

How is Mine Drainage Formed?

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About This Activity...

Prep Time Required:

10 minutes

Grade Level:

Middle School,
High School

Subjects:

Chemistry, Earth Science,
Physical Science

Duration of Activity:

30 minutes

Pennsylvania

Standards Addressed:

1.1.5.CEG
1.2.5.A
1.2.8-11.A
1.8-11.CEG
4.3.7-10.B
4.7.7.C
4.8.7-10.C

Setting:

Classroom

Vocabulary:

Oxidation-Reduction
Reaction
Pyrite

Prerequisites:

Knowledge of basic
chemistry, science

Summary:

Students read information about AMD and complete worksheets about how mine drainage is formed.

Materials:

- Reading Handout
- Worksheet
- Crossword Puzzle

Objectives:

Students will be able to:

- explain how mine drainage is formed.
- Define chemical terms.
(oxidation-reduction reaction,
precipitation reaction, acid-base
reaction)

Background:

Pyrite or fool's gold is found in most coal mine sites. Abandoned mine drainage (AMD) is formed when groundwater comes in contact with **pyrite** (iron sulfide). The pyrite dissolves into the water and forms iron ions and sulfide ions. The sulfide reacts with oxygen to form sulfate and acid. The iron usually stays dissolved until it reaches the surface. If the pH of the discharge is increased above 3, the oxygen in the air reacts with the iron to form iron hydroxide, an orange gelatinous solid.

These reactions can be used to illustrate a wide variety of chemical reactions. The reaction of iron and sulfide with oxygen is an example of an **oxidation-reduction reaction**. The formation of acid in the reaction could lead to acid-base reactions if it is neutralized by limestone in the soil. The reaction to form iron hydroxide is also a precipitation reaction.

Procedure:

Warm-up:

Show students photographs of mine drainage discharges and ask what they notice about the photographs. Ask the students if they know what the orange color is from.

If you have mine drainage available,

hold up a beaker of the fresh drainage.

It should be clear. Ask the students if they would drink the water (don't let them). They might be able to smell the rotten egg smell of sulfide in the drainage. Then, slowly add 3% hydrogen peroxide (from the drug store). The iron hydroxide should start to precipitate and turn the solution orange and cloudy. Ask the student where the orange color came from.

Activity:

Have students read the student hand-out. There are several different parts. You could have each student in a group read a different part and then explain his or her section to the rest of the group. The student should then complete the worksheet and crossword puzzle in groups.

Wrap-up/Conclusion:

Have each group explain to the entire class a step in the formation process.

Assessment:

- Observe students' understanding of the activities as they work together to complete the worksheets and discuss AMD formation.

Extensions:

- Take a field trip to an AMD treatment facility and/or an AMD impacted watershed to see the affects of the pollution on the environment.

Adaptations:

Younger students can just explain steps in the formation process to the class in a general form, and not complete the worksheets.

Mine Drainage Formation

Student Reading Handout

Abandoned Mine Drainage

Orange water flows through beautiful valleys. White powder coats the bottom of a clear mountain stream. A huge fountain of smelly water pours out of the edge of a stream. Water that should be full of life is dead. These and thousands of other similar scenes are found all throughout the Appalachian Mountains. What's going on here? ... Abandoned Mine Drainage!

Mine drainage is formed in coal mines. Many of these mines were abandoned by the mining companies years before. Water coming out of the coal mines contains metals that leave orange, white, and black solids when they mix with the air. The water can also contain acids (strong chemicals that can burn your skin). Both metals and the acid are harmful to the fish and bugs that live in the streams.

Forming Mine Drainage

Mine drainage is formed first in the coal mines. After all the coal has been removed from the mines, the mining companies remove the last supports that hold up the roof of the mines. Eventually, the mine fills up with water and the roof collapses. In the roof material, there is a mineral called pyrite. Pyrite is also called Fool's Gold because it looks very much like gold. Pyrite though is made of iron and sulfide. The pyrite breaks up into small pieces when the mine caves in. These pieces are surrounded by water. Slowly, the iron and the sulfide dissolve into the water.

The water in the mines is part of the groundwater system. Groundwater is the water that seeps slowly into the ground and fills spaces between pieces of rock and soil. Groundwater moves very slowly from the places it seeps in to places where the groundwater flows out of the ground. You may have seen a flowing spring or a wetland where groundwater flows out of the ground. If groundwater has been in a mine, it is now mine drainage. It has in it particles of iron and sulfide. These particles are so small that you can't see them, so the mine drainage might look clear when it first comes out of the ground. But, often it smells like rotten eggs from the sulfide.

