LIGHT IN TRANSMISSION

PERCY ECHOLS II, CURATOR
FEBRUARY 5 - MAY 9, 2021

EXPLORING NEON

LESSON PLAN - GRADES 6-12

CARNEGIE SCIENCE CENTER

PITTSBURGH glass CENTER

EXPLORING NEON

At a Glance

TARGET GRADES: 6–12

NEXT GENERATION SCIENCE STANDARDS (NGSS)

nextgenscience.org

MS-PS1-1 Matter and its Interactions
Develop models to describe the atomic composition of simple molecules and extended structures.

MS-PS1-4 Matter and its Interactions
Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

HS-PS1-5 Matter and its Interactions
Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

HS-PS1-8 Matter and its Interactions
Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

HS-PS3-3 Energy
Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

HS-PS1-1 Matter and its Interactions
Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

HS-PS1-4 Matter and its Interactions
Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

LEARNING OBJECTIVES

Students will understand the structure of neon atoms and how it can be used to produce neon lights. Students will also explore other forms of luminescence and understand how materials can glow by different processes.

Funding for this exhibition was provided by The Pittsburgh Foundation and Advancing Black Arts in Pittsburgh, a joint program of The Pittsburgh Foundation and The Heinz Endowments.

Featuring images from Pixabay

PITTSBURGH glass CENTER

CARNEGIE SCIENCE CENTER
ONE OF THE FOUR CARNEGIE MUSEUMS OF PITTSBURGH

ACTIVITIES INCLUDED

01 **Is it Neon?** —Learn what makes a sign glow.

02 **Building Neon** —Construct a neon atom model out of household materials.

03 **Illumination Catalog** —Observe what glows in your own home.

04 **Glow in the Dark** —Use a black light to make materials glow.

05 **Who Doesn't Love a Glowstick?** —Use glowsticks to learn more about luminescence.

06 **Homemade Stained Glass** —Craft your own stained-glass creation.

LESSON PREPARATION

- One of the following activities requires the use of a black light. If you do not have access to a black light, look into purchasing one for this particular activity.
- We will use an iron and freezer for some of our activities. Be sure to ask for permission and assistance from an adult to use these appliances.
- Be sure to follow all instructions carefully to avoid damaging your appliances.

INTRODUCTION TO NEON

If you have ever seen a lit "OPEN" sign outside of a restaurant or store, than you have probably witnessed neon in action. While neon is an odorless and colorless noble gas, under the right conditions, it can also produce incredible reactions.

Throughout this lesson, we will explore what neon is, how it is used, and more about the power of luminescence.

VOCABULARY

- **Neon** —A nonmetallic chemical element that is found in minute amounts in air and is used especially in electric lamps
- **Atom** —The smallest particle of an element
  - **Proton** —An elementary particle that carries a positive charge
  - **Neutron** —An uncharged elementary particle
  - **Electron** —An elementary particle that carries a negative charge
- **Electricity** —A form of energy observable in positive and negative forms that occurs naturally (as in lightning) or is produced (as in a generator) and that is expressed in terms of the movement and interaction of electrons
- **Element** —An atom with a specific number of protons
  - **Ion** —An element which has more or fewer electrons than the number of protons it has (which makes it negatively or positively charged)
  - **Isotope** —An element which has more or fewer neutrons than the number of protons
- **Inert** —Something that is stable and won't break apart or combine with something else; not reactive
- **Luminescence** —The low temperature emission of light
  - **Chemiluminescence** —Luminescence due to chemical reaction
  - **Phosphorescence** —Luminescence that is caused by the absorption of radiations (such as light) and continues for a noticeable time after these radiations have stopped
  - **Bioluminescence** —The emission of light from living organisms (such as fireflies) as the result of internal chemical reactions
- **Model** —Something that is created to look, feel, move, etc., like whatever it is representing. We can use models to help us learn about things that are really big or really small. For example, a globe is a model of the Earth!
- **Neutral atom** —An atom that has the same number of electrons as protons
- **Photons** —A small amount of electromagnetic radiation
- **Reactive** —Something that can or is especially prone to breaking apart or combining with something else or changing; not inert
- **Ultraviolet Light** —Situated beyond the visible spectrum; radiation having a wavelength shorter than wavelengths of visible light and longer than those of X-rays

IS IT NEON?

Activities

OVERVIEW

What makes a neon sign glow the way it does? Let's see if we can recreate a neon sign using other types of materials!

