detail this fascinating history (see below).

ART

Tie Dye

Use concentrated Kool-Aid to tie dye different fabrics. This dye is not permanent.

RESOURCES

Web – <http://www.chemguide.co.uk/physical/basicratesmenu.html#top>

A great Web site with sections on all areas of reaction rates: theories, causes, factors, etc.

Web – <http://jchemed.chem.wisc.edu/HS/classact/ClassActsList.html>

The activity "A Kool Reaction from the Fine Print" on this page provides an alternative version of this activity, along with student questions and further information on the chemistry behind the reaction. Scroll down to the link and click through to the PDF file.

Delamare, Guineau and Francois, Ber, *Colors: The Story of Dyes and Pigments*

Reading level: 6th-8th grade

This small book details the history and uses of colors over the ages, from cave paintings to medieval alchemy to modern textiles. It is packed with colorful pictures and small anecdotes about color, dye-making, and the use of pigments.

VOCABULARY

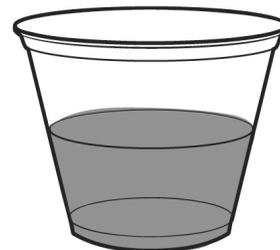
azo dyes:	a class of clothing and food dyes which contain a nitrogen-nitrogen double bond
chemical reaction:	the foaming, heating, cooling, glowing, color change, or appearance of something new when two or more chemicals are mixed together
concentration:	the ratio of the amount of a chemical in a solution to the volume of the solution
energy:	the ability to do work; anything that is not matter
molecule:	a group of at least two atoms held together in a definite arrangement
oxidize:	in a chemical reaction, to lose electrons; always paired with a reduction process

- reaction rate:** the speed at which two chemicals react with each other
- reduce:** in a chemical reaction, to gain electrons; always paired with an oxidation process
- surface area:** the amount of accessible space for a reaction to happen
- temperature:** a measure of the warmth of a substance, based on how fast its molecules are moving
- variable:** a changeable factor in a scientific experiment

Kool Colors

SCIENTIFIC PROCEDURE

1. Label four cups "Cold," "Room Temp," "Hot," and "No Steel Wool."
2. Add 4 spoonfuls of **cold** Kool-Aid into the cup labeled "No Steel Wool."
 - **Record:** Write the flavor of Kool-Aid at the top of the Data Table.
 - **Record:** Write the initial color of the Kool-Aid on the Data Table.



3. Look at the pieces of steel wool.
 - **Record:** Describe what the steel wool looks like at the beginning of the experiment. Write this on the Data Table.

4. Add 4 spoonfuls of **cold** Kool-Aid into the cup labeled "Cold."

5. Add a clump of steel wool to the **cold** Kool-Aid in the cup.
 - **Record:** Write the beginning color of the cold Kool-Aid.
 - **Record:** Every 30 seconds, write the color of the Kool-Aid on the Data Table.
 - Continue for 5 minutes.



6. Add 4 spoonfuls of **room temperature** Kool-Aid into the cup labeled "Room Temp."

7. Add a clump of steel wool to the **room temperature** Kool-Aid in the cup.
 - **Record:** Write the beginning color of the room temperature Kool-Aid.
 - **Record:** Every 30 seconds, write the color of the Kool-Aid on the Data Table.
 - Continue for 5 minutes.



8. Add 4 spoonfuls of **hot** Kool-Aid into the cup labeled "Hot."
9. Add a clump of steel wool to the hot Kool-Aid in the cup.
- **Record:** Write the beginning color of the hot Kool-Aid.
 - **Record:** Every 30 seconds, write the color of the Kool-Aid on the Data Table.
 - Continue for 5 minutes.

10. Take the steel wool out of all the cups.
- What does the steel wool look like now?
 - **Record:** Describe what the steel wool looks like at the end of the experiment. Write this on the Data Table.

11. Clean up your area.
- Follow your teacher's directions.



Kool Colors

DATA SHEET

Flavor of Kool-Aid Tested: _____

Time (minutes)	Types of Kool-Aid (Record color of Kool-Aid below)		
	Cold Kool-Aid	Room Temp Kool-Aid	Hot Kool-Aid
Begin (0:00)			
0:30			
1:00			
1:30			
2:00			
2:30			
3:00			
3:30			
4:00			
4:30			
5:00			

Steel Wool	Beginning Appearance	Ending Appearance
Record observations here →		

SUPPLY WORKSHEET

This worksheet is available online at www.oms.edu/k8chemistry.

Kool Colors

Recommended group size: 2–4

Number of Students: Number of Groups:

Supplies	Amount Needed	Supplies on Hand	Supplies Needed
fine grade (#000 or #0000) steel wool	3 small clumps, 1 tablespoon each, per group		
unsweetened Kool-Aid (grape, black cherry, cherry, strawberry, watermelon-cherry, and orange all work)	1 cup per group (1–3 packets total per class)		
clear plastic cups, 4 oz. or larger	4 per group		
spoons, plastic	1 per group		
stopwatch or line of sight to a clock with a second hand	1 per group		
masking tape	1 roll for teacher		
access to hot water (from the tap, from a microwave, etc.)			
access to fridge			
pop-top squeeze bottles (e.g., water or sports drink)	3 per group		
paint color strips from paint store (optional) * See Notes and Hints in Advance Preparation	1 or more per group		
Extension A			
other grades of steel wool, e.g., #00, #0, #1, etc.	3 small clumps per group		
Extension B			
additional packets of Kool-Aid	1–3 per class, depending on the concentration desired		
Teacher Demonstration			
Kool-Aid solution	1 cup each color		
clear plastic cup	1 per Kool-Aid flavor		
diluted bleach solution (5 drops of bleach to 2 cups of water)	1 spoonful per Kool-Aid flavor		