As the water moves through the ground, it can dissolve other metals as it contacts rocks and minerals. The most common metal in rocks is aluminum and mine drainage can dissolve the aluminum. Other metals commonly found in mine water include manganese, calcium, and magnesium.

Once the mine drainage comes up out of the ground, it mixes with oxygen in the air. When that happens, the oxygen reacts with the iron, sulfide, and other metals. When the oxygen reacts with the iron, it forms an orange-yellow solid called iron oxide. The process of forming a solid from a clear solution is called precipitation and the solid is called a precipitate. The orange solid is very sticky and slippery. It coats the bottom of the streams with a sticky, orange mess. The orange precipitate can make the water cloudy and more difficult for the animals to see. It is also slippery, so insects that cling to rocks have a hard time holding on. The orange solid in a stream makes it difficult for plants and animals to survive there.

The oxygen also reacts with the sulfide and forms sulfate and acid. This can happen below ground as well if there is a little bit of oxygen still in the mines. The sulfate makes the water taste bad, but the acid makes the water uninhabitable for most plants and animals.

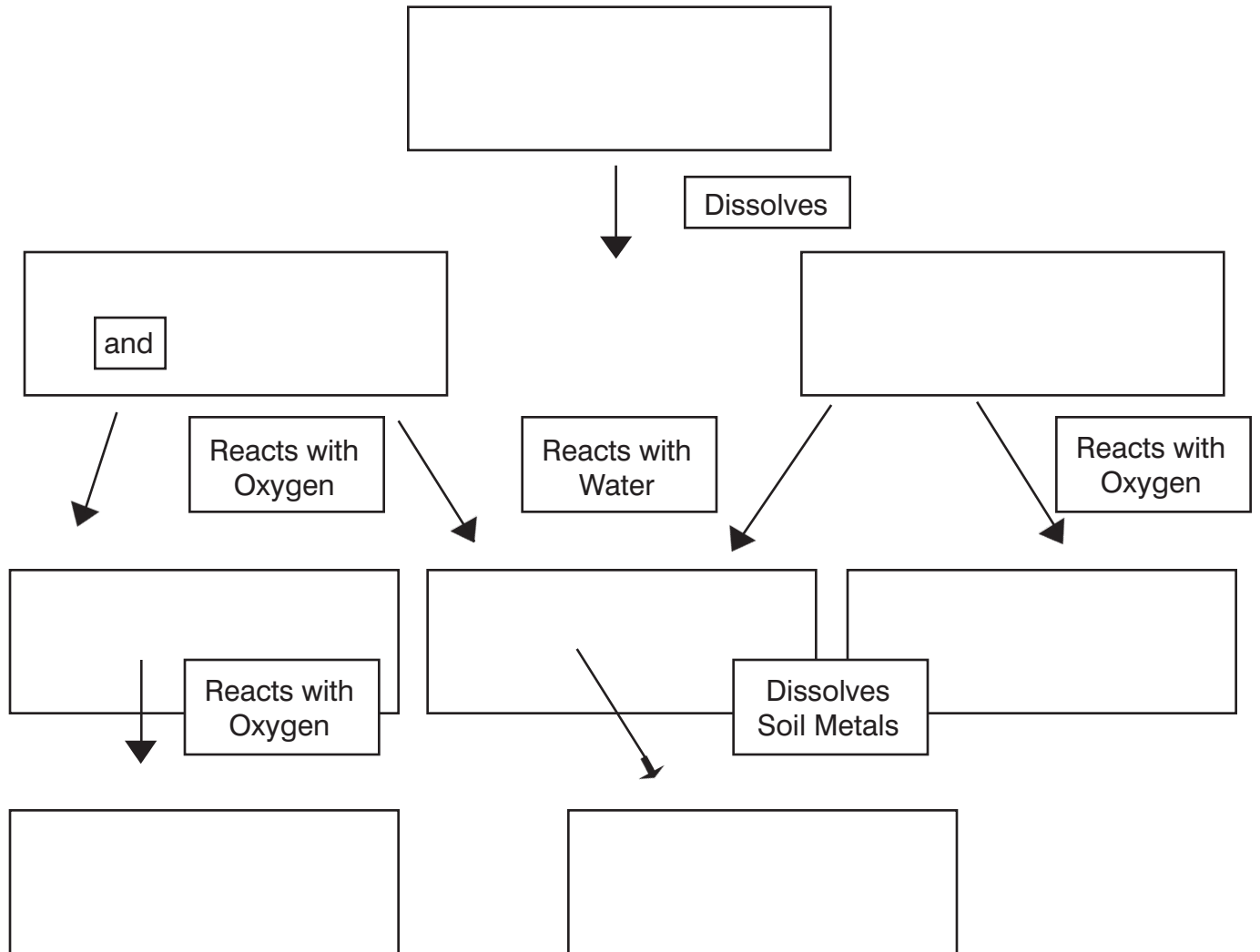
Aluminum is particularly harmful to animals that live in the water. A very tiny amount of aluminum can kill fish and other animals. The aluminum also forms a precipitate when it flows into a stream. This white precipitate can cling to the gills of the water animals and makes it impossible for them to breathe.

