

Endeavor

STEM Teaching Certificate Project



A Quantum Leap to Mars: Learning about Mars through Fireworks

Grades 10/11

Chemistry

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This lesson sequence is the compilation of several adapted labs, lessons as well as some resources I have been using for the last several years.

****Hyperlinks are embedded throughout the document, but are also uploaded as separate files in the dropbox.****

BIG IDEAS

In 1913, Bohr refined the model of the atom using Max Planck's quantum theory combined with Ernest Rutherford's model of the atom. Ernest Rutherford's Gold Foil Experiment elucidated the idea that the center of the atom was a positively charged nucleus and the electrons were surrounding the nucleus, while the bulk of the volume of the atom was actually empty space.

Bohr's model described the electrons arranged in discrete energy levels surrounding the nucleus. Bohr postulated that these electrons can take leaps to higher energy levels and when they return to the ground state, that energy is released from the atom and can be seen in the form of light. This also unlocked a mystery from the nineteenth century, where scientists had observed atomic spectra but couldn't explain it.

Understanding how the emission spectra are formed, the spectra can be used to identify specific elements, as they have their characteristic, identifying spectra.

Using this information and technology of the Mars Rover, elements in rocks on Mars could be identified. Additionally, on earth, we use this science to entertain through the beauty of elaborate fireworks displays.

EDUCATION STANDARDS

NGSS Performance Expectation(s)

HS-PS1-1 Use the Periodic Table as a model to predict the relative properties of the elements based on the pattern of electrons in the outermost energy level of atoms.

HS-PS1-3 Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

HS-PS1-4 Develop a model to illustrate that the release or absorption of energy from a chemical reaction depends on the changes in total bond energy

HS-PS4-1: Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.

HS-PS4-3: Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

HS-PS4-5 Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts:
<p>Developing and Using Models Use a model to predict the relationships between systems or between components of a system.</p> <p>Planning and Carrying Out Investigations</p> <ul style="list-style-type: none"> Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., 	<p>PS1.A: Structure and Properties of Matter</p> <ul style="list-style-type: none"> Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect 	<p>Patterns :Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.</p> <p>Cause and Effect: <i>Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.</i></p> <p>Cause and Effect : Systems can be designed to cause a desired effect.</p> <p>Connections to Engineering,</p>

<p>number of trials, cost, risk, time), and refine the design accordingly.</p> <p>Use of Mathematics and Computational Thinking: Mathematical and computational thinking at the 9-12 level builds on K-8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.</p> <ul style="list-style-type: none"> Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations. <p>Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs.</p> <ul style="list-style-type: none"> Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). <p>Engaging in Argument from Evidence Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed worlds. Arguments may also come from current scientific or historical episodes in science.</p> <ul style="list-style-type: none"> Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. 	<p>patterns of outer electron states.</p> <ul style="list-style-type: none"> The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. <p>PS1.B: Chemical Reactions</p> <ul style="list-style-type: none"> Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. <p>PS4.A: Wave Properties Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.</p> <p>PS4.C: Information Technologies and Instrumentation</p> <ul style="list-style-type: none"> Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. 	<p>Technology, and Applications of Science</p> <p>Interdependence of Science, Engineering, and Technology</p> <ul style="list-style-type: none"> Science and engineering complement each other in the cycle known as research and development (R&D). <p>Influence of Engineering, Technology, and Science on Society and the Natural World</p> <ul style="list-style-type: none"> Modern civilization depends on major technological systems.
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Math: MP4 Model with Mathematics

HSA.CED.A 4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations

ELA: SL11-12.5 Make strategic use of digital media

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes to any gaps or inconsistencies in the account

RST 9-10.7 Translate quantitative or technical information expressed in words in a text into visual form and translate information expressed visually or mathematically into words

RST.11.12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media in order to address a question or solve a problem.

ITEEA Standards *N/A*

Other Standards *N/A*

MEASURABLE STUDENT LEARNING OBJECTIVES

Students will be able to:

- Relate energy changes in atoms to electron transitions
- Observe the shift in electron position when energy is absorbed and subsequently released
- Identify patterns in graph changes over several simulations
- Use the graphical analysis to hypothesize which color of light would be seen during each simulation.
- Use flame tests to identify a metal or metallic salt
- Estimate frequency and/or wavelength from the visible spectrum chart
- Calculate the frequency of light given its estimated wavelength
- Calculate the wavelength of light given its estimated frequency
- Identify an unknown element based on known results
- Identify that all elements have unique line emission spectra.
- Diagram and describe how line emission spectra are produced by an atom.
- Apply their knowledge of emission spectra to determine the composition of a star.
- Draw a model of fireworks
- Explain the scientific principles behind fireworks
- Choose and defend which is a more reliable method of analysis of electron energy emissions
- Propose elemental composition of rock samples from different locations on Mars citing evidence from the Rovers

STEM INTEGRATION

The core of this topic is science. The physical science of chemistry and the concept of quantum energy transitions of electrons explaining several phenomena. By moving through three different lab activities that convey transition of electrons, the more advanced technology techniques become evident and foster deeper understanding of the science.

