

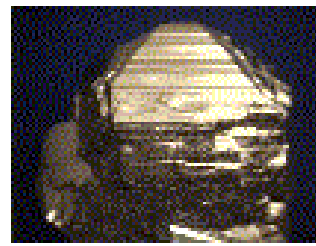


Acid Neutralization Lab

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TESI V

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Introduction

The following lab may be used as an acid-base lab, an earth science lab, in a mining unit, or any other class that relates to this topic. I will probably just teach the acid-base portion of the lab without the mining connection in physical science, using the tailings problem as an example in the real world, but in earth science I will incorporate it into the geology unit, using the mining history of Colorado as a background and then an application for this process. The students will problem-solve a real-life situation where sterile streams occur due to the acid-drainage from tailings over 100 years old.

Background Information for the Teacher

Appendices are attached with basic information about pyrite, limestone, and a review of pH. This information may be shared with students in any manner the teacher wishes. To practice good research techniques, the students may be required to search a variety of sources for this information instead of being given this information by the instructor. Most physical science textbooks will have pH information for the students. The chemical reactions of limestone, CaCO_3 , and pyrite, FeS_2 , with water may be found in a variety of science texts. If you are unsure, check with your local chemistry teacher or mining engineer! In any discussion of acids and bases, the concept of buffering should be discussed.

For my earth science students I will provide them with the history of mining in Colorado or at least websites for them to research themselves. I plan on touring mining sites for specific information about pyrite leaching and photographs for a PowerPoint to set up the problem of acid runoff from leaching of old tailing piles. The students will perform the lab itself, analyze the data, and as a summary of this project propose a reclamation plan for sterilized streams using the limestone neutralization methods (although, some students may do additional research and come up with other plans that are feasible as well!).

Websites for the history of mining in Colorado or the problem of contamination of streams from tailing piles in Colorado are <http://geosurvey.state.co.us> , <http://www.coloradomining.org> , http://www.atsdr.cdc.gov/HAC/PHA/summit/sum_p1.html 2005 and http://www.geotimes.org/dec03/NN_skiresorts.html 2005 .

Colorado's Science Standards that relate to this lesson are in Appendix E.

The Task

Students will discuss and design a lab to measure pH of limestone, pyrite, limestone-pyrite mixtures, and their control. Before students can actually perform the lab, their lab safety analysis (LSA, appendix C), and lab procedure must be approved by the instructor. At this time, the number of days for collection of data will be set. If you want your limestone and pyrite samples dried before testing the mixture, have them collect their last data on a Friday so the samples can dry over the weekend or use an oven.

After approval of the student's procedures, students will perform the lab.

Analysis of the data and a summary of the lab are required. The extent of the summary depends upon the teacher's use of this lab, class, etc. In the idealized lab write up in Appendix D, are a few questions to guide the student or teacher in their analysis and summary of the data and experiment.

Pre-lab discussion may set the problem up as a mining reclamation problem so that a post-lab report would address how limestone could be used to buffer the acid-drainage from tailings containing pyrite. If so, a PowerPoint will be shown of the Colorado mining regions with additional data on water quality standards for high mountain streams.

Lesson Plan Objectives (*The teacher may emphasis all of these or some of these depending upon the focus of the class this lab is used in.*)

1. Experimental Design: controls, independent and dependent variables
2. Collect and analyze real data
3. Apply information from experiment/data to a real-world problem/situation
4. Relate impact by a human activity on an environment
5. Understand acid-base interactions and the concept of neutralization

Basic Materials for Lab

Five (5) 100 mL beakers

Deionized water in a spray bottle

pH paper

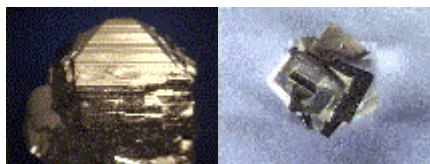
Samples of industrial and local limestone, crushed

