Chemistry

Atomic and Molecular Structure

1. The Periodic Table displays the elements in increasing atomic number and shows how periodicity of the physical and chemical properties of the elements relates to atomic structure. As a basis for understanding this concept, students know:

j.* spectral lines are a result of transitions of electrons between energy levels. Their frequency is related to the energy spacing between levels using Planck's relationship (E=hn).

AGN Spectroscopy

Students will participate in an ongoing experiment sponsored by the University of Arizona to determine if the spectra of Active Galactic Nuclei are related to the type of galaxy in which they are found.

Spectroscopic Analysis Lab

In this activity spectrograms of stars are analyzed to determine their spectral class, temperature, radial velocity, and other characteristics. This is an introductory Teacher Leaders in Research Based Science Education activity.

Nuclear Processes

11. Nuclear processes are those in which an atomic nucleus changes, including radioactive decay of naturally occurring and man-made isotopes, nuclear fission, and nuclear fusion. As a basis for understanding this concept, students know:

a. protons and neutrons in the nucleus are held together by strong nuclear forces which are stronger than the electromagnetic repulsion between the protons.

Radiation lab

Students will investigate a number of variables in relation to the intensity of low-level radiation in naturally occuring minerals. They will also learn about radioactive decay rates, nuclear reactions, and other related topics. They will design categories of objects to use as radiation shielding and display data in a histogram.

Distribution of Novae in M31

Students will read about a study done in the summer of 2002 and attempt to extend the analysis to improve the reliability of the results. This experiment tried to determine if there was a relationship between the radial distance of a nova to the center of M31 and the rate at which the nova decayed. No relationship was found, but there were limitations to the analysis.

b. the energy release per gram of material is much larger in nuclear fusion or fission reactions than in chemical reactions: change in mass (calculated by E=mc^2) is small but significant in nuclear reactions.

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c. many naturally occurring isotopes of elements are radioactive, as are isotopes formed in nuclear reactions.

Radiation lab

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d. the three most common forms of radioactive decay (alpha, beta, gamma) and how the nucleus changes in each type of decay.

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e. alpha, beta, and gamma radiation produce different amounts and kinds of damage in matter and have different penetrations.

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f.* how to calculate the amount of a radioactive substance remaining after an integral number of half lives have passed.

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g.* protons and neutrons have substructure and consist of particles called quarks.

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Earth Science

Earth's Place in the Universe

1. Astronomy and planetary exploration reveal the structure, scale, and change of the solar system over time. As a basis for understanding this concept, students know:

a. how the differences and similarities among the sun, the terrestrial planets, and the gas planets may have been established during the formation of the solar system.

Asteroid Search

Students will attempt to either discover new asteroids or verify the orbits of existing asteroids.

b. evidence from Earth and moon rocks for the solar system's formation from a nebular cloud of dust and gas approximately 4.6 billion years ago.

Radiation lab

Students will investigate a number of variables in relation to the intensity of low-level radiation in naturally occuring minerals. They will also learn about radioactive decay rates, nuclear reactions, and other related topics. They will design categories of objects to use as radiation shielding and display data in a histogram.

Asteroid Search

Students will attempt to either discover new asteroids or verify the orbits of existing asteroids.

c. evidence from geological studies of the Earth and other planets that the early Earth was very different from today.

Asteroid Search

Students will attempt to either discover new asteroids or verify the orbits of existing asteroids.

d. evidence that the planets are much closer than the stars.

Asteroid Search

Students will attempt to either discover new asteroids or verify the orbits of existing asteroids.

Jupiter's moons lab

Students will analyze photographs of the moons of Jupiter to determine the orbital periods, and distances of the moons of Jupiter, and the mass of Jupiter, and the speed of light in vacuum. Photographs will be taken as original source material for this project using both local telescopes and remote controlled telescopic observations.

f. evidence for the dramatic effects of asteroid impacts in shaping the surface of planets and their moons, and in mass extinctions of life on Earth.

Asteroid Search

Students will attempt to either discover new asteroids or verify the orbits of existing asteroids.

g.* evidence for the existence of planets orbiting other stars.

Jupiter's moons lab

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Measuring the distance to the moon through

Simultaneous photographs of the moon taken from widely separated areas show a shift in position of the moon due to parallax. The parallax shift can be used to determine the distance to the moon.

2. Earth-based and space-based astronomy reveals the structure, scale, and change over time of stars, galaxies and the universe. As a basis for understanding this concept, students know:

a. the solar system is located in an outer edge of the disc-shaped Milky Way galaxy which spans 100,000 light years.

