Processing Chemical Reactions

Lesson Plan

Description

Students will learn about the role of metallurgists in the processing phase of mining and learn how to process lime from limestone.

Learning Outcomes

- Associate careers with the processing of rocks and minerals
- Use lab practices to process lime from limestone
- Understand the applications of chemistry to the mining industry
- Understand the importance of lab safety

Introduction

Mixtures

A mixture is a term used in chemistry to describe a combination of substances.

There are different kinds of mixtures. Mixtures can be homogeneous or heterogeneous. Lemonade is an example of a homogeneous mixture. It is made up of lemon juice, water, and sugar, but you cannot visibly see those three ingredients. Salad dressing is an example of a heterogeneous mixture. It is made of vinegar, oil, and spices. You can see pockets of oil and vinegar, and you can see the spices floating in it.

Lemonade is also an example of a solution. A solution is a mixture in which a small particle has dissolved in another substance. If there are too many small particles, more than the other substance can hold, it will come out of solution. While a mixture is a solution, it is homogeneous.

Salad dressing is an example of a suspension. A suspension is a mixture which, if it is left undisturbed, will separate again into its component substances.

Mixtures can also be solid, instead of fluid. For example, soil is a mixture of organic matter, silt, sand, and clay. Alloys – metals made of more than one element – are also mixtures.

States of Matter

There are four fundamental states of matter: solid, liquid, gas, and plasma. The same substance changes state when energy is added or taken away.

Molecules in a substance are attracted to one another. When they have less energy, the molecules therefore have to stay close together, in a much more rigid structure. This is the solid state.

If some energy is added, the molecules can gain more distance from each other, and move more quickly. The structure therefore becomes loosened, and the state changes to liquid.

If even more energy is added, the molecules can break even further from one another, and move even faster, changing state to gas.

The most common way to add energy to a substance is to apply heat. The same process can be done in reverse. We call the point at which a substance changes from liquid to gas a boiling point, and the point at which liquid becomes solid a freezing point.

A change in state is a physical reaction.

Chemical and Physical Reactions

A physical reaction is one which only affects the physical attributes of a substance. While molecules may be rearranged, they are not altered. A change in state is an example of a physical reaction. Another is peeling an orange or whipping cream. Whipped cream has a different viscosity than table cream, but the chemical formula for that cream has not changed. It has simply been turned into a mixture of table cream and air.

A chemical reaction is one which alters the substance itself. When you combine baking soda and vinegar, they create carbon dioxide, water, acetate, and sodium. The original substance no longer exists; it has been turned into something else.

If you tear a piece of paper, that is a physical reaction. Nothing has been changed; it is just in two pieces now. If you then burn those halves of paper, that is a chemical reaction. The paper is no more; now it is ash and smoke.

Mining: The Processing Phase

When ore is mined, the valuable mineral or metal is contained inside that ore, alongside other minerals or metals. The valuable mineral or metal has to be separated from the rest of what makes up the ore. This is called processing. Processing is overseen by metallurgists. Metallurgical engineers design, develop and operate the industrial processes that transform these source materials into the useful materials and manufactured products

Ores are all processed differently, depending on what the ore is, what company has extracted that ore, and what kind of facilities are available. All mining companies have proprietary methods which they don't share, so we don't know exactly what chemical reactions are used, but we do know that processing involves the addition of heat, water, and various chemicals. What exactly is added depends on what metals or elements are being extracted. In some cases, magnets or gravity can be used for certain metals. For example, in Sudbury, nickel-rich pentlandite is hosted in magnetic pyrrhotite. The

ore is crushed into small pieces, and the pyrrhotite is separated from the copper-rich bornite and chalcopyrite by magnets. Gold is another metal mined in Sudbury. In some cases, cyanide might be added to extract the gold from surrounding rocks and minerals, but the ore can also be crushed, and gravity can be used to separate the very heavy gold from the other minerals.

Pyro processing is processing via the addition of heat. It often uses combustion as a source of sustained heat, in order to change the ore. It may do so by decomposition, in which case the heat causes the components to break apart from one another. It may also be used to induce oxidation, chlorination, or other gas-solid reactions. Smelting releases oxygen, leaving only carbon, by melting the ore to a liquid state. There are many varieties of tools, ovens, and machineries used in pyro processing, much of which is proprietary and unique to different mining companies. However, the use of heat to process a mineral into something more valuable is far from new.

Richard Zane Smith is a Wendat man hard at work at reviving traditional Wendat pot-making. This process involves two processing stages – one which uses water and motion, and one which uses heat. First, clay must be found naturally. Then it must be crumbled and dried. Once completely dried, the clay is added to rainwater and left for an hour, until it is smooth to the touch. Then it is vigorously stirred, so that organic material floats to the top, and stones collect on the bottom, and the clay becomes a mixture with the water. Floating organic material is filtered out, and stones are removed by hand. The clay solution is passed through a very fine mesh screen to remove impurities and left to settle overnight. The water is siphoned off, and this process is repeated over days or weeks, removing water until the clay has the consistency of pancake batter. It is then left on a prepared surface to dry until it has the texture of margarine, at which point it is ready for temper to be added. Temper is crushed pottery shard, shale, or shell which helps the clay dry evenly and reduce thermal shock in the heat processing phase.

