High School Lessons

Acids & Bases

Acids, Bases and pH
Students create a spectrum of colorful indicators in developing an original solution to identifying the pH range of common substances.

Natural Dyes Lab: Cogent Industry Example
Students learn about an innovative greener alternative to the polyester manufacturing process as they investigate chemical bonds, fibers, pigments and dyes by extracting natural dyes and experimenting with pH and mordants.

Recycling Polylactic Acid
Students extend the lifetime of a renewable product, a polylactic acid (PLA) plastic cup, by chemically converting the cup into a cleaning solution via a base hydrolysis.
NEW! Kit available from Flinn Scientific: http://ow.ly/avFX309FUhu

Wood Ash Titration
Introduce acid-base titrations with a new spin. This green chemistry version of a strong acid-base titration uses wood ash, a renewable source of base, in place of NaOH.
NEW! Kit available from Flinn Scientific: http://ow.ly/X8vA309FUuP

Atoms & The Periodic Table

Electronic Transitions
This lab replaces traditionally used flame test activities that use nitrate salts of sodium, potassium, lithium, strontium, calcium, barium, lead and copper (II). The redesigned lab uses acetate salts of sodium and potassium.

Flame Test and Emission Spectra
Students use inquiry to identify the elements in Colorflame candles. Unlike traditional flame emission labs, where student see a bright burst of color, this procedure allows students to safely observe an emission spectra and use online tools to match the element.

Biotechnology

Lesson 1 – What's up with Gena? Introduction to Biotech Case Study
Students are challenged to formulate a hypothesis for what is wrong with a patient named Gena based on her family history and complaints of sickness.

Lesson 2 – Genetic Testing
In this two-part lesson, students take DNA samples and perform a paper electrophoresis experiment while learning about genes and restriction enzymes.

Lesson 3 – Family Interviews
Students are introduced to the field of genetic counselling as they use information gathered from an interview with Gena's family to build a pedigree chart.

Lesson 4 – Counselling my Genetics
Students consider how they feel about genetics and the issues around medical/pharmaceutical biotechnology by considering whether Gena's family members should undergo genetic testing.

Lesson 5 – Electrophoresis Discovery
Students perform gel electrophoresis to test Elizabeth's DNA and determine the presence of a mutated gene.

Lesson 6 – Recombinant DNA Technology
Students are put in the role of a molecular biologist as they explore the use of recombinant DNA technology in treating genetic disorders and the usefulness of scientific models in biotechnology.

Lesson 7 – Phixagene Inc.
Students put themselves in the role of pharmaceutical researchers and brainstorm new medical treatments using different types of genetic mutations.

Lesson 8 – Biotechnology Career Exploration
Students explore different types of jobs and opportunities within the constantly expanding field of biotechnology.

Supplemental - Jeopardy Review: Evaluation
Review biology and biotechnology concepts (bacteria, viruses, reproduction & genetic recombination, treatment & prevention) with the help of an interactive jeopardy game with your class. See individual PowerPoints for concepts covered in each activity.

Supplemental - What do you get if you cross biology with technology?
Students begin discussions on biotechnology as a class, addressing pre-conceived notions and exploring the role biotechnology plays in their lives, especially related to medicine. This lesson can be used both as an activator and/or a debrief of the unit.

Supplemental - Design-O-Saur
Students build a model to observe the connection between DNA, RNA, and amino acid sequences and to see the variation of traits that can occur in offspring by doing either a dihybrid cross or monohybrid cross of the parents.

Supplemental – Additional Biotech Resources
List of websites for teachers looking for additional resources related to biotechnology.

Chemical Bonding

Green Chemistry, Biomimicry and Intermolecular Forces
Students explore the use of adhesives, intermolecular forces and how biomimicry is being used by chemists to invent greener alternative products.

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Polymers & Molecular Models: Petretec Industry Example
Students practice molecular model building and Lewis dot structures while considering a common plastic material and a more benign Presidential Green Chemistry Award winning technology.

Chemical Names & Formulas

Chemical Hazard Awareness Investigation
This multi-lesson module is designed to introduce the language of chemical hazards and safety protocols for the laboratory and to ask students to analyse chemical hazards utilizing SDS's associated with traditional types of reactions labs.

Chemical Reactions

Chemical or Physical?

This lab replaces traditional reactions involving chemicals such as copper(II) chloride, 6M hydrochloric acid, potassium hydroxide, and copper sulfate. The goal is to use observations of different types of reactions to discover common threads, ultimately leading to conclusions regarding evidence of chemical reactions. Students will ultimately learn the difference between chemical and physical changes and dispel common misconceptions; i.e. boiling water is not a chemical reaction.

Environmental Impact Factor

Using the E-Factor formula, students compare the amount of a final product to the amount of waste generated in a chemical process, leading to a discussion of additional green chemistry metrics with respect to chemical reactions.

Green Precipitation Reaction

This lab determines the percent composition of zinc acetate by precipitation of zinc carbonate, replacing a lab that determines the composition of sulfate in alum by precipitation with excess barium sulfate.