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b. galaxies are made of billions of stars and form most of the visible mass of the universe.

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c. evidence that all elements with an atomic number greater than that of Lithium have been formed by nuclear fusion in stars.

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Spectroscopic Analysis Lab

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Supernova Search

Students will attempt to find supernovas in recently taken photos from the Hands On Universe project.

d. stars differ in their life cycles, and visual, radio, and X-ray telescopes collect data that reveal these differences.

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f.* evidence that the color, brightness and evolution of a star are determined by a balance between gravitational collapse and nuclear fusion.

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g.* how the red-shift from distant galaxies and the cosmic background radiation provide evidence for the "big bang" model that suggests that the universe has been expanding for 10 to 20 billion years.

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Investigation and Experimentation

1. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept, and to address the content the other four strands, students should develop their own questions and perform investigations. Students will:

a. select and use appropriate tools and technology (such as computer-linked probes, spread sheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.

Centripetal Force Lab

Students will design an experimental procedure to independently discover the three major relationships in the Centripetal Force equations. Curve fitting techniques will reveal the mathematical formulas. These results will be combined into a hypothetical result for the structure of the definition of Centripetal Force.

Radiation lab

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Selection and Pursuit of a Research Project

Students, working alone or in small groups, will design and carry out an original research project. Results will be published in a venue beyond the classroom, and a presentation to the class and others is required. Research projects must be substantial in nature and not repeat previously done research.

Acceleration lab

Students will determine the acceleration of a rocket based on a videotape of its motion. Differences between the theoretical and observed accelerations will be thoroughly investigated in an iterative fashion. For example, at first the values will be close which was good enough for a physics concept lesson. One by one interfering variables will be eliminated until the theory matches the observation as closely as possible.

Photogate Lab

A careful analysis will be made of the motion of a pendulum through a photogate. The first analysis will be focused on the conservation of energy. The second analysis will investigate the sinusoidal nature of the motion. The lab will conclude with the derivation of the damped harmonic oscillator constant for the system.

Plate Scale Lab

This lab has students measure the plate scale of a telescope through theory and devise a method to measure the plate scale experimentally using a digital camera.

Rocket Impulse Lab

Students will measure the impulse generated by model rocket engines in considerable detail and develop a numeric integration model to determine the total change in velocity of a model rocket.

b. identify and communicate sources of unavoidable experimental error.

Paper Analysis activity

Students will read research papers from actual science journals and extract from them information such as the hypothesis, the conclusion, the structure of the paper, the audience, sources of error, and other major experimental design issues. This will be done regardless of whether or not the specific content of the paper is understood due to the background of the student.

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c. identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.

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d. formulate explanations using logic and evidence.

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Plate Scale Lab

This lab has students measure the plate scale of a telescope through theory and devise a method to measure the plate scale experimentally using a digital camera.

e. solve scientific problems using quadratic equations, and simple trigonometric, exponential, and logarithmic functions.

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Rocket Impulse Lab

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f. distinguish between hypothesis and theory as science terms.

Paper Analysis activity

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g. recognize the use and limitations of models and theories as scientific representations of reality.

Paper Analysis activity

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Momentum lab

This lab will be primarily an exercise designed to review the concepts of vector addition, conservation of momentum, and presentation of data for reports. Students will videotape air hockey pucks seen from above and analyze the motion using Videopoint software.

AGN Spectroscopy

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h. read and interpret topographic and geologic maps.

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i. analyze the locations, sequences, or time intervals of natural phenomena (e.g., relative ages of rocks, locations of planets over time, and succession of species in an ecosystem).

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Students will measure the impulse generated by model rocket engines in considerable detail and develop a numeric integration model to determine the total change in velocity of a model rocket.

j. recognize the issues of statistical variability and the need for controlled tests.

Paper Analysis activity

Students will read research papers from actual science journals and extract from them information such as the hypothesis, the conclusion, the structure of the paper, the audience, sources of error, and other major experimental design issues. This will be done regardless of whether or not the specific content of the paper is understood due to the background of the student.

Centripetal Force Lab

Students will design an experimental procedure to independently discover the three major relationships in the Centripetal Force equations. Curve fitting techniques will reveal the mathematical formulas. These results will be combined into a hypothetical result for the structure of the definition of Centripetal Force.

Radiation lab

Students will investigate a number of variables in relation to the intensity of low-level radiation in naturally occuring minerals. They will also learn about radioactive decay rates, nuclear reactions, and other related topics. They will design categories of objects to use as radiation shielding and display data in a histogram.

