

- **Aim:** To write a secret message using lemons

- **Materials required:**

- ✓ Lemon
  - ✓ Water
  - ✓ Small Bowl
  - ✓ Q Tips or paint brush
  - ✓ White paper
  - ✓ Heat source (bright lightbulb, candle, stovetop)
- BE CAREFUL AND HAVE AN ADULT HANDLE THE HEAT SOURCE

**HELPFUL TIPS**

You can use fresh lemons or lemon juice.

Don't get the paper too wet or it will take much longer to dry.

Using a candle or stove will work much faster, but a lightbulb will work as well.

- **Questions to think about before you start:**

- ✓ How can I use a lemon to write a secret message?
- ✓ Why do we need heat?

- **Instructions:**

Make sure to perform the experiment as a team (parent and student).

- **Parent:** Cut the lemon in half
- **Student:** Squeeze half of the lemon into a bowl or cup and add a small amount of water
- **Student:** Stir the lemon juice and water together
- **Student:** Optional: You can write a decoy message in pen or pencil before you write your secret message.
- **Student:** Take your Q tip or brush and dip it into the lemon water and write your secret message on the paper.
- **Parent:** Once the paper is dry hold the paper over your chosen heat source to reveal the secret message. Be careful not to hold it to close or it may catch on fire

- **Extensions Activities:**

- ✓ Does it matter which side of the paper you expose to the heat?
- ✓ Try using another acidic substance like orange juice, milk, honey or vinegar to write your messages, notice which substances work better.
- ✓ What other ways could you heat up your invisible ink to reveal what it says?
- ✓ What happens if you add more or less water to the lemon juice, how does that change the invisible ink?

- **The science behind the fun:**

Lemon juice like other substances has carbon compounds in it, these were absorbed by the fibers of the paper. When you heated the paper up some of the chemical bonds broke down freeing the carbon and exposing it to the air and turn a darker color. This process is called oxidation and it is the same thing that happens to cut fruit that you leave out too long.



- **Vocabulary:**
- **Oxidation:** A chemical reaction that involves the moving of electrons or release of oxygen atoms.
- **Chemical bond:** The sharing or giving of electrons that joins atoms together
  
- **Real world application:**  
Understanding how oxidation reactions happen is useful for spies but for many other fields as well. The process of rusting is an oxidation reaction and something that can harm vehicles, building and equipment made from metal. Oxidation is also a problem for cooks knowing ways to prevent fruit and other foods from browning too quickly makes food taste and look better.

#### Did you know?

- George Washington and his spies used lemon juice as invisible ink during the Revolutionary War.
- Invisible ink substances vary and can be revealed by using heat, an acid or base or Ultraviolet (UV) light

spark. inspire. engage.



MATHNASIUM  
The Math Learning Center

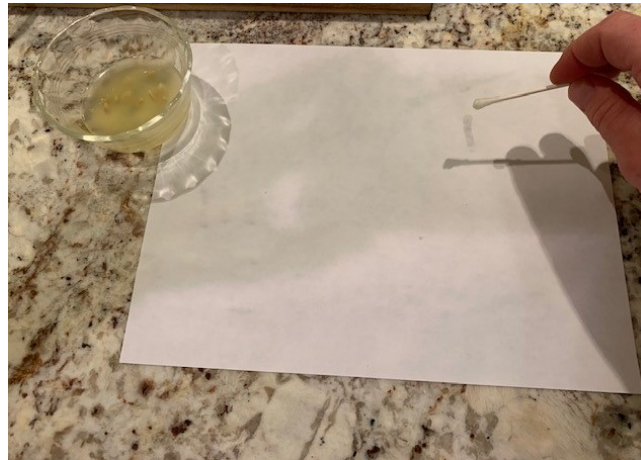


National  
PTA  
everychild. every voice.

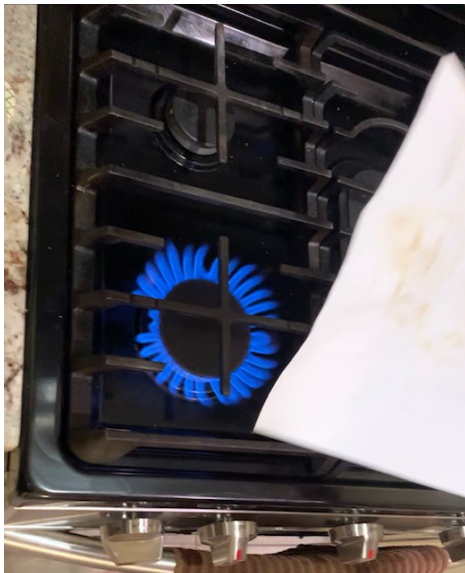
## Invisible Ink Photo Guide



Cut a lemon in half, squeeze them lemon into small bowl/cup and mix with a small amount of water.



Use a plain sheet of paper and a cotton swab to write your secret message.



Have an adult hold your secret message over a stove, candle or bright lightbulb to reveal the message

