Atomic Structure & Nuclear Fusion

Approximately 2 Weeks

Authors

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SUBJECT/GRADE LEVEL

Subject Area(s) Science
Grade Level(s) Middle & High School

Unit: Atoms and Nuclear Fusion

Time duration: approximately 2 weeks

Document Hyperlinks:

Station Labs

Choice Board Elaboration

Rubric

Unit Test - Atoms and Nuclear Fusion in Stars

Materials

- Computers for each student
- Exploration Station Lab Sheets & Materials

Every station:

Computer Open to Video & Lab Sheets

- Make It:
  - Red gumdrops (4 per group)
  - Green gumdrops (4 per group)
  - Blue/Purple/White Gumdrops (3 per group)
  - Wooden Toothpicks (4-5 per group)
  - Wooden Skewers (3 per group)
  - Sticker Dots (10 per group)
- Explore It:
  - Mini Marshmallows
  - Uncooked pasta
  - Periodic Table of Elements

- Hands-on supplies to construct atoms and to label subatomic particles or handout copies to label-
  -https://www.homesciencetools.com/product/atoms-isotopes-and-ions-kit/ (5 kits) or
  -3 different colored dot stickers or hole punch- out pieces, construction paper and markers or
  - poster paper and markers
- Handout, textbook or websites with vocabulary for subatomic particles, atom, electron cloud/orbits/levels, and nuclear fusion
  https://docs.google.com/document/d/19rnvRvNbNThVVyjmfBI-lOVwg5zS7BTThhP9mVJ8ljo/edit
- Handouts/link to "Fusion in Stars " video and worksheet (see references list)
- PhET link "Build an atom" (see references list)
- Uncovering Student Ideas in Physical Science Vol.3 "What do you know about atoms and molecules/" p. 29 "Describing Energy" p. 177 amd "Matter and Energy" p. 183
- Choice Board Handout (1 per student)
  - Computers, hands-on materials, paper, pencil, etc

STANDARDS

Next Generation Science Standards

- **MS-PS1-1:** Develop models to describe the atomic composition of simple molecules and extended structures.
- **HS-PS1-1:** 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-PS1-8:** 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-ESS1-1**: Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.

LESSON OBJECTIVE(S)

Students connect the structure of an atom, how protons identify an element, and the nuclear fusion process/reaction to create an infographic on how changes in the nuclei of distant stars produce visible light and release energy.

CAREER CONNECTION(S)

Mentor Background: Dr. James J. Carroll, Physicist & Team Lead

Dr. Carroll leads ARL's Nuclide Power Team, which investigates ways of tapping into nuclear energy without the use of fission reactors. They perform mostly basic (publishable) research in experimental nuclear physics and radiation detection, and have a wide array of instrumentation and extensive expertise (the Team members have published hundreds of peer-reviewed articles, including in Nature). They are also interested in outreach to the next generation of scientists and engineers, and to those who educate them. Dr. Carroll joined ARL in 2011 after being a physics professor for 15 years, where he taught physics courses and also led a group of undergraduate researchers from various departments who were learning physics by doing physics.

STEM Careers: Physicists, Communications and Electrical, Energy Research, Mechanical and chemical engineering jobs with Oak Ridge National Laboratory, Nuclear Fuel Chemist, teachers, professors

ENGAGEMENT

Duration: Approximately 90-120 minutes
Brief Description: Introducing concepts for atomic structure/nuclear fusion & busting misconceptions about nuclear energy.

Procedures:
Day 1: Atoms:
Video Link: Voyage into the World of Atoms
Play the video. Have student groups think, pair, and share their thoughts on what we will be studying based on the video before discussing it as a class.

Individually, students will complete "What do you know about atoms and molecules/" p. 29 from Uncovering Student Ideas in Physical Science Vol.3. Student groups will then discuss in groups and make changes (not erasing, but making corrections with a blue pen to indicate their thoughts changed based on others' bright ideas). We will then discuss the probe as a class.

This probe will be revisited at the end of the unit where students will complete it once again and note changes in their thinking based on the unit.

Day 2: Nuclear Fusion:
Pass out a post it to each student as they enter the room. Tell them to write the first word that comes to mind when they see the word on the board. Have someone collect the post its and enter the words into **https://www.freewordcloudgenerator.com/generatewordcloud**

Display the word cloud on the board for the class.

Display the following cartoon on the board. https://i.redd.it/q0cgfry4jqy71.jpg

Have students write on a note card how this could be true or false backing up their answer with at least one reason. Divide students into the front and back of the class based on who agrees and disagrees with the cartoon.

Allow groups 5 min to discuss why they believe what they believe and come up with a list of reasons for their stance. Each group should choose one person to be their spokesperson. With two chairs up front, the two spokespeople will each take turns explaining what they think and why.