Samples of industrial and local pyrite, crushed

Masking tape for labeling beakers

Appendices

Appendix A



THE MINERAL PYRITE

- **Chemistry:** FeS₂, Iron Sulfide
- **Class:** [Sulfides](#)
- **Group:** [Pyrite](#)
- **Uses:** A very minor ore of sulfur for sulfuric acid, used in jewelry under the trade name "marcasite" and as mineral specimens.
- [Specimens](#)

Pyrite is the classic "Fool's Gold". There are other shiny brassy yellow minerals, but pyrite is by far the most common and the most often mistaken for [gold](#). Whether it is the golden look or something else, pyrite is a favorite among rock collectors. It can have a beautiful luster and interesting crystals. It is so common in the earth's crust that it is found in almost every possible environment, hence it has a vast number of forms and varieties.

Bravoite is the name given to a nickel-rich iron sulfide. It is closely related to pyrite but contains up to 20% nickel. Some mineral books treat it as a variety of pyrite.

Pyrite is a polymorph of [marcasite](#), which means that it has the same chemistry, FeS₂, as marcasite; but a different structure and therefore different symmetry and crystal shapes. Pyrite is difficult to distinguish from marcasite when a lack of clear indicators exists.

Pyrite's structure is analogous to [galena's](#) structure with a formula of PbS. Galena though has a higher symmetry. The difference between the two structures is that the single sulfur of galena is replaced by a pair of sulfurs in pyrite. The sulfur pair are covalently bonded together in essentially an elemental bond. This pair disrupts the four fold symmetry that a single atom of sulfur would have preserved and thus gives pyrite a lower symmetry than galena.

Although pyrite is common and contains a high percentage of iron, it has never been used as a significant source of iron. Iron oxides such as [hematite](#) and [magnetite](#), are the primary iron ores. Pyrite is not as economical as these ores possibly due to their tendency to form larger concentrations of more easily mined material. Pyrite would be a potential source of iron if these ores should become scarce.

Pyrite has been mined for its sulfur content though. During WWII, sulfur was in demand as a strategic chemical and North American native [sulfur](#) mines were drying up. A sulfide deposit near Ducktown Tenn. was found to be able to mine pyrite and other sulfides such as [pyrrhotite](#) and [pentlandite](#) and produce the needed sulfur as well as iron and other metals. The sulfur was used in the production of sulfuric acid, an important chemical for industrial purposes. Now most sulfur production comes from H₂S gas recovered from natural gas wells.

PHYSICAL CHARACTERISTICS:

- **Color** is brassy yellow.
- **Luster** is metallic.
- **Transparency:** Crystals are opaque.
- **Crystal System** is isometric; bar 3 2/m
- **Crystal Habits** include the cube, octahedron and pyritohedron (a dodecahedron with pentagonal faces) and crystals with combinations of these forms. Good interpenetration [twins](#) called iron crosses are rare. Found commonly in nodules. A flattened nodular variety called "*Pyrite Suns*" or "*Pyrite Dollars*" is popular in rock shops. Also massive, reniform and replaces other minerals and fossils forming pseudomorphs or copies.
- **Cleavage** is very indistinct.
- **Fracture** is conchoidal.
- **Hardness** is 6 - 6.5
- **Specific Gravity** is approximately 5.1+ (heavier than average for metallic minerals)
- **Streak** is greenish black.
- **Other Characteristics:** Brittle, striations on cubic faces caused by crossing of pyritohedron with cube. (note - striations on cube faces also demonstrate pyrite's lower symmetry). Pyrite unlike gold is not malleable.
- **Associated Minerals** are [quartz](#), [calcite](#), [gold](#), [sphalerite](#), [galena](#), [fluorite](#) and many other minerals. Pyrite is so common it may be quicker to name the unassociated minerals.
- **Notable Occurrences** include Illinois and Missouri, USA; Peru; Germany; Russia; Spain; and South Africa among many others.
- **Best Field Indicators** are crystal habit, hardness, streak, luster and brittleness.

