Name: _____ **Date:** _____

MARVLS: Plasma:The Fourth State of Matter

Learning Objective	I can predict and describe the state of a substance when thermal energy is added or removed.

What's the matter?

Define the following:

matter:

atom:

All matter is made up of atoms.

Materials

- Pencil
- Smartphone
- Merge Cube
- MARVLS: Plasma App
  to install: Scan QR Code below
  And follow prompts to install.

App Store
MARVLS: Plasma Physics

Google Play Store
MARVLS: Plasma Physics

Phases of Matter

Give an additional example related to each phase of matter:

What is the fourth phase?

phase	example	my example
solid	metal	
liquid	apple juice	
gas	oxygen	

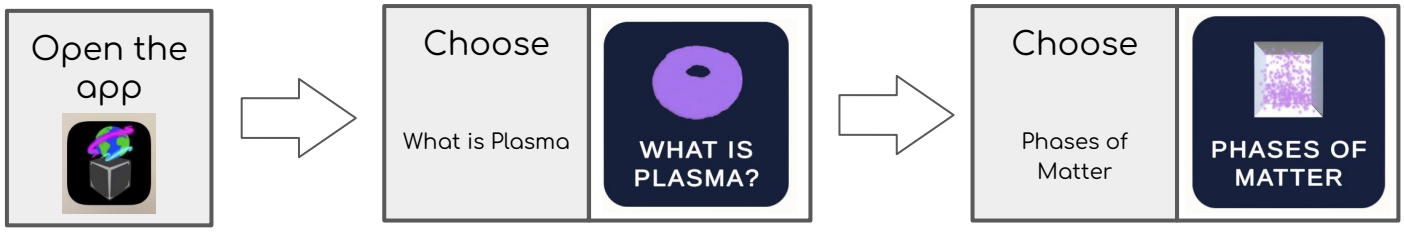
When have we seen changes in phase of matter?

Think of a time when you have seen a change in a phase of matter?
For example: Solid to liquid or liquid to gas

What was added or taken away from the matter to initiate the change?

Time to View in 3D AR! (...that's three dimensional augmented reality!!)

MARVLS Navigation



1. **Click** the view in AR button on the bottom right of the screen.

2. **Point** your phone's camera toward the Merge Cube.
   Change the cube's orientation until the three dimensional model appears.

3. **Drag the slider from the snowflake to the fire icon. What happens at each slider position?**

Let's create our own visualizations!

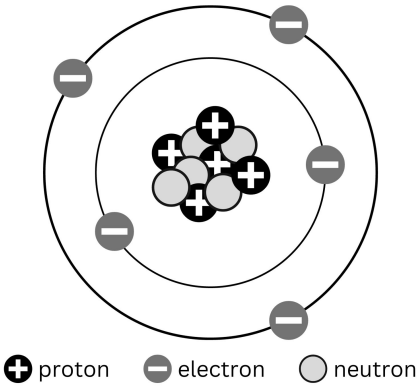
Sketch the representation of the four phases of matter.
Use a dot to represent an atom in your sketches.

Solid	Liquid	Gas	Plasma

Notice: What do you notice about the speed of the atoms in each phase?

Pause: Let's dive into what is really happening when we add heat to matter.

Since all matter is made up of atoms, let's take a look at the atom.



Parts of an Atom

proton: a positively charged subatomic particle, located at the center of an atom.

electron: a negatively charged subatomic particle, orbits the nucleus extremely fast

neutron: a subatomic particle with no charge, located at the center of an atom.

Calculating Charge

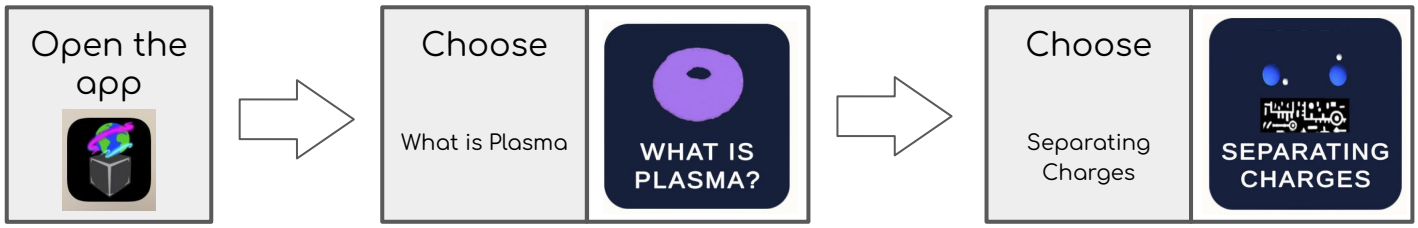
To determine the net charge of an atom you add the total number of protons and subtract the number of electrons. **Remember, neutrons have no charge!

Determine the net charge of each atom:

3 protons 3 neutrons 2 electrons Net Charge = _____	3 protons 3 neutrons 3 electrons Net Charge = _____	3 protons 3 neutrons 4 electrons Net Charge = _____

Separating Charges

MARVLS Navigation



1. **Click** the view in AR button on the bottom right of the screen.

2. **Point** your phone's camera toward the Merge Cube.
   Change the cube's orientation until the three dimensional model appears.

3. Click fire button. What happens?

4. Click snowflake button. What happens?

An atom with a net charge is called an **ion**. The process by which ions are formed by gain or loss of an electron from an atom is called ionization.

Electric Fields

MARVLS Navigation

1. **Click** the view in AR button on the bottom right of the screen.

2. **Point** your phone's camera toward the Merge Cube.
   Change the cube's orientation until the three dimensional model appears.

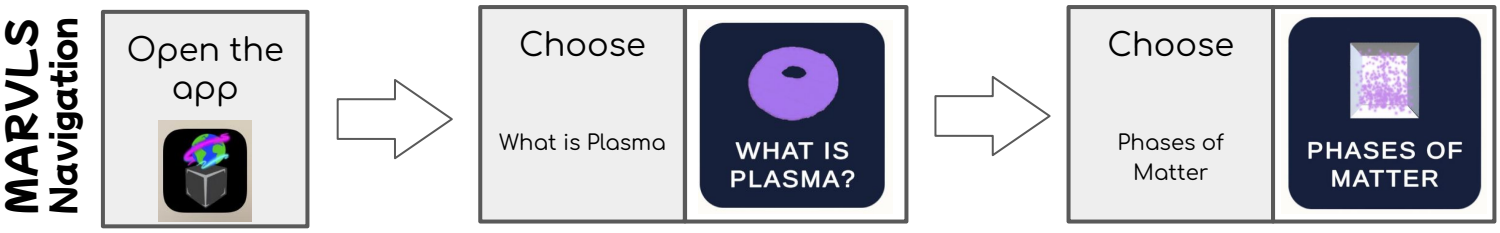
3. Click the **ion** button to view the electric field for an ion.
   Try viewing the visualization from different angles and orientations.
   Try to draw the electric field of an ion. How would you describe it?

4. Click the electron button to view the electric field for an electron.
   Try viewing the visualization from different angles and orientations.
   Try to draw the electric field of an electron. How would you describe it?

Notice: What are some similarities and differences between ions and electrons?

What do you notice about the arrows in each model?

Let's go back to view our phases of matter



1. **Click** the view in AR button on the bottom right of the screen.

2. **Point** your phone's camera toward the Merge Cube.
   Change the cube's orientation until the three dimensional model appears.

3. Add heat until you reach the plasma phase. Click the E field button, what do you notice?

Final Thoughts

1. What do you think the change in the speed of the atoms represents?

2. What makes plasma different from the other three phases?