

SUGGESTED REFERENCES

- *The Coalition for Plasma Science Teacher's Guide*
http://www.plasmacoalition.org/edu.htm
- *Fusion Energy Educational Web Site*
http://fusedweb.pppl.gov/
- *Guide to the Nuclear Science Wallchart*
http://www.lbl.gov/abc/wallchart/guide.html
- Michael Parfit
"Future Power, where will the world get its next energy fix?"
National Geographic, August 2005
- Francis F. Chen
Introduction to Plasma Physics and Controlled Fusion
- Alexander A. Fridman and Lawrence A. Kennedy
Plasma Physics and Engineering

NATIONAL SCIENCE EDUCATION STANDARDS

Grades 5 - 8

Physical Science
Transfer of Energy

Science and Technology

Understandings about Science and Technology

Grades 9 - 12

Physical Science
Interactions of Energy and Matter
The Structure of Atoms

Science and Technology

Abilities of Technological Design

*Source: *National Science Education Standards, 1996, National Academy Press*

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VOLUME 37 ISSUE 5

PLASMA: AN UNLIMITED ENERGY SOURCE



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and
Technology



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for Excellence in
Mathematics
and
Science Teaching



Junior Engineering
Technical Society
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SYNOPSIS

This program explores the properties of plasmas. Plasma is the most common form of matter in the universe, though very little is found on Earth. Scientists are creating plasmas to make new materials with fantastic properties that will make everyday tasks easier.

Students will learn how different kinds of plasma are created. They will see scientists experimenting with different methods to create diamonds out of methane gas. Students will also see the future of electric power generation as they learn about nuclear fusion generators.

CURRICULUM UNITS

- PHYSICAL SCIENCE
- PHYSICS
- PHYSICS IN THE WORKPLACE

RUNNING TIME

15:00

BACKGROUND

Plasmas compose approximately 99% of the mass of the universe. Considered a 4th state of matter, they are produced when atoms in a gas are heated and pressurized so that some electrons escape from the nuclei. This produces an ionized gas that has many unique properties. Some examples of plasma include lightning, a candle flame and “plasma balls.”

Today, scientists and engineers are taking advantage of the properties of plasmas. The most common use is in an arc welder. The welder can be used to cut metal or join two pieces together. Some plasmas are so hot that they can be used underwater.

Plasmas can be precisely controlled. A laser guided plasma flame is used to cut very intricate shapes into metal, leaving smooth edges. The size of the flame can be controlled down to the millimeter. The hot plasma flame can also be used to melt one material onto another. In this program, aluminum oxide is melted by a hot plasma and then applied to another material that makes it scratch proof.

Cold plasma is different from hot plasma in that fewer electrons are separated from their nuclei, so the resulting plasma is much cooler than the hot plasma. Cold plasmas are formed when a gas is subjected to very low pressures and heated with microwave radiation. In a vacuum, the free electrons are moving at a very high speed, but the rest of the plasma is at about 40 to 50 degrees celsius.

Cold plasmas can be used to sterilize medical instruments. They can also be used to coat the surface of one material with another. In this program, solar cells are coated with quartz. The quartz protects the cell from damage and is extremely light compared to the glass that is normally used for this function.

The most important benefit of plasma research will be the construction of power plants that use fusion energy to generate electricity. Our current nuclear reactors use the heat released from radioactive elements, such as uranium, to heat the water that generates our electricity. The material is expensive and yields other radioactive material that is difficult to dispose of, but the process is fairly simple. These power plants rely on nuclear fission, or the splitting of atoms.

Nuclear fusion occurs in stars. Most stars, when they are formed, are composed primarily of hydrogen. The pressure in the center of the star is extremely high. Confining a large number of atoms in a very small space increases the average kinetic energy of the atoms. Atoms in a gas are stripped of their electrons and the gas turns into a plasma. Hydrogen protons moving at very high speeds and under great pressure will collide with each other instead of repelling. Through a series of collisions, hydrogen protons can be combined to form helium atoms. Because smaller atoms combine to form larger atoms, this complicated process is called fusion.

Nuclear fusion also releases a great deal of heat and other forms of radiation. But it is different from nuclear fission in several ways. The raw materials are plentiful and their extraction will not harm the environment. The process in stars is self-sustaining; the release of heat from one fusion reaction makes other fusion reactions more likely to occur, so the fusion reaction can continue indefinitely. Finally, there are no toxic waste products produced.

Creating a fusion reaction on Earth has been very difficult. This program demonstrates the process involved and how this effort requires international cooperation.

CRITICAL THINKING EXERCISES

1. EXPLAIN how an arc welder can be used underwater.
2. COMPARE hot and cold plasmas.
3. DESCRIBE three different uses for plasmas in creating new materials.
4. COMPARE the advantages and disadvantages of creating an indestructible material.
5. EXPLAIN why nuclear fusion reactions are much safer than nuclear fission reactions.
6. COMPARE fusion and fission reactions.

ADVANCED ORGANIZERS

Prior to showing this program, students should have some understanding of the following benchmarks for Science Literacy, Oxford University Press which are excerpted and, in some cases, abbreviated below. Refer to the Benchmarks for more information.

Benchmark 4: The Physical Setting Section D – The Structure of Matter

Know by Grade 8

- All matter is made up of atoms, which are far too small to see directly through a microscope. The atoms of any element are alike but are different from atoms of other elements.

Know by Grade 12

- Atoms are made of a positive nucleus surrounded by negative electrons. An atom's electron configuration, particularly the outermost electrons, determines how the atom can interact with other atoms.
- The nucleus, a tiny fraction of the volume of an atom, is composed of protons and neutrons, each almost two thousand times heavier than an electron. The number of positive protons in the nucleus determines what an atom's electron configuration can be and so defines the element. In a neutral atom, the number of electrons equals the number of protons.
- Scientists continue to investigate atoms and have discovered even smaller constituents of which neutrons and protons are made.

Section E – Energy Transformations

Know by Grade 8

- Most of what goes on in the universe - from exploding stars and biological growth to the operation of machines and the motion of people-involves some form of energy being transformed into another.
- Energy appears in different forms. Heat energy is in the disorderly motion of molecules; chemical energy is in the arrangement of atoms; mechanical energy is in moving bodies or in elastically distorted shapes; gravitational energy is in the separation of mutually attracting masses.

Know by Grade 12

- Different energy levels are associated with different configurations of atoms and molecules. Some changes of configuration require an input of energy whereas others release energy.
- Energy is released whenever the nuclei of very heavy atoms, such as uranium or plutonium, split into middleweight atoms, or when very light nuclei, such as those of hydrogen and helium, combine into heavier ones. The energy released in each nuclear reaction is greater than the energy given off in each chemical reaction.

**Benchmarks can be found at www.project2061.org/tools/bencho/bolintro.htm*

VOCABULARY

Cold plasma	Laser	Precipitate
Corrosion	Lightning	Reactor
Diamonds	Magnetic field	Solar Cells
Ellipse	Microwave	Spectrometer
Hydrogen	Nuclear fusion	
ITER	Plasma	

CAREER POSSIBILITIES

- CHEMICAL ENGINEER
- MATERIALS ENGINEER
- NUCLEAR ENGINEER
- PHYSICIST