<http://mineral.galleries.com/minerals/sulfides/pyrite/pyrite.htm> 2005

Appendix B

Limestone Information

<http://volcano.und.nodak.edu> 2005

Limestone is the most abundant of the non-clastic sedimentary rocks. Limestone is produced from the mineral calcite (calcium carbonate) and sediment. The main source of limestone is the limy ooze formed in the ocean. The calcium carbonate can be precipitated from ocean water or it can be formed from sea creatures that secrete lime such as algae and coral.

Chalk is another type of limestone that is made up of very small single-celled organisms. Chalk is usually white or gray in color.

Limestone can easily be dissolved by acids. If you drop vinegar on limestone it will fizz. Put a limestone rock into a plastic jar and cover it with vinegar. Cover the jar and watch the bubbling of the calcium carbonate and also the disintegration of the rock over a few days.



<http://www.fi.edu/fellows/fellow1/oct98/expert/limestone.htm> 2005



This sample of limestone has a large fossil in it. This happens all the time since limestone is made of shells and dead sea creatures that collect at the bottom of the ocean. They get buried by other sediment and, after millions of years of being under pressure, the particles get cemented together to form solid rock.

Limestone is a very strong rock and is often cut into large blocks and used in the construction of buildings and skyscrapers. Crushed limestone is also used to make cement, plaster and chalk.

Limestone fizzes in vinegar, which means that it reacts to acids. This also means that the outsides of many of our buildings and monuments are being affected by acid rain. Acid rain occurs when large companies pollute the air by releasing chemicals like sulfur into the atmosphere. The sulfur combines with hydrogen and oxygen in the air to form sulfuric acid!

<http://www.ivyhall.district96.k12.il.us/4th/kkhp/RocksandMinerals/Limestone.html> 2005

Appendix C

LAB SAFETY ANALYSIS

(For new task, a lab, to design safely the procedures and materials required)

Name of Project:

Worker (s) Name (s):

Description of Task (lab)	Materials Needed	Hazards Associated with this Task	Methods to Avoid Associated Hazards

I have completed this form with assistance from an experienced person or MHSSHA (Meeker High School Safety and Health Advisor) and am aware of the hazards associated with this new task. I will perform this task safely and appropriately.

Signature of Worker (s): _____

Date: _____

Signature of MSSHA or experienced person: _____ Date: _____

Lab Write-up Format

- Title
- Objective/Hypothesis
- Materials
- Procedure
- Data Table
- Analysis of Data
- Summary

Appendix D Idealized Lab Write-up and Procedures

Title: Acid Neutralization Lab

Objective: (*Varies but should relate to acid-base neutralization or buffering; maybe to acid run-off stream clean-up*)

Materials: (*Varies with what equipment you have and use in your school. See the list above.*)

Lab Procedure

1. Pick up beakers, pH paper and spray bottle filled with deionized water
2. Mass equal amounts of crushed limestone, industrial and locally-derived, adding each to own beaker. Record the mass values. Label the beakers: Ls industrial and Leadville Limestone
3. Mass equal amounts of crushed pyrite, industrial and locally-derived, adding each to own beaker. Record the mass values. Label the beakers: Pyrite industrial and Local Pyrite
4. Label the fifth beaker, Control.
5. Spritz the beakers with the deionized water until the bottom of each beaker has enough liquid to measure the pH. Measure the pH in each beaker and record.
6. Repeat step 5 for x days. Record your measurements daily in your data table.
7. On the x + 2 day, combine the industrial limestone and pyrite in one beaker and the locally derived limestone and pyrite in another beaker. Spritz the limestone-pyrite mixture as well as the control as you did in step 5, measuring and recording the pH values.
8. Repeat step 7 for x days. Record your measurements daily in your data table.
9. Clean up your experiment by dumping the rock-mineral mixture in to the trash can, and returning your beakers to the appropriate place.

Data Table 1 pH of Limestone, Pyrite, Limestone & Pyrite Samples and Control

Sample		pH measurements				
		Day 1	Day 2	Day 3	Day 4	Day 5
Chemical grade materials	Limestone					
	Pyrite					
	Limestone & Pyrite					
Naturally-occurring materials	Limestone					
	Pyrite					
	Limestone & Pyrite					
Control	Deionized Water					

Analysis of Data

1. What was the pH of the control? Did it change over time? Why is a control necessary?
2. What was the pH of the limestone? Did it change over time?
3. What was the pH of the pyrite? Did it change over time?