Distribution of Novae in M31

Students will read about a study done in the summer of 2002 and attempt to extend the analysis to improve the reliability of the results. This experiment tried to determine if there was a relationship between the radial distance of a nova to the center of M31 and the rate at which the nova decayed. No relationship was found, but there were limitations to the analysis.

Measuring the distance to the moon through

Simultaneous photographs of the moon taken from widely separated areas show a shift in position of the moon due to parallax. The parallax shift can be used to determine the distance to the moon.

RA 1420 Investigation of Jupiter/Io

Students will extend an activity begun in 2002 with the RA1420 project at Deer Valley HS and collect data to determine if there is a relationship between the radio frequency signal from Jupiter and the relative Earth/Sun, Jupiter, and Io angle.

Selection and Pursuit of a Research Project

Students, working alone or in small groups, will design and carry out an original research project. Results will be published in a venue beyond the classroom, and a presentation to the class and others is required. Research projects must be substantial in nature and not repeat previously done research.

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k. recognize the cumulative nature of scientific evidence.

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AGN Spectroscopy

Students will participate in an ongoing experiment sponsored by the University of Arizona to determine if the spectra of Active Galactic Nuclei are related to the type of galaxy in which they are found.

Asteroid Search

Students will attempt to either discover new asteroids or verify the orbits of existing asteroids.

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l. analyze situations and solve problems that require combining and applying concepts from more than one area of science.

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m. investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings. Examples include irradiation of food, cloning of animals by somatic cell nuclear transfer, choice of energy sources, and land and water use decisions in California.

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n. know that when an observation does not agree with an accepted scientific theory, sometimes the observation is mistaken or fraudulent (e.g., Piltdown Man fossil or unidentified flying objects), and sometimes the theory is wrong (e.g., Ptolemaic model of the movement of the sun, moon and planets).

Paper Analysis activity

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Students, working alone or in small groups, will design and carry out an original research project. Results will be published in a venue beyond the classroom, and a presentation to the class and others is required. Research projects must be substantial in nature and not repeat previously done research. Research is not necessarily limited to astronomy and physics.

Physics

Conservation of Energy and Momentum

2. The laws of conservation of energy and momentum provide a way to predict and describe the movement of objects. As a basis for understanding this concept, students know:

a. how to calculate kinetic energy using the formula E=(1/2)mv2.

Photogate Lab

A careful analysis will be made of the motion of a pendulum through a photogate. The first analysis will be focused on the conservation of energy. The second analysis will investigate the sinusoidal nature of the motion. The lab will conclude with the derivation of the damped harmonic oscillator constant for the system.

b. how to calculate changes in gravitational potential energy near the Earth using the formula (change in potential energy) =mgh (change in the elevation).

Jupiter's moons lab

Students will analyze photographs of the moons of Jupiter to determine the orbital periods, and distances of the moons of Jupiter, and the mass of Jupiter, and the speed of light in vacuum. Photographs will be taken as original source material for this project using both local telescopes and remote controlled telescopic observations.

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c. how to solve problems involving conservation of energy in simple systems such as falling objects.

Photogate Lab

A careful analysis will be made of the motion of a pendulum through a photogate. The first analysis will be focused on the conservation of energy. The second analysis will investigate the sinusoidal nature of the motion. The lab will conclude with the derivation of the damped harmonic oscillator constant for the system.

d. how to calculate momentum as product mv.

Momentum lab

This lab will be primarily an exercise designed to review the concepts of vector addition, conservation of momentum, and presentation of data for reports. Students will videotape air hockey pucks seen from above and analyze the motion using Videopoint software.

Rocket Impulse Lab

Students will measure the impulse generated by model rocket engines in considerable detail and develop a numeric integration model to determine the total change in velocity of a model rocket.

e. momentum is a separately conserved quantity, different from energy.

Momentum lab

This lab will be primarily an exercise designed to review the concepts of vector addition, conservation of momentum, and presentation of data for reports. Students will videotape air hockey pucks seen from above and analyze the motion using Videopoint software.

f. an unbalanced force on an object produces a change in its momentum.

Momentum lab

This lab will be primarily an exercise designed to review the concepts of vector addition, conservation of momentum, and presentation of data for reports. Students will videotape air hockey pucks seen from above and analyze the motion using Videopoint software.

Rocket Impulse Lab

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g. how to solve problems involving elastic and inelastic collisions in one dimension using the principles of conservation of momentum and energy.