Abandoned mine drainage is a serious problem throughout Appalachia. It has turned beautiful mountain streams into lifeless orange ditches. The mine drainage is formed in the abandoned coal mine from the mineral pyrite. Because it contains high amounts of metals and acid, mine drainage can have serious impacts on stream life. Because of these problems we need to find ways to clean up the mine drainage.

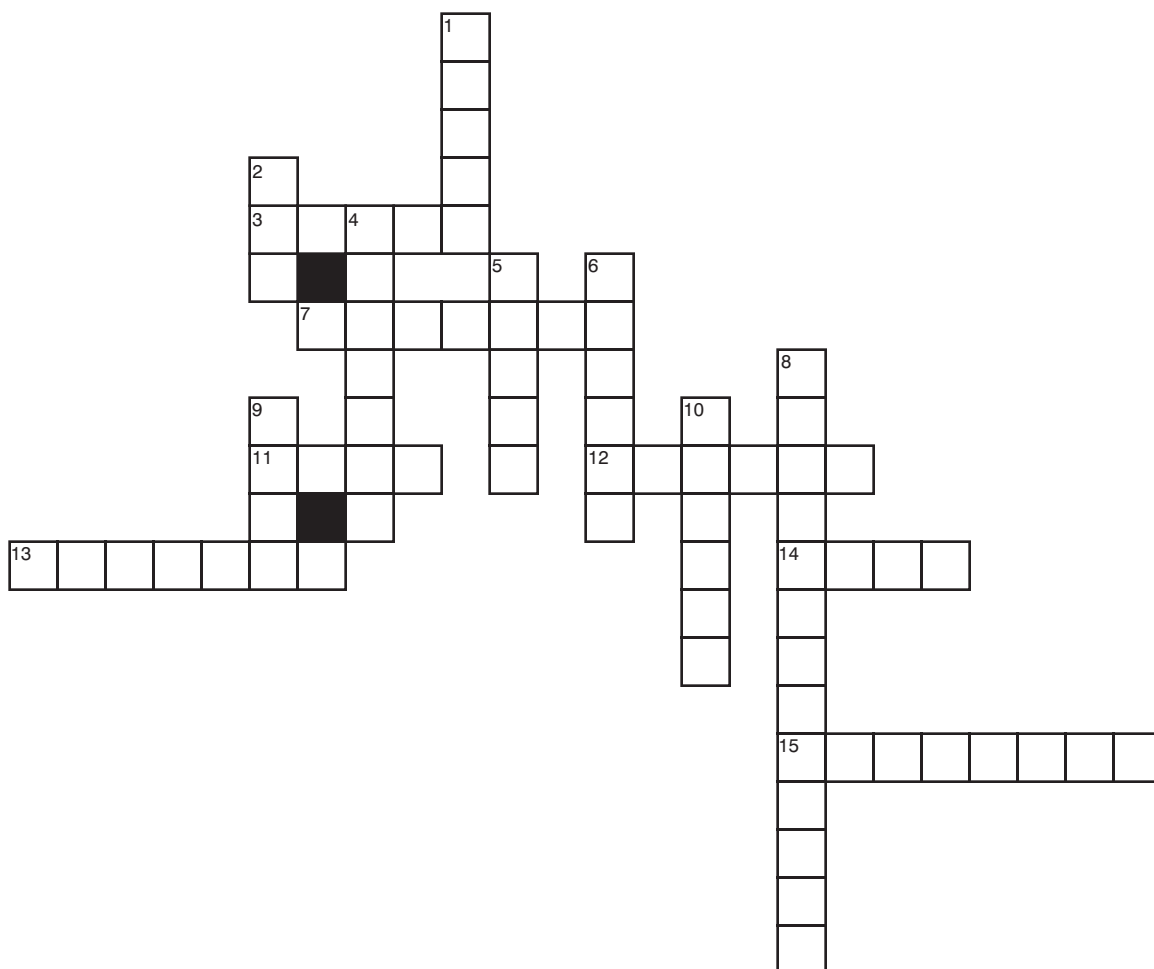


Mine Drainage Formation Student Worksheet

Directions: Use the reading to fill in the blanks in the following diagram.



