Assessment

Finish the demonstration by asking questions that assesses whether participants can do the following:

- Name four of the states of matter
- Describe characteristics of matter in each state
- Describe that energy transforms matter from one state to another
- Describe that NASA's IBEX mission explores plasma's effect on the Solar System

floor and their arms linked. Make the observation that they cannot do it because their bonds are so tight. They keep the same shape and take up the same amount of space.

10. Tell participants that they represent matter that is solid. Therefore, a solid always has the same shape and takes up the same amount of space. For instance, if you try to put an ice cube in a glass, the ice cube won't change its shape or get bigger to fill up the glass – it just stays the same shape and takes up the same amount of space. Point out to participants that they still have a neutral charge. Nothing happened to their positive proton and negative electron.
11. Explain that you are going to add more energy to the atoms. One way to add energy is to heat something up. This energy makes the atoms vibrate faster, which loosens their bonds. Act out adding energy to the atoms by pantomiming lighting a fire at their feet.
12. Ask the human atoms to unlink their arms and to hold hands as a result of the energy loosening their bonds. Remind them to keep holding hands while they move around, and to stop when you say, "Stop". Have the human atoms move around, holding hands, for about 5-7 seconds after you say, "Go". Ask them to stop.
13. Ask participants how difficult it was to move now that their chemical bonds were loosened by the heat energy. Could they change their shape to make a circle now that their bonds are looser? (Yes) Did the total amount of space they took up change each time they moved? (No, the amount of space it took up stayed the same).
14. Tell participants that they represented a liquid. By adding energy, the ice cube melted and was able to take the shape of a circular container. Therefore, a liquid does not always keep the same shape, but it does always takes up the same amount of space.
15. Ask participants to line up horizontally again while holding hands. Tell the participants that you are adding even more energy to the atoms. This causes their bonds to break. Explain that when you say go, the human atoms are to drop hands and move freely, but carefully, around the room. They must stop in their place when you say, "Stop". Act out adding heat energy. The energy causes the liquid to boil.
16. Say, "Go," and allow the human atoms to move about the room for 5-7 seconds or so before saying, "Stop". Make the observation that it seemed very easy for them to move now that their bonds were broken by the energy. They were able to move around the whole room, taking up more space than the liquid and the solid. Tell the participants that they were demonstrating the properties of gas. Gas does not stay the same size, and it does not always take up the same amount of space.
17. Now, ask participants to demonstrate this by imagining that the gas atoms are being squeezed together and must move to fit in a circular container. Can they fill it? (Yes) Observe that the atoms take up less space than when they moved around the room, which means that a gas does not always take up the same amount of space. Explain that a gas does not keep the same shape, either. Point out that the gas still has both its positive proton and negative electron, so it is still neutral.
18. Ask participants to line up horizontally again. Explain that you are going to add even more energy to the human atoms. This added energy causes them to lose their negatively charged electrons. When you say, "Go," they will take off their negative badges, which represent their electrons, and place them on the floor. They will continue to carefully move around the room until you say, "Stop".
19. When the participants stop moving, ask them to look around the room. What do they observe? (Electrons on the floor and human atoms – now ions because they have lost their charge - wearing protons spread throughout the room). What happened to the atoms? (They lost an electron) What is their charge? (They are now positive) Explain that when gas atoms lose an electron and become positive, they become a state of matter called plasma. Ask, "Is there the same number of electron badges as there are proton badges?" (Yes) The loose electrons and ions make up the plasma in equal numbers. Point out that in a real plasma, the electrons move around, too (although we can't make our badges move around). Therefore, plasma is a hot gas that is charged.
20. Explain that plasma is a very common state of matter in the Universe. In fact, plasma from the Sun helps form a protective boundary around our Solar System. A NASA mission called IBEX, the Interstellar Boundary Explorer, will make a map of the Solar System's boundary. This will help us learn more about it.
21. Thank the human atoms for their help before asking them to hand in their badges.

Related Websites

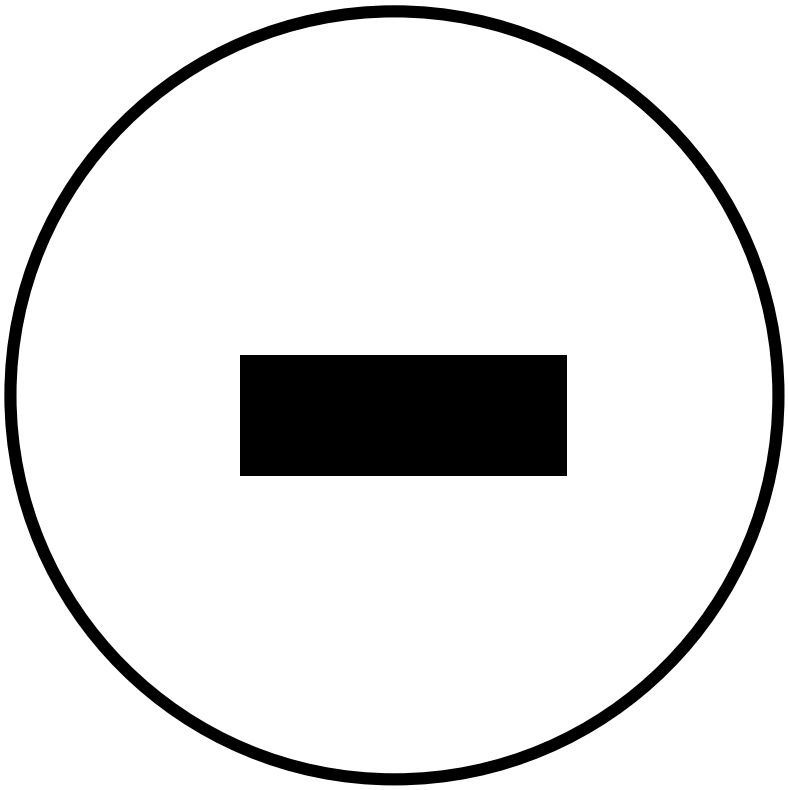
NASA's IBEX mission page discusses plasma for a general audience.
http://www.ibex.swri.edu

IBEX's "Museums and Planetaria" page includes more activities to use in the museum.
http://ibex.swri.edu/planetaria/index.shtml

The Coalition for Plasma Science has educational publications about plasma.
http://www.plasmacoalition.org/edmaterials.htm

Templates

Electron Badge



Proton Badge