Momentum lab

This lab will be primarily an exercise designed to review the concepts of vector addition, conservation of momentum, and presentation of data for reports. Students will videotape air hockey pucks seen from above and analyze the motion using Videopoint software.

Electronic and Magnetic Phenomena

5. Electric and magnetic phenomena are related and have many practical applications. As a basis for understanding this concept, students know:

e. charged particles are sources of electric fields and experience forces due to the electric fields from other charges.

Radiation lab

Students will investigate a number of variables in relation to the intensity of low-level radiation in naturally occuring minerals. They will also learn about radioactive decay rates, nuclear reactions, and other related topics. They will design categories of objects to use as radiation shielding and display data in a histogram.

i. plasmas, the fourth state of matter, contain ions and/or free electrons and conduct electricity.

Radiation lab

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o.* how to apply the concepts of electrical and gravitational potential energy to solve problems involving conservation of energy.

Photogate Lab

A careful analysis will be made of the motion of a pendulum through a photogate. The first analysis will be focused on the conservation of energy. The second analysis will investigate the sinusoidal nature of the motion. The lab will conclude with the derivation of the damped harmonic oscillator constant for the system.

Motion and Forces

1. Newton's laws predict the motion of most objects. As a basis for understanding this concept, students know:

c. how to apply the law F=ma to solve one-dimensional motion problems involving constant forces (Newton's Second Law).

Acceleration lab

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f. applying a force to an object perpendicular to the direction of its motion causes the object to change direction but not speed (for example, the Earth's gravitational force causes a satellite in a circular orbit to change direction but not speed).

Centripetal Force Lab

Students will design an experimental procedure to independently discover the three major relationships in the Centripetal Force equations. Curve fitting techniques will reveal the mathematical formulas. These results will be combined into a hypothetical result for the structure of the definition of Centripetal Force.

RA 1420 Investigation of Jupiter/Io

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g. circular motion requires application of a constant force directed toward the center of the circle.

Centripetal Force Lab

Students will design an experimental procedure to independently discover the three major relationships in the Centripetal Force equations. Curve fitting techniques will reveal the mathematical formulas. These results will be combined into a hypothetical result for the structure of the definition of Centripetal Force.

Jupiter's moons lab

Students will analyze photographs of the moons of Jupiter to determine the orbital periods, and distances of the moons of Jupiter, and the mass of Jupiter, and the speed of light in vacuum. Photographs will be taken as original source material for this project using both local telescopes and remote controlled telescopic observations.

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l.* how to solve problems in circular motion, using the formula for centripetal acceleration in the following form: a=v2/r.

Centripetal Force Lab

Students will design an experimental procedure to independently discover the three major relationships in the Centripetal Force equations. Curve fitting techniques will reveal the mathematical formulas. These results will be combined into a hypothetical result for the structure of the definition of Centripetal Force.

Waves

4. Waves have characteristic properties that do not depend on the type of wave. As a basis for understanding this concept, students know:

a. waves carry energy from one place to another.

Photogate Lab

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b. how to identify transverse and longitudinal waves in mechanical media such as springs, ropes, and the Earth (seismic waves).

Photogate Lab

A careful analysis will be made of the motion of a pendulum through a photogate. The first analysis will be focused on the conservation of energy. The second analysis will investigate the sinusoidal nature of the motion. The lab will conclude with the derivation of the damped harmonic oscillator constant for the system.

c. how to solve problems involving wavelength, frequency, and wave speed.

Jupiter's moons lab

Students will analyze photographs of the moons of Jupiter to determine the orbital periods, and distances of the moons of Jupiter, and the mass of Jupiter, and the speed of light in vacuum. Photographs will be taken as original source material for this project using both local telescopes and remote controlled telescopic observations.

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e. radio waves, light and X-rays are different wavelength bands in the spectrum of electromagnetic waves whose speed in vacuum is approximately 3x108 m/s (186,000 miles/second).

Jupiter's moons lab

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Spectroscopic Analysis Lab

In this activity spectrograms of stars are analyzed to determine their spectral class, temperature, radial velocity, and other characteristics. This is an introductory Teacher Leaders in Research Based Science Education activity.

Plate Scale Lab

This lab has students measure the plate scale of a telescope through theory and devise a method to measure the plate scale experimentally using a digital camera.

f. how to identify the characteristic properties of waves: interference (beats), diffraction, refraction, Doppler effect, and polarization.

Plate Scale Lab

This lab has students measure the plate scale of a telescope through theory and devise a method to measure the plate scale experimentally using a digital camera.