GUIDING QUESTIONS

- How are the signs glowing? How is the glow spread out so evenly?
- What other shapes can you try?
- Does it shine all the way through to the other end? Does it light up throughout the entire shape the way neon signs do?

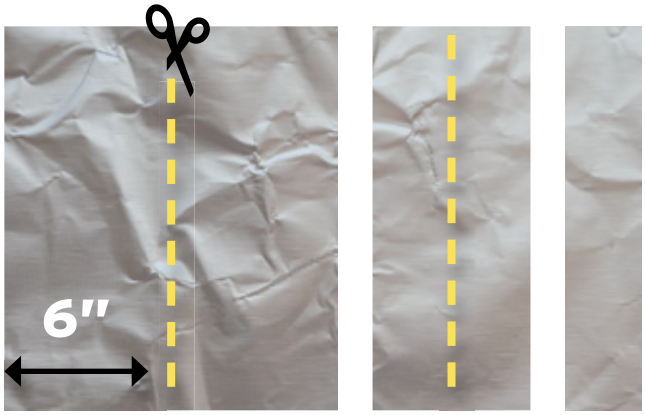
MATERIALS

- Aluminum foil
- Flashlight

PROCEDURE

1) Take a look at these "OPEN" signs. What do you notice? How are they similar? How are they different?

2) Let's try to create our own sign. We'll start by using something that can help us scatter light: aluminum foil! Take a strip of aluminum foil that is the width of its box and about 4–6 inches long.



3) Fold it in half "hotdog style" and then turn it into a trough.

4) Keeping it hollow, carefully bend it into a C-shape.

5) Shine a flashlight into one end.

6) Try to alter your shape to get the maximum brightness!

REFLECTION QUESTIONS

- Where in your shape did the light start to disappear? Why?
- How could we make your shape brighter?
- Are there other shapes you can make that will still shine? Try it!
- What shapes don't work?
- Did it matter how narrow your "trough" is? Why?

BUILDING NEON

OVERVIEW

Our aluminum shapes didn't glow like a real neon sign, but why is that? We used a **flashlight to bounce light throughout our** shape to emulate a neon sign, but a real **neon sign is a glass tube filled with neon gas. Ours was filled with regular air. Let's** take a look at what neon gas actually is!

MATERIALS

- Toothpicks or pipe cleaners
- Soft candies (like gum drops or marshmallows) or cotton balls
- Glue

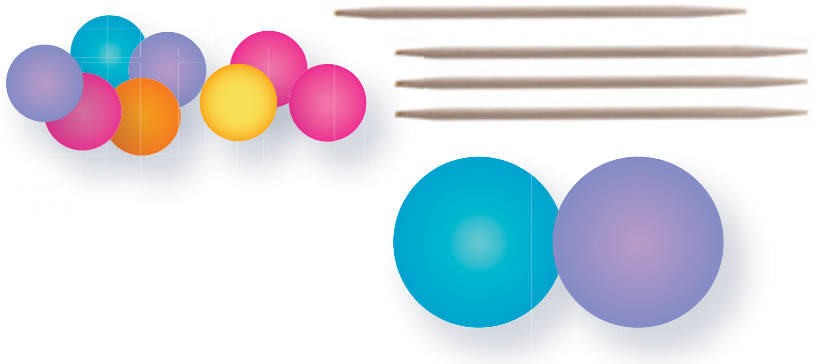
GUIDING QUESTIONS

- How are the signs glowing? How is the glow spread out so evenly?
- What other shapes can you try?
- Does it shine all the way through to the other end? Does it light up throughout the entire shape the way neon signs do?
- For each step during model-building, which element could your model represent?
- What atom is the mystery model atom (pictured)? Does it have enough electrons?
- Some gases glow when their electrons get excited —sometimes by adding an electrical current! Most elements have one electron for each proton. How many electrons would neon have?
- What do you notice about where each glowing gas (helium, neon, and argon) is located on the periodic table? They're all in the last column and called noble gases!

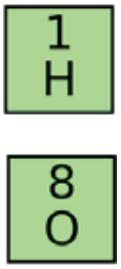
PROCEDURE

1) We're going to build **atoms...** that is, **models** of atoms! Real atoms are way too small for us to see, but millions of them together make up everything around us —the air, your hands, this paper! What makes some atoms different from others? Why **is this paper bendy and kind of rough, but your fingernails are** hard and smooth?