The quantification and graphical analysis of the energy shift weaves in a mathematical component. Additionally, there are a minimum of two articles to read, annotate and discuss. These address literacy standards.

In the article “A Conceptual Framework for Integrated STEM Education,” by Todd Kelly and J. Geoffrey Knowles, they discuss situated cognition theory, where context is critical and learning is authentic. Utilizing the hands-on learning activities to build a database, which will then be used to analyze mathematically will give students agency and ownership over their data analysis. The greater investment should lead to deeper understanding.

NATURE OF STEM

In the article “Is there a Nature of STEM?” by Erin E. Peters-Burton, several points were made about the Nature of STEM, which several elements of this lesson cycle address. The activities are scaffolded from least to most sophisticated and this allows students to work in the meta realm, as they evaluate which is more effective and why. It also allows them to see the information in a cyclic manner, with deeper inquiry at each level.

The first activities use science and math, which, according to the article, “discover the secrets” of the world and by the end of the lesson cycle, students are understanding how the science and math that they have been learning apply to the engineering and technology that “shape the world” when they address data from Mars.

MATERIALS NEEDED

Activity 1: Exciting Electrons Simulation handout and link to simulation, Chromebooks or other device to run simulation

Activity 2: Article from ChemMatters: Fireworks?, copies of graphic organizers and question sheets

Activity 3: Flame Test Lab lab handouts and the following supplies: wooden splints, bunsen burner, striker or matches, 50ml of 1M solutions of each of the following: copper II chloride, sodium tetraborate (borax), potassium chloride, sodium chloride, strontium chloride and iron chloride, waste beaker, safety goggles, calculators

Activity 4: Link to NASA reading on spectrum and video on spectroscopy, graphic organizer

Activity 5: Emission Spectra Lab Handouts and the following supplies: rainbow prism glasses or handheld spectrosopes, colored pencils, power supplies and gas discharge tubes.

Activity 6: Teachers supply a flame test to revisit the concept, slide presentation on Mars Rovers and handouts of data from NASA regarding using light to investigate Mars.

ENGAGING CONTEXT/PHENOMENON

The engaging phenomenon will be a video showing fireworks. It is a brief video from YouTube, which is accompanied by an energetic backdrop of John Phillips Sousa's 1812 overture. Fourth of July parties, baseball games, weddings and amusement parks have fireworks as a source of engagement and entertainment. People view these events with awe and wonder at the beauty of the pyrotechnics. This is a great "hook" to engage students for this topic, which segues into other STEM areas and deepens their learning.

DATA INTEGRATION

Data is being integrated in several areas:

- 1) Excited Electrons Simulation, students are collecting graphical representations of the electron changes.
- 2) Flame Test Lab, students are collecting qualitative data and translating it into quantitative data.
- 3) Emissions Lab, students are collecting qualitative data.
- 4) Mars lesson, students are using NASA data regarding the content of rocks on Mars.

TEACHER BACKGROUND KNOWLEDGE

Teachers should know atomic structure, how to use simulations, appropriately conduct laboratory investigations in a safe and effective manner, how to make solutions for the lab and how to organize a station activity.

DIFFERENTIATION OF INSTRUCTION

Depending on the makeup of students in the class, modifications can be made based on IEP and/or 504 considerations. These modifications can include decreasing the number of calculations for the flame test lab, either shortening the problems to single step problems or eliminating two or more math problems. Modifying articles to meet a more appropriate lexile is a consideration, if necessary, as well.

REAL-WORLD CONNECTIONS FOR STUDENTS

As mentioned in the section with the engaging phenomenon, fireworks are a fun and entertaining part of our culture. Using this as a phenomenon will help them understand how something so marvelous and visible is due to the activity of particles that are so small they are invisible.

INTEGRATION POSSIBLE MISCONCEPTIONS

Students may have no idea of exactly how fireworks displays are made. Asking a simple “how do fireworks displays happen?” question, the teacher could collect answers on an interactive google slide from the class, which will elucidate some misconceptions. Also, students may not connect that what they're seeing is the result of the work of atoms, which they can't see.