4. What was the pH of the limestone-pyrite mixture? Did it change over time?
5. Was there a difference between the chemical grade materials and the naturally-derived materials?
6. Explain how limestone works to alleviate the acid-leaching problem.
7. Write a balanced chemical equation for the reaction between water and limestone? Between pyrite and water? Between limestone, pyrite, and water?

Summary

(Write a summary statement or two of this lab, your results, if your hypothesis was correct, if incorrect, why, etc.) (On the back of this single page, have the lab format you expect your students to follow so that they can now write up the lab. Since materials needed are listed here, you may decide not to have them repeat that in their lab write-up.)

Appendix E Colorado's State Science Standards

The following standards may apply to this specific activity depending upon your emphasis.

1. Students understand the processes of scientific investigation and design, conduct, communicate about, and evaluate such investigations.

As students in grades 9-12 extend their knowledge, what they know and are able to do includes

- asking questions and stating hypotheses, using prior scientific knowledge to help guide their development; *[Review mining history of Colorado, the associated problems with tailings from over one hundred years ago, related environmental problems from run-off from the tailings and stream health]*
- creating and defending a written plan of action for a scientific investigation; *[Design the lab to test the problem presented]*
- selecting and using appropriate technologies to gather, process, and analyze data and to report information related to an investigation; *[How and what would be easy to measure for water quality, pH paper and review pH scale, deionized water—why should it be used instead of distilled water, etc..]*
- identifying major sources of error or uncertainty within an investigation *(for example, particular measuring devices and experimental procedures)*; *[Water purity—is it really deionized? How can we test that? What kind of human errors should we look for?]*
- constructing and revising scientific explanations and models, using evidence, logic, and experiments that include identifying and controlling variables; *[How do we fix problems with lab design?]*
- communicating and evaluating scientific thinking that leads to particular conclusions; *[Organizing and analyzing data to share and discuss with others.]*
- recognizing and analyzing alternative explanations and models; and *[Listen to other students' analysis of their data and conclusions.]*
- explaining the difference between a scientific theory and a scientific hypothesis. *[During debriefing of lab, results, etc.]*

Colorado Content Standards Adopted 5-10-95; Amended 11-9-95 Science - 7

For students continuing their science education beyond the standards, what they know and are able to do **may** include

- designing and completing an advanced scientific investigation—either individually or as part of a student team—that extends over several days or weeks; and

- continuing to practice and apply inquiry skills as they extend their understanding of science content through further study. *[Enrichment or extensions that may arise due to students' interest]*

2. Physical Science: Students know and understand common properties, forms, and changes in matter and energy.

2.1 Students know that matter has characteristic properties, which are related to its composition and structure.

As students in grades 9-12 extend their knowledge, what they know and are able to do includes

- examining, describing, measuring, classifying, and predicting common properties of substances (*for example, electrical charge, chemical reactivity, acidity, electrical conductivity, radioactivity, relationships in the periodic table*); *[pH measurements, predicting what could happen based on prior knowledge or the handout on limestone & pyrite]*
- describing and explaining properties and composition of samples of matter using models (*for example, atomic and molecular structure, the periodic table*); *[Acid-base interactions]*
- using word and chemical equations to relate observed changes in matter to its composition and structure. *[Explain reactions; balance with given chemical formulas]*

4. Earth and Space Science: Students know and understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space.

4.1 Students know and understand the composition of Earth, its history, and the natural processes that shape it.

As students in grades 9-12 extend their knowledge, what they know and are able to do includes

- evaluating the feasibility of predicting and controlling natural events (*for example, earthquakes, floods, landslides*); *[Water run-off through tailings piles that have been abandoned years (one hundred +) ago; groundwater movement—fracturing of limestone, faults in mineral-bearing igneous and metamorphic rocks; can limestone be found adjacent or near mine tailings naturally in Colorado?]*
- analyzing the costs, benefits, and consequences of natural resource exploration, development, and consumption. *[As demands for certain metals & minerals increase, tailings will become another source for those materials; costs of re-milling vs. a new mine; current prices of minerals associated with pyrite in Colorado; use of limestone]*