2) Take two candies or cotton balls and glue them together like this:



3) Each ball represents a proton. **Protons** make up atoms! The number of protons tells us what kind of atom we have. The **periodic table** below helps us keep track of how many protons each kind of atom has. This hydrogen (H) has one proton. This oxygen (O) has eight protons.

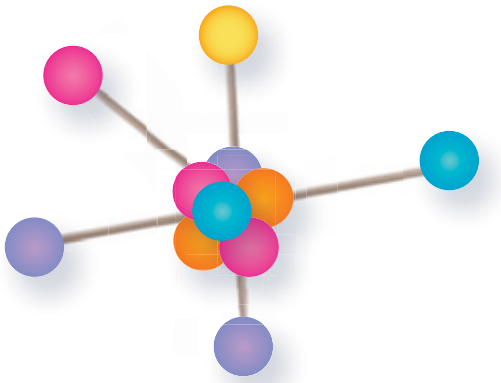


Group →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
↓ Period																		
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra		104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Uut	114 Fl	115 Uup	116 Lv	117 Uus	118 Uuo

It has 2 protons so it must be helium ("He")!

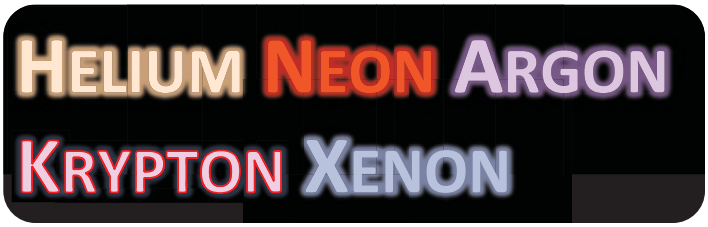
4) Can you find neon (Ne) on the periodic table? How many protons does it have? Try to make a **model** of it!

5) Using your toothpicks or pipe cleaners, add some electrons to your neon atom, like the mystery atom below:



6) Different kinds of atoms can glow different colors. Artists can use gases like helium (He), neon (N), argon (Ar), krypton (Kr), and xenon (Xe) for lighting because they're all very stable **(inert)** elements —they don't like to break apart and **react** (change) with other atoms! How can you turn your neon atom into argon? Argon into krypton? Krypton into xenon?

Try it!



REFLECTION QUESTIONS

- What was the hardest part about making your models? How did you overcome it?
- What did your pieces in the center represent? What did they represent when they were on the outside?
- What are some differences between your model atoms and real-life atoms?

ILLUMINATION CATALOG

OVERVIEW

In this activity, students will become aware of their surroundings and where lighting of different types exists within the space.

We will look at where light is in our surroundings and how that light was created. Light is created by a transformation of energy. The main types are **luminescence, chemiluminescence,** and **electric light.**

GUIDING QUESTIONS

- What makes light in your surroundings?
- How do these objects/materials glow?

MATERIALS

- Paper
- Color pencils
- Color markers
- Your creativity

PROCEDURE

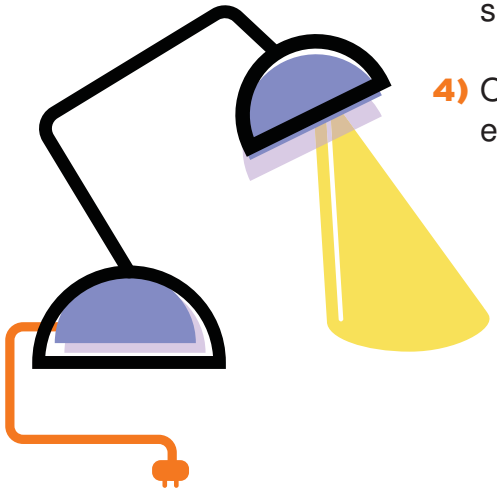
1) **Take five minutes to** walk around your home looking for items that **illuminate light. Create a list of the items you find that produce** light.

2) Once you have compiled a list, take an educated guess on how the light is produced. Which category or type of illumination would apply to each light source you found?

   Electric Light | *Luminescence* | *Chemiluminescence*

3) Create a sketch of one of the examples you found in your surroundings.

4) On this drawing, add detail in separate colors to show the input of energy and the output of light.



REFLECTION QUESTIONS

- **What type of light did you find?**
- How was the light produced?

GLOW IN THE DARK

GUIDING QUESTIONS

- What kind of light does a black light produce?
- What materials will glow under a black light? How does this work?

OVERVIEW

Throughout our lesson, we have learned a lot about how neon works and how it glows. Now we want to compare this process with even more forms of luminescence. How do other materials glow in the dark?