Reactions Lab

Students are challenged to choose and perform the 'greener' of two procedures for the same unknown type of reaction based on the provided toxicity information for reactants and products. The students complete this process for each of the following types of reactions: single displacement, double displacement, composition and decomposition.

Gases

Climate Change Chemistry

In this unit students consider the chemistry behind the concept of climate change while exploring gases and gas laws.

Hydrocarbon Compounds

Bio-Inspired Polymers: VBT

Vinylbenzyl thymine (VBT) is a water-soluble polymer that is used to make photoresists. Students make their own photoresists in this lab as they learn about greener solutions to the global e-waste problem.

Recycling Polylactic Acid

Students extend the lifetime of a renewable product, a polylactic acid (PLA) plastic cup, by chemically converting the cup into a cleaning solution via a base hydrolysis.

NEW! Kit available from Flinn Scientific: http://ow.ly/avFX309FUhu

Synthesis of Biodiesel

In this multi-lesson module students consider the physical properties of different oils used to make biodiesel and then make their own fuel. Students will then analyse the enthalpy of combustion of the biodiesel they have made.

Introduction to Chemistry

Environmental Impact Factor

Using the E-Factor formula, students compare the amount of a final product to the amount of waste generated in a chemical process, leading to a discussion of additional green chemistry metrics with respect to chemical reactions.

Hard Water Lab: TAML Industry Example

A Presidential Green Chemistry Award winning technology is the inspiration for this lab that looks chemically at the difference between hard and soft water and the role of catalysis in reactions. The lesson reinforces the scientific method by careful manipulation of variables to develop a rich understanding of the bleaching process through an inquiry-based activity.

Introduction to Green Chemistry and Biomimicry

Students are introduced to biomimicry, an approach to innovation that derives inspiration from nature, through examples of technologies inspired by nature.

Lifecycle and Sustainability Analysis

The 3 E's (Environment, Economy, Equity) of the sustainability of a product are evaluated by a metric, the Sustainability Triangle, to create a mathematical correlation to the life cycle analysis of a common product from cradle to grave.

Writing the Principles

Introduce the 12 Principles of Green Chemistry by a lab simulation that encourages students to critically think about how a chemical process may be improved.

MIT BLOSSOMS video lesson:
http://blossoms.mit.edu/videos/lessons/introducing_green_chemistry_science_solutions

Lab Safety & Chemical Hazard

Bio-Inspired Polymers

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Sharklet Surface Chemistry Lab

Students are introduced to a cutting-edge technology that mimics shark's skin patterns, a natural anti-microbial. In the lab, students simulate the pattern to investigate surface chemistry.

Toxicity and Sea-nine 211 Industry Example

Students perform an LD_{50} test to determine the toxicity of a chemical, inspired by the Sea-nine 211 Presidential Green Chemistry Award winning technology of a less harmful marine Antifoulant. The lesson can be used to teach bioassays, bioaccumulation and serial dilutions.

NEW! Kit available from Flinn Scientific: http://ow.ly/OXVV309FUcX

Materials Science

Bio-Inspired Polymers

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problem.

Mushroom Materials: Ecovative Industry Example

Students evaluate the life-cycle analysis of polystyrene and mushroom materials (mycelium and agricultural waste). In addition students grow their own mushroom materials and utilize experimental design to test mechanical properties of the material.

Natural Dyes Lab: Cogent Industry Example

Students learn about an innovative greener alternative to the polyester manufacturing process as they investigate chemical bonds, fibers, pigments and dyes by extracting natural dyes and experimenting with pH and mordants.

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Math & Engineering

Cell Phone Sustainability

Students access and review statistical concepts and graphical representations to investigate the issues of sustainability surrounding a personal electronics item that they use every day. Students estimate and rewrite large numbers, calculate the mean of a given data set, calculate the median, upper and lower quartiles of a data set using algebraic and graphical methods, construct a box-and-whisker plot for a given data set.

Ecological Footprint: Introduction to Green Math

Students use an online ecological footprint calculator to learn about the impact that each human has on the environment. This lesson acts as both the activator for the unit and a debriefing tool at the end of the unit.

Got Gas

Students explore the concept of miles per dollar. By using information about gasoline, students solve word problems involving basic arithmetic operations and to analyze, graph and interpret their results.

Lifecycle and Sustainability: Enrichment Lesson

Students understand how to evaluate a product or process for "Greenness". Students will be introduced to the sustainability triangle and the lifecycle diagram and use these tools to evaluate a product.

Plastic Bags
Students compute ratios with large numbers and study the effects of plastic bag consumption in countries across the world. Students will manipulate data to show bag consumption per person/year/week/month. They will then use this information to draw conclusions about their own consumption and ways to reduce plastic bag usage.

Population
Students apply statistical modelling tools to world population data. These will then be used to predict the population of the world in 2050. Students will calculate ratios and percentages, represent data via circle graphs, use exponential equations to make calculations, model data using trend lines and the regression capabilities of the graphing calculator.

The Big Melt
Students will use research on ice cap melting to formulate an exponential decay equation.

