The Secret Life of Atoms Home Labs

Scientist: _____ Date: _____

Mission: Watch electric charges at work. Some charged objects behave like giant ions. Some charge objects show the power of ions, some charges have nothing to do with ions and some charges allow you to see the busy work of ions way up close. Have fun!

LAB 1 | Bad Hair Day Gives a Good Visual: The Balloon or Comb Experiment (you choose what you use)

Supplies: A balloon or comb; dry hair or carpet and optional tiny paper scraps

Directions

1. Inflate the balloon and tie it.
2. Rub the balloon briskly against dry hair for 15-20 seconds.
3. Slowly lift it away. Watch what the hair does.
4. Bring it close to the hair again without touching.
5. Another version if you don't want your hair crazy is to rub your plastic comb up and down on your shirt or carpet, then hold over the small pieces of paper.

What to look for: Hair may reach toward the balloon; or paper may jump onto the comb.

What happened, and why? Rubbing transfers electrons between materials. Typically the balloon gains electrons and becomes negatively charged; the rubbed hair loses some and becomes positively charged. Opposite charges attract and ta-da, static electricity. In the experiment with the comb and paper, it is doing the same thing. The comb picks up additional electrons. The paper pieces when torn, will not tare with equally dispersed electrons, leaving some with a net positive charge and some a net negative charge. Opposite charges within the comb and the paper will attract and ta-da, connection.

While these experiments do NOT show actual ion formation, they do give a good visual of opposite electron charges attracting to each other, giving the mind a visual of elements with an unfilled outer shell of electrons desiring an

exchange of electrons to satisfy their electron stability needs. Make sense? Lets move on to experiments with actual ions in action.

LAB 2 | Tiny Lightning: Sock Shuffle (bet you didn't know this)

Supplies: Fuzzy socks; dry carpet; a willing partner; optional dim room.

Directions

1. Put on socks and shuffle on a dry carpet for 20-30 seconds.
2. Ask a willing partner to stand still (or shuffle, then compare results).
3. Slowly bring one fingertip near your partner's fingertip.
4. Listen for a snap or watch for a tiny spark. Record what happens.

What to look for: A tiny spark, snap, or tingle - or perhaps nothing!

What happened, and why? Friction transfers electrons, creating a difference in electric charge. If the voltage difference is large enough, charge suddenly travels through air. **The air can briefly become ionized in the spark.** Here's the break down. When the conditions are right, the electric field becomes so intense that it violently rips electrons away from the neutral gas molecules (like nitrogen and oxygen) in the air between your fingers. This is the creation of the ion- stripping an electron from a neutral air molecule turns that molecule into a positively charged gas ion. The newly freed electrons and the positive gas ions form a temporary path of super-conductive, ionized gas called a plasma. This bridge of ions and free electrons allows the built-up static electricity to rapidly discharge. The electrons jump through this ionized air gap in a fraction of a second, creating the tiny blue spark, a "snapping" sound, and the classic shock you both feel. I bet you didn't realize all of THAT when you were a kid.

LAB 3 | Candy Lightning

Supplies: Regular sugar-containing wintergreen Life Savers; very dark room, non-breakable floor, hammer.

Directions

1. Check the candy label: use a sugar-containing wintergreen Life Saver, not sugar-free.
2. Darken the room and allow your eyes to adjust.
3. Watching closely, crush one candy with the hammer.
4. Look for brief bluish flashes; repeat if needed.

What to look for: A faint blue flash may appear as the candy cracks.

What happened, and why? As you apply mechanical force, you rip apart the sugar crystal's orderly structure. Sucrose crystals are asymmetrical. When they snap, the electrons are not divided evenly between the two separating faces. One broken side steals electrons and becomes **negatively charged**, while the other side is left **positively charged**. The built-up static electricity becomes too strong to hold back. Electrons violently launch themselves across the gap from the negative side to the positive side. As these electrons shoot through the space, they slam into normal, neutral air molecules (mostly nitrogen) with incredible speed. The impact is so hard that it **rips electrons right off the air molecules**. When a normal air molecule loses its electrons, it turns into a **positively charged ion**. Like when you touched fingers with someone after charging up your fuzzy socks, for a split second, the air inside the crack turns into a tiny streak of glowing **plasma**—a super-charged soup of those free electrons and newly formed ions. As everything settles back down and the ions grab their electrons back, they release that energy in what's called a photon of light. If you crush normal sugar in a pitch-black room, the blue flash is very hard to see because human eyes can't detect the ultraviolet light. However, if you crush Wintergreen Life Savers, the flash becomes brilliantly visible. This is because wintergreen flavoring contains methyl salicylate. This chemical acts as a phosphor: it absorbs the invisible UV light produced by the nitrogen and re-emits it as a bright, **visible blue-green spark**.