MATERIALS

- Three empty bottles, jars, or drinking glasses (any size will work, can be as small as 8 fl oz)
- Highlighter
- Pliers
- Tonic water
- Tap water
- Black light

PROCEDURE

1) Pull off the back of a highlighter and drop the ink stick into a cup of water. Set aside. You may need to use pliers to pull off the end of the highlighter.

2) **Fill the first bottle with tonic water.**

3) Fill the second bottle with regular tap water.

4) Fill the third bottle with the highlighter water.

5) Position the black light behind the bottles, turn on the black light, and see what happens!

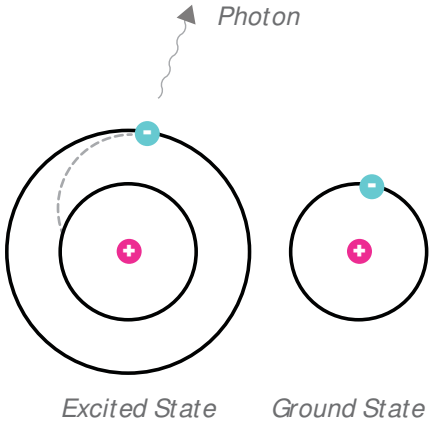
What is going on?

The bottles with the tonic and highlighter water in them will glow when placed near a black light. Both the highlighter dye and the tonic water contain a substance called phosphor.

Phosphors emit light when exposed to radiation like the black light. When the black light shines onto these phosphors, they become "excited" and glow.

Why do these materials glow?

Luminescence is when a material emits light without producing any heat. There are many different ways in which something can produce this light. It can be done in a process of **chemiluminescence,** which is the result of a chemical reaction; by **bioluminescence,** when light is produced by a living organism; or in a process called **phosphorescence,** which we are observing in this experiment.



During phosphorescence, the atoms inside a material gain energy from a light source (in our case, the black light) and become "excited." When these atoms stop being "excited" and return to their normal energy level, they emit a little bit of light (called a **photon**) which makes this material glow.

What is a black light?

A black light produces ultraviolet (UV) light. Ultraviolet light is a type of electromagnetic radiation, which can be found on the spectrum between visible light and x-rays.

This kind of radiation cannot only make things glow, but can also cause summer tans or burns.

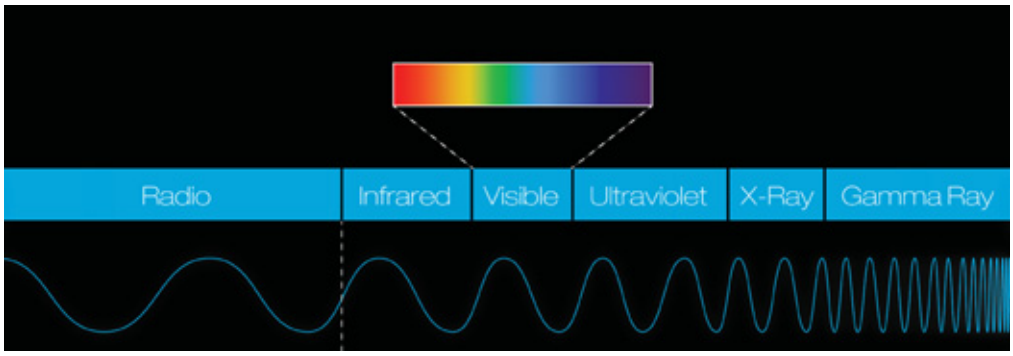


Image courtesy nasa.com

REFLECTION QUESTIONS

- What kind of luminescence causes neon to glow?
- What kind of luminescence causes the bottles in this activity to glow?
- What happens when you turn off the black light? Do any of the bottles keep glowing?
- What else can you find at home that will glow under the black light?

WHO DOESN'T LOVE A GLOWSTICK?

GUIDING QUESTIONS

- Why does a glow stick glow?
- What do you think is inside of a glow stick?

OVERVIEW

Let's continue our exploration of different forms of luminescence and dive deeper into the process of chemiluminescence. To learn more about how this works, let's look closer at a common party item: glow sticks!