LESSON PROCEDURE

5E	Details of 5E Lesson Implementation
<u>Engage</u> <u>1 period</u>	Procedure: This short video will be shown of fireworks: Chemistry of Fireworks Video First the teacher will show the first 20 seconds and pause to discuss with students , asking relevant questions to see what their thoughts are, share anecdotes about when, where and what their favorite fireworks viewing is/was. Then the rest of the video will be shown with some pauses to discuss what is being seen. We will then proceed with a quick refresher on Bohr diagrams

	<p>with an interactive Pear Deck activity.</p> <p>Modifications: wait time, pre-drawn diagrams that just need labels can be provided as prompts for those that need it, descriptors for students who may have visual impairments</p> <p>Standards Addressed: HS-PS1-1 Use the Periodic Table as a model to predict the relative properties of the elements based on the pattern of electrons in the outermost energy level of atoms.</p> <p>Formative/Summative Assessments: assessment via student diagrams on Pear Deck will reinforce that students are ready to move forward with the lesson.</p> <p>Bohr Model Refresh</p> <p>Resources access to video, projector</p>
<p><u>Explore</u></p> <p><u>1 period</u></p>	<p>Procedure: students will proceed with the Excited Electrons Simulation, which will allow them to explore the results of electrons absorbing different amounts of energy.</p> <p>Exciting Electrons Activity</p> <p>Modifications: Students may need a text-to-speech app to follow the instructions of the simulation</p> <p>Standards Addressed HS- PS1-4 Develop a model to illustrate that the release or absorption of energy from a chemical reaction depends on the changes in total bond energy</p> <p>HS-PS4-1: Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.</p> <p>Formative/Summative Assessments Answers to lab questions will be the assessment</p> <p>Resources chromebooks, excited electrons lab handout</p>

<p><u>Explain</u></p> <p><u>3 periods</u></p>	<p>Procedure: students will be using the reading, “Fireworks!” to explain how the electrons are being excited and releasing energy in the form of light. There is time for discussing preconceived notions about fireworks and revisiting discussions with some newer knowledge Students will also be doing the Flame Test Lab</p> <p>Fireworks! Article</p> <p>Fireworks Article Handout</p> <p>Fireworks Graphic Organizer</p> <p>Flame Test Lab</p> <p>Modifications: Translating the article to an appropriate lexile if necessary and either modifying the calculations or decreasing the number of calculations could help with math issues. Translating materials for ELLs may also be appropriate. Students who may have color blindness should be partnered with students who can help discern and describe the changes.</p> <p>Standards Addressed HS-PS1-3 Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. (<i>this addresses the conduct part of the standard</i>)</p> <p>HS-PS1-1 Use the Periodic Table as a model to predict the relative properties of the elements based on the pattern of electrons in the outermost energy level of atoms.</p> <p>Formative/Summative Assessments Answers to the readings and lab questions</p> <p>Resources Handouts and materials for The Flame Test Lab</p> <p>Graphic organizers and questions for the article</p> <p>(see links in the procedure)</p>
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<p><u>Elaborate</u></p> <p><u>1-2 periods</u></p>	<p>Procedure: Students will complete the article on spectra and the perform the emissions spectra lab (article can be homework if pressed for time)</p> <p>Spectra Article and Graphic Organizer</p> <p>Spectra Lab Handout</p> <p>Modifications: Translating materials for ELLs may also be appropriate. Modifying the questions or adding sentence starters.</p> <p>Standards Addressed: HS-PS4-4: Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.</p> <p>Formative/Summative Assessments: Answers to the questions in the lab</p> <p>Resources: Spectra article and graphic organizer, lab handouts and materials as listed in the labs (see links in procedure)</p>
<p><u>Evaluate</u></p> <p><u>1 period</u></p>	<p>Procedure: The teacher will present a brief slide show about the rovers and data collected on Mars. Students will synthesize their learning and apply it to an activity where they analyze data from the NASA JPL of photos and spectroscopy evidence from Mars.</p> <p>Mars Slides</p> <p>Mars Rover CER Activity</p> <p>Modifications: sentence starters, modified vocabulary, enlarged graphs for visually impaired</p> <p>Standards Addressed: HS-PS4-3: Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.</p> <p>HS-PS4-5 Communicate technical information about how some technological devices use the principles of wave</p>

	<p>behavior and wave interactions with matter to transmit and capture information and energy.</p> <p>Formative/Summative Assessments: Students will make a CER chart pertaining to the composition of rocks on Mars and complete a ten question Regents based self-evaluation</p> <p>Resources: Slide deck, projector, Mars rover data, handouts and ten question evaluation (see links in procedure)</p>
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