4 | The Color-Changing Chemistry of Ions Due to Strong Acids and Stong Bases

Mission: Investigate how acids, bases, and dissolved ions affect a natural color indicator solution (ph water)

Safety First

- Wear chemical-resistant nitrile gloves throughout the experiment ALONG WITH YOUR GOGGLES.
- Container D holds sodium carbonate (kind of like a laundry soap booster), This is an alkaline powder and its solution can create a chemical burn on skin, blindness in eyes and can irritate or injure skin. Do not touch, taste, or inhale the powder and keep liquid away from eyes, mouths, nose and bare skin.
- Place ALL containers on a rimmed cookie sheet before beginning. A, B, C containers contain Ph indicator solution and this can stain counters, clothing, and other surfaces. Clear dish labeled "vinegar" needs to be filled with white vinegar from your own home.
- Use only the labeled pipette for each solution. Do not mix up the pipettes. Never drink any solution.
- If the solution D gets on skin, rinse promptly with plenty of running water. If it gets in eyes, rinse with running water for 15–20 minutes and contact Poison Control (U.S. 1-800-222-1222) or seek urgent medical guidance.

Your Supplies

- Container A: prepared indicator solution — CONTROL
- Container B: prepared indicator solution — for BASE (sodium carbonate) TEST
- Container C: prepared indication solution— for ACID (vinegar) TEST
- Container D: pre-measured Sodium Carbonate (concentrated laundry booster, Na_2CO_3) powder
- Vinegar container: place in it your own household white vinegar
- Two pipettes: one marked "SODIUM CARBONATE" and one marked "VINEGAR"

- About ¼ cup warm water, a rimmed cookie sheet, splash goggles, nitrile gloves, and paper towels

Directions

1. Put on your gloves and goggles. (Have your mom take a picture because you will want this for your future wedding video- just kidding). Set A, B, C, D, and "Vinegar" containers on the cookie sheet.

2. Open lids to all.

3. Leave container A untouched. It is your control: the original cabbage-water color for comparison.

4. Carefully add about ¼ cup of warm (not hot) water to the sodium carbonate powder in container D. Stir gently with the pipette labeled SODIUM CARBONATE until the powder dissolves (may not completely dissolve)

5. Fill "Vinegar" labeled container with white vinegar from your own home.

6. Use the SODIUM CARBONATE (your base) pipette to draw up the solution from D. Slowly squeeze one full pipette into container B. For fun, you may want to add little droplets at a time. Repeat two more times (two- to three pipettes total). Observe and compare solution B with solution A.

7. Use the separate pipette labeled VINEGAR (your acid) to draw up vinegar from the vinegar container. Slowly squeeze one full pipette into container C. Repeat two more times (two - three pipettes total). Observe and compare C with A.

8. Do not pour B into C. Record your observations, then read "What Is Happening at the Ion Level?" below.

9. To clean up, dump each solution down the sink with running water. Wipe up any spills with soapy water followed by clean water. Rinse equipment and the cookie sheet with soap and water. Wash hands after removing gloves. Bring the cleaned containers to class. Throw out the sodium carbonate pipette. Wash out the vinegar pipette and keep if you would like.

Record Your Observations

Container A (control): _____

Container B (after sodium carbonate): _____

Container C (after vinegar): _____

What In the world happened and what did it have to do with ions?

In this experiment, we added two different substances to our indicator solution : vinegar and sodium carbonate. One made the indicator change toward pink or red, and the

other made it change toward blue or green. To understand this, let's look at what acids (things like vinegar) and bases (things like sodium carbonate) are made of and really do.

First, what is an acid? An acid is a substance that can **donate** hydrogen ions (H^+) to another substance. A hydrogen atom normally has one proton and one electron. If it loses its electron, what remains is a positively charged hydrogen ion (H^+). In chemistry, this is also called a proton (We will learn more about that later). When an acid is mixed with water, it can transfer these protons or hydrogen ions to water molecules. This changes the chemical conditions (or parts) of the solution. Vinegar contains an acid called acetic acid. When vinegar is added to our indicator, it makes the solution more acidic (or in other wards can donate hydrogen ions to the solution).

What is a base? A base is a substance that can **accept** hydrogen ions (H^+) from another substance. Some bases also react with water to produce hydroxide ions (OH^-). Hydrox**ide** ions have a negative electrical charge. In water, hydrox**ide** ions can react with **hydrogen** ions to form water. Sodium carbonate is an example of this. When it dissolves, it separates into positively charged sodium ions (Na^+) and negatively charged carbonate ions (CO_3^{2-}). The carbonate ions react with water, producing hydroxide ions.

So how does this effect color?

Our indicator solution contains natural color molecules called anthocyanin. These molecules can exist in different chemical forms. When the surrounding solution becomes more acidic or more basic, the indicator molecules anthocyanin can gain or lose hydrogen ions (H^+). This changes their chemical structure and the physical structure which effects the way the indicator absorb different wavelengths of visible light. So in one state of the anthocyanin, we see one color, and when it changes state, it also changes what wavelengths it can absorb, the changing its visible light. Add vinegar: The solution becomes more acidic, and the indicator usually shifts toward pink or red. Add sodium carbonate: The solution becomes more basic, and the indicator usually shifts toward blue or green. The exact colors depend on how acidic or basic the solution becomes.

This experiment is truly all about ions. However, those sneaky little things are incredibly small, to small for the eye to see moving around in the liquids, but we could see the result of their chemical interactions! In this experiment, the color change gives us evidence that something about the solution has changed.