After each have spoken, display the following image:
https://tr.toonpool.com/user/558/files/solar_energy_3049995.jpg
Have students guess what this could mean. Once discussion dies down, explain to students that the remainder of the unit will actually show how nuclear energy in stars provides light and heat necessary for light and (from our sun) for life.
Thermonuclear Fusion: Songs about Energy Play the video.
Exit Ticket: students explain on an exit ticket how this supports Kowalski's claim.

EXPLORATION Station Labs

Duration: Approximately 120-150 min
Brief Description: Students will work through several stations that introduce concepts relevant to parts of an atom and nuclear fusion in stars.

Procedures:
Station labs will consist of several stations where students will work in pairs to explore concepts and ideas about the composition of atoms and that light coming from the stars is the result of changes to the nucleus of the atom through nuclear fusion.

Station lab ideas:

Station Lab Google Slides:

These slides can be sent to students so that they fill out the Station Lab Sheet on their device in Google Slides and work independently with all videos and materials on their device, or the slides can be printed so that each station is set up at a different table with a device pulled up to the corresponding task. In the second method, teachers can print the Station Lab Sheet for students to write on or send a copy of the slides to each student for them to type their answers on the Station Lab Sheets.

Explore it: Nuclear Fusion in Stars:

Students follow along with Nasa Video to create a model of nuclear fusion in stars then use the CER method to explain the process.

Read It: "The Nuclear Regulatory Commission's Science 101: What is an Atom?"

Students read the article and fill in the cloze notes on the Station Lab Sheet that go with that article.

Read It 2: "About Nuclear Fusion in Stars"

Students read the article and fill in the cloze notes on the Station Lab Sheet that go with that article.

Watch It: "What is an atom?"

Students watch the video and summarize the information on the Station Lab Sheet.

Make It: Gumdrop Atoms

Students follow along with video to create a model of an atom then illustrate and label that model on the Station Lab Sheet.

Listen to It: Stars Song Parts of an Atom Song

Students will listen to two songs about the two standards covered in the Station Labs and create a multiple choice question to go with each that helps check that those answering the question understand the standards.

EXPLANATION

Duration: Approximately 150 minutes

Brief Description: Students will draw diagrams and give descriptions of what they know about atoms, subatomic particles, how to identify elements based on the subatomic particles, and the nuclear fusion process in stars before and after explaining and exploring parts of this plan. Initial thought processes and misconceptions will be addressed before and after lessons through videos, discussions, group work, research, hands-on activities and handouts.

Procedures:

At this point students should have background knowledge of subatomic particles, atomic number/proton number, atomic mass, balancing equations in chemical reactions where elements break bonds and rearrange to form different substances. Students have discussed how energy produces light and heat. Students have learned about the life of stars and their colors as well as how light travels from the stars to earth in waves.

- Using "Uncovering Student Ideas in Physical Science Vol.3 ", have students read through the probes and decide which answers are the best explanations for the scenario and be able to give justification for their choices. (this will help see what they have learned/what they are thinking, 20 min)

  "Describing Energy" p. 177

  "Matter and Energy" p. 183

- Teacher recaps vocabulary words, calls on volunteers to describe/explain each (5-10 minutes)
- Explain how proton numbers identifies elements, have students to draw and explain parts of the atom (10 minutes)
- Teacher explains how this information relates to elements in stars and how energy is used to produce light and colors. (10-15 minutes) (star child link below can help with this also)
- Teacher can show the 4 video clips , "Fusion in Stars"

  https://www.nagwa.com/en/lessons/395132863736/, stop along and discuss/explain/ask questions about content. The worksheets that link with the videos can be printed out and given to students to do and be checked for understanding through discussions or taking up the papers. (30 minutes)

- Show, read through , explain the link below to bring all the terms and concepts go together https://starchild.gsfc.nasa.gov/docs/StarChild/questions/question13.html (20-30 mins)

  This link is in vocabulary list link to google doc if would rather use there

- Finally explain and combine what you have taught/they should have learned up to this point such as what identifies an element and how when fusion happens elements come together to create heavier elements as the star gets bigger. Color of elements/gasses that are present in the star give off certain colors and amounts of energy/light as the fusion process is happening. (20 minutes)

ELABORATION

Duration: Approximately 120-150 minutes (Some can be done as independent work outside of class.)
Brief Description: Students are verbally and interactively demonstrating what they have learned from the lesson and information. Teacher is actively monitoring students to help guide and clear up any misunderstandings.

Procedures:
Both of the following "Whole Class" options can be used in lieu of a choice board for students.

PhET simulation Whole Class Option to review "What is an Atom?"
(This is offered again on the student choice board below.)