Truckin' To Your Table
Students investigate food sources using statistics and percentage applications and consider the carbon footprint of the food we consume.

Waste Generation
In this multi-lesson unit, students explore municipal waste and its impacts upon communities. Students will read and interpret various graphs, use estimation, use percentages and fractions, correlation coefficients and use function notation.

Water Bottle, Inc.
This unit gives students an understanding of the waste generated through consuming bottled water. Students will use statistics, linear algebra, functions and regression models to analyze data in order to make an environmental decision.

Mole Concepts & Chemical Quantities

Mole of Rice
Students are asked to calculate if there were a mole of rice grains stacked evenly over the surface of the planet and make relevant connections to green chemistry.

Oxidation-Reduction Reactions & Electrochemistry

Dye-Sensitized Blackberry Solar Cell
Students build their own dye-sensitized solar cell using blackberry fruit as the dye. This lab highlights how current photovoltaic solar cells are manufactured and the green chemistry research towards greener solar energy. Demonstration: https://youtu.be/_PyuApQnrWg

NEW! Kit available from Flinn Scientific: http://ow.ly/Feq3309FTRP

Green(er) Redox Lab
This lab is a "greener" redox experiment using magnesium metal and zinc chloride in place of redox reactions between copper solid and silver nitrate. This exercise will be used to show a redox reaction between solid magnesium metal and an aqueous solution of zinc chloride. The students will calculate the theoretical yield and percent yield.

Project Based Learning

Mushroom Materials
Students evaluate the life-cycle analysis of polystyrene and mushroom materials (mycelium and agricultural waste). In addition, students grow their own mushroom materials and utilize experimental design to test mechanical properties of the material.

Synthesis of Biodiesel
In this multi-lesson module students consider the physical properties of different oils used to make biodiesel and then make their own fuel. Students will then analyse the enthalpy of combustion of the biodiesel they have made.

Reaction Rates & Equilibrium

Catalysts and Oxygen

This lab replaces manganese dioxide to demonstrate the effect of a catalyst in a reaction. Students will understand the effect of a catalyst on reaction rates and how a catalyst can improve the efficiency of a process.

Equilibrium/Le Chatelier's Principle

This lesson gives students an understanding of the concept of chemical equilibrium and demonstrates Le Chatelier's Principle using inexpensive household materials. Demonstration: https://www.youtube.com/watch?v=fBdYL3hlBuI

Greening the Clock Reaction

This lesson replaces the traditional clock reaction use of iodate ions, hydrogen sulphite ions, mercury(II) ions and uses Vitamin C, tincture of iodine, 3% hydrogen peroxide and starch solution.

Hard Water Lab: TAML Industry Example

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Solutions

Freezing Point Determination

A modification of the Molar Mass Determination by Freezing Point Depression with a focus on the qualitative effects of colligative properties.

Molar Mass Determination by Freezing Point Depression

Students determine the molar mass of an unknown fatty acid dissolved in a known fatty acid using freezing point depression and colligative properties. This lab replaces traditional experiments using hazardous organic solvents.

Solubility

Students qualitatively and quantitatively describe the relationship between temperature and solubility for gases and solids. This lab uses two forms of magnesium (magnesium chloride and magnesium sulfate) to compare solubility of ionic solids and create a solubility curve.

States of Matter

Chemical or Physical?

This lab replaces traditional reactions involving chemicals such as copper(II) chloride, 6M hydrochloric acid, potassium hydroxide, and copper sulfate. The goal is to use observations of different types of reactions to discover common threads, ultimately leading to conclusions regarding evidence of chemical reactions. Students will ultimately learn the difference between chemical and physical changes and dispel common misconceptions; i.e. boiling water is not a chemical reaction.

Essential Oil Extraction Using Liquid CO2

Students use dry ice to extract essential oils from citrus fruits and evaluate the methods used against the 12 Principles of Green Chemistry.

Sublimation

This lab replaces the traditional naphthalene sublimation lab. Students will observe sublimation of caffeine from inexpensive pharmacy tablets and explain the type of change that occurred.

Stoichiometry

Empirical Formula

This lab replaces traditional labs that use the synthesis of magnesium oxide or the decomposition of silver oxide with a greener reaction using iron filings. By using 3% hydrogen peroxide and leaving the experiment for 3-4 days students can calculate the empirical formula of the rust.

Stoichiometry Challenge

This lab replaces a traditional aluminium to alum stoichiometry lab with a greener precipitation reaction of sodium carbonate and calcium chloride. It is used to demonstrate how stoichiometry works, showing that if concentrations and amounts of the starting materials are known that the theoretical yield can be calculated from a balanced chemical equation.

Thermodynamics

Enthalpy of Combustion

By investigating the molar heat of combustion of paraffin compared to soy wax students measure the thermal heat absorbed by water, measure the heat of combustion of paraffin and soy wax and calculate the molar heat of the combustion of paraffin.

Exothermic and Endothermic Reactions

These labs use catalase, an enzyme found in nearly all living organisms, to decompose peroxide in an exothermic reaction and citric acid and water to produce an endothermic reaction and a change in enthalpy (ΔH).

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