4.3 Students know major sources of water, its uses, importance, and cyclic patterns of movement through the environment.

As students in grades 9-12 extend their knowledge, what they know and are able to do includes

- identifying and explaining factors that influence the quality of water needed to sustain life; *[What is clean water definition? What do trout, microorganisms, humans, etc. need for live in regards to water quality?]*
- identifying and analyzing the costs, benefits, and consequences of using water resources; *[How much water is used in mining? What is the cost? What is the cost of water for human consumption? What is the cost to keep water clean?]*

Colorado Content Standards Adopted 5-10-95; Amended 11-9-95 Science – 24

5. Students know and understand interrelationships among science, technology, and human activity and how they can affect the world.

As students in grades 9-12 extend their knowledge, what they know and are able to do includes

- analyzing benefits, limitations, costs, and consequences involved in using technology or resources (*for example, X-rays, agricultural chemicals, natural gas reserves*); *[Why do we need clean water? Relate the problem to this question.]*
- analyzing how the introduction of a new technology has affected or could affect human activity

(for example, invention of the telescope, applications of modern telecommunications); [New ways to clean-up mine tailings; new ways to mine the tailings; new ways to clean water]

- demonstrating the interrelationships between science and technology (for example, building a bridge, designing a better running shoe); [Tailings clean-up and mining due to current/recent technology].

For students continuing their science education beyond the standards, what they know and are able to do **may** include

- applying their knowledge and understanding of chemical and physical interactions to explain present and anticipated technologies (for example, lasers, ultrasound, superconducting materials, photocopy machines); and
- exploring the scientific and technological aspects of contemporary problems (for example, issues related to nutrition, air quality, natural resources). [Enrichment and/or extensions dependent upon students' interests]

Colorado Content Standards Adopted 5-10-95; Amended 11-9-95 Science - 28

6. Students understand that science involves a particular way of knowing and understand common connections among scientific disciplines.

As students in grades 9-12 extend their knowledge, what they know and are able to do includes

- explaining that the scientific way of knowing uses a critique and consensus process (for example, peer review, openness to criticism, logical arguments, skepticism); [How do you know that your design is good? What about your data results? Is your interpretation the only possible one?]
- using graphs, equations, or other models to analyze systems involving change and constancy (for example, comparing the geologic time scale to shorter time frames); [Chemical equations of reactions; graphs of the various substrate and their pH changes over time]
- identifying and predicting cause-effect relationships within a system (for example, the effect of temperature on gas volume, effect of carbon dioxide level on the greenhouse effect, effects of changing nutrients at the base of a food pyramid); [Acid-base reactions and interactions; will the limestone form an acid or a base? Will the pyrite form an acid or a base?]
- identifying and describing the dynamics of natural systems (for example, weather systems, ecological systems, body systems, systems at dynamic equilibrium); [Water equilibrium with run-off from tailings and through limestone; limestone as a buffer]
- identifying and testing a model to analyze systems involving change and constancy (for example, a mathematical expression for gas behavior; constructing a closed ecosystem such as an aquarium); [Acid-base reactions; chemical formulas]
- refining a hypothesis based on an accumulation of data over time (for example, Alvarez's theory on dinosaur extinction). [Was your hypothesis correct? If not, what can you do to re-test, modify, etc.]

Colorado Content Standards Adopted 5-10-95; Amended 11-9-95 Science - 30

For students continuing their science education beyond the standards, what they know and are able to do **may** include

- relating small-scale phenomena to large-scale properties (for example, intermolecular forces related to physical properties); and
- tracing the development of an invention, theory, or discovery to demonstrate the dynamic nature of science. [Enrichment and or extensions dependent upon student interest.]

Colorado Content Standards Adopted 5-10-95; Amended 11-9-95 Science - 31