- Give students time to work on the website, **"Build an Atom" PhET simulation.**

  The teacher will walk around to check on student progress with the information. (20 minutes)

- Teacher lists atomic numbers/proton numbers on board and gives students time to identify the element. (5-10 minutes)

- Teacher can list different elements in a star, based on those elements, have students choose from options what element can be produced with nuclear fusion, have students describe a small, medium or large star, tell how much energy is being released such as light elements= more energy, heavier elements= less energy. (20 minutes)
- Put students in small groups and have them explain in their own words the subatomic particles, nuclear fusion, how it all works together to use energy. Teacher is walking around listening, commenting if needed/redirecting thoughts if needed/clearing up any misconceptions. (15-20 minutes)

Helios Game Whole Class Option to review "Nuclear Fusion in Stars"

(This is offered again on the student choice board below.)

- Give students time to interact with the tutorial for the game, **"Helios"** before playing the game.
    - The teacher will walk around to check on student progress with the information. (20 minutes)
    - Put students in small groups and have them explain in their own words the process of nuclear fusion & how this process is what causes us to see lights from distant stars. Teacher is walking around listening, commenting if needed/redirecting thoughts if needed/clearing up any misconceptions. (15-20 minutes)

Choice Board Elaboration:

At the conclusion of the unit, students will be given this choice board. They will need to choose one of two options to "Build an Atom" with their choice board.

Choose either Option 1 for regular assignment credit or Option 2 for regular credit + extra credit.
Option 1: Create a H atom by choosing 1 Proton & 1 Electron project from the boards below.
Option 2: Create a He atom by choosing 2 Protons, 1-2 Neutrons, & 2 Electrons from the choice board.

EVALUATION

Brief Description:

Infographic Poster &/or Unit Test

Procedures:

Poster:
Using Canva or Piktochart create an Infographic to explain what an atom is made of, its design, and why atoms are important and to explain Nuclear Fusion in Stars: the process & products.

Rubric

Unit Test - Atoms and Nuclear Fusion in Stars

https://docs.google.com/forms/d/1HsgI_x6hahgZYblvbqn2ZyUnCbmxvNdbDEMR87ksx4g/edit

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REFERENCES

- "Helios": A Game about How the Sun Makes Energy https://spaceplace.nasa.gov/helios-game/en/ July 18, 2022.
- "Nuclear Fusion in Stars" Activity, Night Sky Network https://nightsky.jpl.nasa.gov/download-view.cfm?Doc_ID=340 Oct 2008.
- "Fusion in Stars" https://www.nagwa.com/en/lessons/395132863736/
- "The Nuclear Regulatory Commission's Science 101: What is an Atom?" https://www.nrc.gov/docs/ML1829/ML18290A910.pdf March 19, 2020
- "What is an Atom?" FuseSchool-Global Education Youtube Channel **https://www.youtube.com/watch?v=pNroKeV2fgk Jan 2, 2018**
- **"About Nuclear Fusion in Stars" Sciencing.com https://sciencing.com/nuclear-fusion-stars-4740801.html April 24, 2017**
- **"Hands-on Activity: Gumdrop Atoms" Teach Engineering https://www.teachengineering.org/activities/view/cub_mix_lesson1_activity1 Feb 25, 2020**
- **"Stars Song" Mr. Parr Youtube Channel https://www.youtube.com/watch?v=7IyrZI8ldb0 Sept 1, 2014**
- **"Artwork for the Brain Basic Infographic Rubric" https://docs.google.com/document/preview?hgd=1&id=100h88OVSrEkF_YRpHjlSHxIe58nXYNP1Ssl6WwPHhlE**
- **Pixton.com https://www.pixton.com/**
- **"** What are Atoms?-Atoms Explained" **Edpuzzle. https://edpuzzle.com/media/612564e77aae24417db2b00d**
- **"Nuclear Fusion: Inside Stars" Edpuzzle https://edpuzzle.com/media/6216381375a9c442c7df35bf**
- **"Atoms" Study Jams. https://studyjams.scholastic.com/studyjams/jams/science/matter/atoms.htm**
- **"What is Nuclear Fusion?" Study.com https://study.com/academy/lesson/what-is-nuclear-fusion-definition-process-quiz.html#lesson**
- **"Stellar Spectroscopy" Edpuzzle. https://edpuzzle.com/media/60a1befa8ae1ad41333daef4**
- **Uncovering Student Ideas in Physical Science Vol.3**

- **" Build an Atom" PhET simulation**
  https://phet.colorado.edu/en/simulations/build-an-atom
- **"Parts of an Atom Song" Mr. Parr Youtube Channel**
  https://www.youtube.com/watch?v=O5iaw5WNuB0 Aug 21, 2011

Some vocabulary words: others from science textbook and workbooks

- **www.conversation.com**
- **https://www.britannica.com/science/nuclear-fusion/Fusion-reactions-in-stars**
- **https://www.energy.gov/science/doe-explainsnuclear-fusion-reactions**

***https://starchild.gsfc.nasa.gov/docs/StarChild/questions/question13.html**