MATERIALS

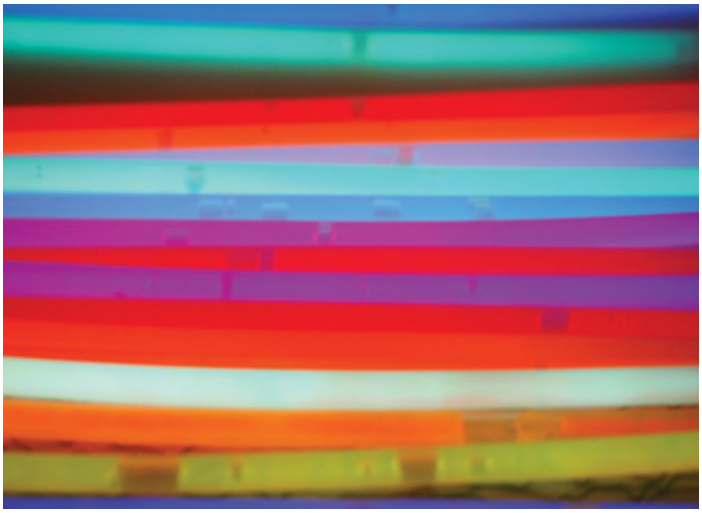
- Glow sticks (at least two, more for extension activity)
- Freezer
- Permanent marker
- Construction paper
- Tape

PROCEDURE

1) Take a close look at an unbroken glow stick and make observations on what you can see inside of the stick.

2) Inside a glow stick, there is a small, yet strong, glass tube containing a chemical called hydrogen peroxide. In the rest of the plastic tube, there is another chemical called phenyl oxalate ester.

3) Bend, shake, and activate the glow stick. Observe what happens. When the glow stick is bent, the smaller glass tube inside breaks, releasing the hydrogen peroxide. The two chemicals will mix, causing a chemical reaction. A result of this reaction is the process of chemiluminescence and the production of light.



4) Break and activate a second glow stick. Using a permanent marker, mark the two glow sticks with the date and time.

5) Put one glow stick into the freezer and leave the other outside.

6) Check back every hour and observe what happens to the two different glow sticks. Depending on the chemicals used, the glowing reaction may last only a few minutes or a few hours. However, adding or taking away energy can change the duration of the reaction. If you heat up the glow stick, it will intensify the glow, but it will not last as long. If you can cool the stick down, it will dim the reaction, but it will last longer.

Myth Busted:

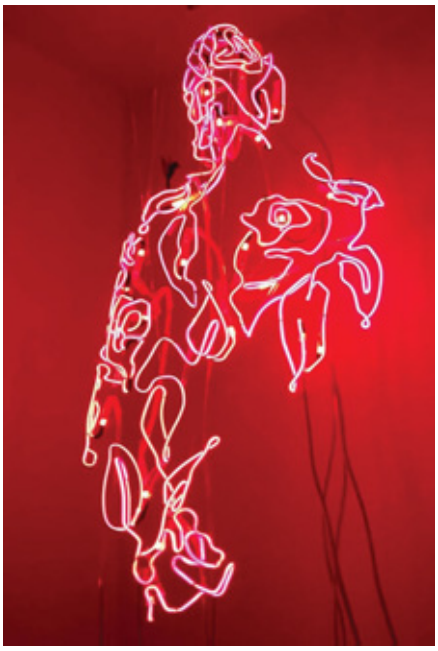
Putting the glow stick into the freezer will not stop the reaction or "recharge" the glow stick, but it will drag out the process.

EXTENSION ACTIVITY

- Use several glow sticks to create your own neon sign.
- Using tape, attach activated glow sticks to construction paper and to each other.
- Below you will see some examples of neon art in the LIT Exhibit. Use these as inspiration to create your own glowing art!

By: Danielle James

By: Michael Flechtner



By: Leticia Maldonado

REFLECTION QUESTIONS

- How does a glow stick glow?
- What other materials glow by the process of chemiluminescence?

HOMEMADE STAINED GLASS

GUIDING QUESTIONS

- What is stained glass?
- How can we use light to make our project glow?

OVERVIEW

Throughout our lesson, we explored many different ways to make something glow. To wrap up, we are going to create something that will allow you to continue observing the ways that light and color interact with each other. Let's create a simulated stained-glass window!

MATERIALS

- Crayons
- Cheese grater or pencil sharpener (both can be cleaned after use)
- Wax paper
- Permanent markers (various colors)
- Iron

PROCEDURE

1) Use the cheese grater or pencil sharpener to grind up the crayons, keeping colors separate.

2) Cut a piece of wax paper about 12 inches long.