In the heat processing phase, the earth at the firing site is dried with a bonfire. The next day, a new fire is built which is burnt down to coals. Pots are placed in a ring around the fire and turned with gloves. The coals are then covered in pottery shards, and the hot pots are placed above those shards without touching each other. When the pots ring when touched, they are placed more huddled in the centre of the fire, now touching. Wood is stacked around the pots, and the fire is relit. When the pots turn black, and then begin to glow red, more wood can be added. When the pots begin to glow orange, they can begin cooling back to the red-heat temperature. Shovels of ash and coals are placed over the pots until they are buried, and they are left overnight or until they can be handled without gloves. They are greased while warm.

Action

Part 1: Sort a Mixture

Put students into groups of 2-4.
Give each group supplies.

Materials:

- Soil samples with pebbles and small pieces of limestone mixed in. Limestone should be no bigger than 1-2cm in diameter; it can be easily shattered with a hammer to reduce size if needed. Limestone screenings can be purchased at most hardware stores with appropriately sized pebbles.
- Sifters
- Vinegar dropper bottles
- Water
- Bowls

Explain to the students that they will be acting as metallurgists today. A sample from the mine has been sent up and needs to be processed from the raw product, limestone, into the product, lime.

While the large slabs of limestone can be sold as-is to landscapers and construction companies, in order to reduce waste, the smaller samples are being processed into lime, to be used in regreening efforts down the line. The limestone first needs to be sorted from the mine waste.

Have students follow the instructions in Part 1 of the provided Lab Manual to separate the limestone from the mine waste.

Part 2: Refine the Product

Explain to the students that the lime needs to be separated from the stone they have separated using a chemical reaction. Provide lab safety equipment at this time, including gloves and goggles.

Have students follow the instructions in Part 2 of the provided Lab Manual to create a lime solution.

Materials:

- Gloves
- Goggles
- Limestone
- Vinegar
- Glass container
- Stir stick

- Indicator

At this stage, the experiment will need to be left overnight to dissolve fully.

Part 3: Isolate the Product

The lime has been extracted, but it is still in solution. Explain to the students that the extracted lime needs to be processed so that it is in powder form. This will be done by applying heat.

Have students follow the instructions in Part 3 of the provided Lab Manual to reduce the lime solution.

Materials:

- Lime solution
- Glass container
- Hot plate

Part 4: Gameplay

Students will play the Mine Evolution digital game and see processors in action while competing to process the most ore. Scores for each student can be collected on the scoresheet.

Materials:

- 1 device per student

Procedure:

- Each student will need a device (laptop, tablet, or mobile phone).
- Each student will need to go to mineevolution.ca on their device. Click “Get the Game”.
- Students can download either the Google Play (Android devices and Chromebooks), App Store (Apple devices), or PC versions of the game depending on what type of device they are using.
- Once the game is downloaded, select “Challenges”.
- Select “Processing Chemical Reactions” and begin playing! The tutorial will show students how to play. There is also a tutorial video and a “How to Play” document with tips and tricks on the Science North educator resources website (https://schools.sciencenorth.ca/educator-resources).

Consolidation/Extension

Soil around a mine site can become acidic, depending on what is being mined, and how. Lime is a base and is used to restore the soil to a state in which things can live and grow again.

Conduct an experiment to see how lime can be used to restore the land.

1. Create a soil suspension by adding a spoonful of soil to a cup of water. Acidify the soil suspension by adding a few drops of vinegar.
2. Use an indicator to test the soil suspension.
3. Weigh your lime solution. Add it to the suspension a pinch at a time, until your indicator shows it has returned to neutral.
4. Weigh the remaining lime solution.
5. How much lime solution did you need to use to restore your soil?

Ask an Indigenous elder in your region if there is a local clay deposit and try following the instructions in the background information to make your own clay!

Accommodations/Modifications

By having students work in groups, you can assign roles within the group which suit each member.

There is a different lab manual for Grades 4-6, 7-8, 9, and 10. Make sure you're using the right one for your class.

Assessment

Have students made thoughtful and accurate observations in their lab manuals?
Do students practice lab safety?
Do students make connections between chemistry, mining, and careers?

Additional Resources

https://www.miningneedsyou.ca/world-of-mining/
https://www.miningneedsyou.ca/interactive-quiz/

https://www.sciencenorth.ca/teachers -> look for the chemistry lessons for your grade!
https://schools.sciencenorth.ca/educator-resources -> look for the chemistry lessons for your grade!

https://miningmatters.ca/resources/education/mining-week