Mine Drainage Formation



ACROSS

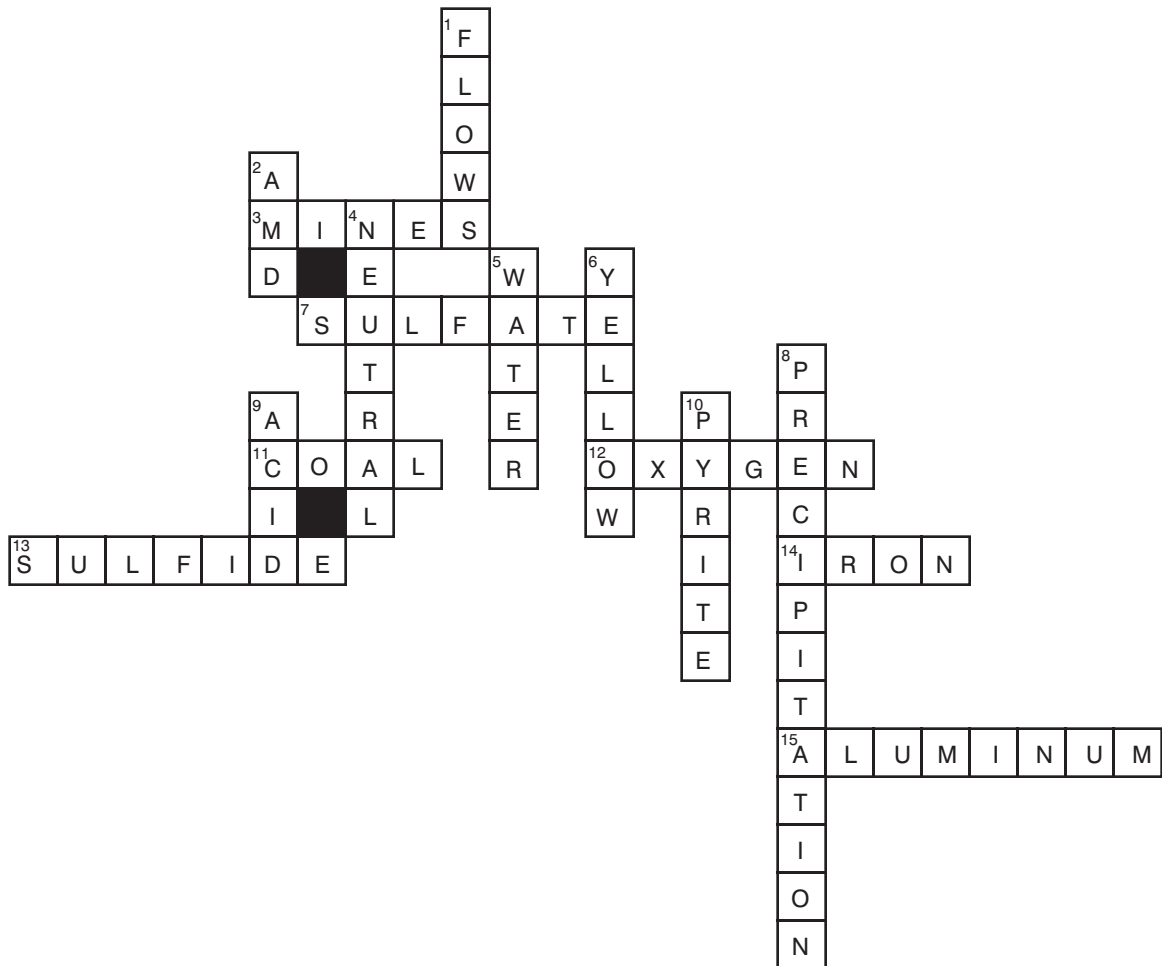
3. Places where coal is extracted
7. The form of sulfur found underground
11. The black rock mined for fuel
12. The part of air that reacts with iron and sulfide
13. The form of sulfur found above ground
14. _____ oxide; the orange solid formed in AMD
15. A metal that dissolves from the soil when water is acidic

DOWN

1. How water moves
2. Abandoned mine drainage, for short
4. When a solution is neither an acid nor a base
5. The liquid that carries iron and sulfide to the surface
6. A local name for the orange solid in AMD _____ boy
8. The chemical process that forms a solid from a clear solution
9. Vinegar or lemon juice, for example
10. Another name for Fool's Gold



TEACHER'S ANSWER SHEET — MINE DRAINAGE FORMATION



ACROSS

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