3) (Optional) Use the permanent markers to draw a picture on the wax paper to follow with your crayon shavings.

4) Spread the grated shavings to make your picture on the wax paper. This can be done one color at a time in multiple ironings or all at once.

5) Cut a second piece of wax paper that's the same length as **the first, and lay it on top of the crayon shavings.**

6) Use the iron on low heat and no steam to press the two sheets together, melting the crayons. Take extra caution when using an iron.

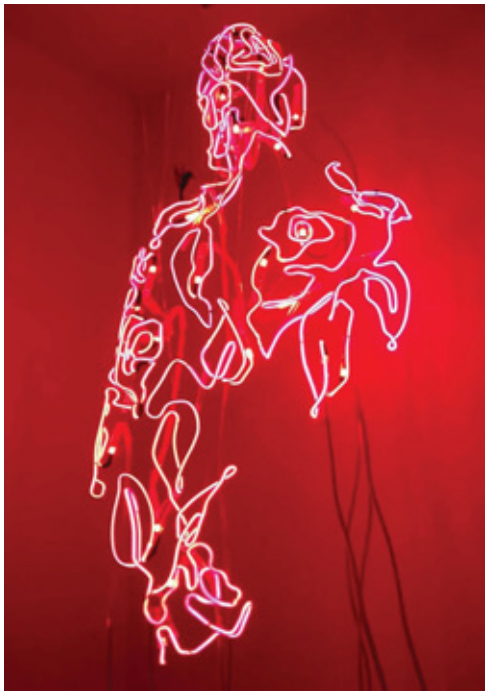
7) Start to peel the top layer of wax paper. If the crayons are not melted well, replace the top layer of wax paper and iron again.

8) Once the crayons are fully melted, peel off the wax paper and hang your art in a window or in front of a light and enjoy your brilliant colors.

REFLECTION QUESTIONS

- What would make your "glass" brighter?
- Can we use any of the processes of luminescence to enhance our project?

Artist Connections



LETICIA MALDONADO

Leticia Maldonado is a multi-media sculptor with a focus on working in luminous glass. Enamored at a young age with the violent **elegance of plants and flowers taking their shape from the journey** of survival, and juxtaposing that energy with a deep love for books and the symbols of personal power available within, Leticia has cultivated a visual vocabulary that endeavors to use object making in service of poetic disruption.

The work of her life is to encourage a connection with self through use of imagination and creative destruction. She believes that connection to self is the path to fostering valuable states of character such as integrity, compassion, and independence.

Pursuing first an education in figurative illustration and sequential storytelling, Leticia spent time at The Art Institute of LV, and later studied at the Los Angeles Academy of Figurative Art. Growing up and spending her formative years in the desert outskirts of Las Vegas, Nevada, it was an easy step to associate the neon lights of the city with the concepts of escape and autonomy. Moving into this medium, Leticia eventually found her way to Lili Lakich's neon design and fabrication classes, and later studied glass bending and processing with the artist Michael Flechtner. Using illuminated glass sculpture as a primary medium since 2013, Leticia chooses to focus on working with the smallest diameter glass available in order to achieve as much detail as possible in her expression.

Art has always served the purpose of connection in her life, both to herself through process and to strangers through exhibitions. Landmarks would include being curated into the "She Bends" collective, a traveling exhibition of all female-identifying benders working in neon, and "Construyendo Puentes," a show of Chicano artists from Los Angeles, which traveled throughout Mexico. In "She Bends," curated by Meryl Pataky, Leticia had the chance to connect with an entire community of neon sculptors espousing the tenant of community over competition. In "Construyendo Puentes," curated by Julian Bermudez, the experience was a chance to connect more strongly to the in-between place of existing equally in two cultures and having to carve out and own a blended identity.

Though preferring to focus on personal projects, Leticia can count among her clients: Life is Beautiful festival, The Standard Hotel, Viceland, and Apple Music. Leticia Maldonado lives and works in Los Angeles, California.

Lesson Recap and Content Review

- **Neon** is a chemical element that, when charged by electricity, becomes an ionized gas that will produce light.

  Ionization can happen when there are too many/too few electrons anchored around its atom.

  Different elements have different structures and different numbers of protons.

- A neon tube contains a mixture of neon and other chemicals that will produce a variety of colors when energized with electricity.

  Different materials (like noble gases) glow in different colors, depending on what they're made from.

- There are many different processes that can cause materials to glow, including: *Chemiluminescence* | *Phosphorescence* | *Bioluminescence*