VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE

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Iron in Cereal

Spring 2016

Goal: To learn the difference between elements, compounds, and mixtures by studying the different forms of iron. To explain why iron is useful in our diet.
Fits Tennessee standard GLE 0507.9.1

Lesson Outline:

I. Background for VSVS members only
Information is given about the forms of iron used in cereals and iron supplements.

II. Introduction: Elements, Compounds, and Mixtures
Discuss elements, compounds, and mixtures and focus on iron.

III. Physical Properties of Iron
A. Students examine the magnetic properties of elemental iron using a magnet.
B. Separating Iron from a Mixture: Demonstration.
VSVS volunteers show students how to separate elemental iron from a mixture using a magnet.

IV. Chemical Properties of Iron - Rusting

V. Removing Iron from a Mixture (Cereal)
Students will use a magnet to remove iron from a cereal (Frosted mini wheats). Be sure that every group is successful in extracting iron particles that they can see, either with the naked eye or with the hand lens.

VI. Review.

1. In the car ride, read through this quiz together as a team. Make sure each team member has read the lesson and has a fundamental understanding of the material.

Lesson Quiz

1. What is the difference between a mixture and a compound in regards to how each can be separated into components??
2. How could you separate iron from a mixture?
3. What is oxidation and what are some real-world examples of it?
4. Why does hydrogen peroxide cause iron to rust faster?
5. Why is iron important for the human body; do we synthesize iron within our bodies?

2. Use these fun facts during the lesson:

- Iron is a mineral that is found in every cell of the body. The most important role of iron in the body is in respiration. Iron binds oxygen in the blood, allowing an adequate supply of oxygen to be carried throughout the body from the lungs.
- Animals and plants require iron. Plants use iron in chlorophyll, the pigment used in photosynthesis. Humans use iron in hemoglobin molecules in blood.
- Iron is the sixth most abundant element in the universe and the fourth most abundant element in the earth's crust. It comprises about 5.6% of the earth's crust and almost all of the earth's core.
- The element symbol for iron is Fe, which comes from the Latin word for iron, "ferrum".
- Steel is made from iron and carbon, which makes it harder than iron. Steel can also be galvanized to prevent iron oxide from forming (ie rusting). This process usually involves a very thin layer of zinc being applied to the surface.

Materials – enough for 16 pairs

1 box of goggles (32)
Models representing iron and oxygen as elements, and in a compound, and mixture
17 8x11 periodic tables in page protectors
16 ziploc bags containing:
- 1 oz sealed wide-mouth bottle of Iron metal
- 1 oz sealed wide-mouth bottle of Iron oxide- Fe_2O_3
- 1 oz sealed wide-mouth bottle of iron filings
- 1 oz sealed wide-mouth bottle of sand containing iron
- 1 white Teflon magnet

1 8 oz jar of sand (half full) and a cow magnet
16 plates
16 ziploc bags containing:
- 1 1 oz wide-mouth bottle of iron filings
- 1 1 oz wide-mouth bottle of salt
- 1 plastic scoop

1 plastic bag containing 32 1oz cups with cotton ball
1 plastic bin containing:
- 16 Dropper bottles containing water
- 16 Dropper bottles containing hydrogen peroxide

16 plastic bags containing
- 1 hand lens
- 1 tissue (Kim wipe)
- 1 laminated piece of paper containing 18mg iron

16 ziploc sandwich bags of sugar mini-bite shredded wheat (35 grams – ½ cup)
10 ziploc sandwich bags (extras to give to students who break the bag with the cereal)
32 Observation Sheets
16 Instruction Sheets in Sheet Protectors with copies of the ingredients list given on the cereal box on back
1 trash bag

Note: The magnets used in this lesson are expensive. Please check carefully to be sure all magnets are returned.

Unpacking the Kit:

VSVSers do this while 1 person is giving the Introduction. Note that students are put into pairs and should have their pencils ready.

For Part II. Elements, Compounds, and Mixtures

- 17 periodic tables in page protectors (1 per pair)
- 1 bag containing iron element, compound and mixture models
- 16 bags containing 1 oz sealed wide-mouth bottle of Iron metal, 1 oz sealed wide-mouth bottle of iron oxide- Fe_2O_3, 1 oz sealed wide-mouth bottle of iron filings, 1 oz sealed wide-mouth bottle of sand containing iron, 1 white Teflon magnet
- 32 observation sheets and 16 instruction sheets

For Part III B Demonstration: Using the magnetic property of iron to separate a mixture.

- 1 8 oz jar with sand and a cow magnet

Your Notes:

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For Part IV. Chemical properties of Iron – Oxidation (Rusting)

16 plates
16 ziploc bags containing 1 oz wide-mouth bottle of iron filings, 1 oz wide-mouth bottle of salt and 1 plastic scoop
1 bag containing 32 1oz cups with cotton balls
1 plastic bin containing dropper bottles of water and hydrogen peroxide

For Part V. Removing Iron from a Mixture (Cereal)

16 sandwich bags of cereal
16 plastic bags containing 1 hand lens,1 tissue and 1 laminated piece of paper with 18mg iron

I. Background for VSVS members only.

Dietary iron supplements are usually in compound form; however, cereal manufacturers prefer to add particles of iron metal (called elemental iron or reduced iron) because elemental iron is stable in storage and does not affect the cereal's flavor. The body cannot use elemental iron, but the body's stomach acid, HCl, reacts with elemental iron to produce iron ions. Cereals with 90 – 100% of the daily adult requirement of iron (18 mg) will be used in this experiment.

II. Introduction: Elements, Compounds, and Mixtures.

Materials

17 periodic tables in page protectors (1 per pair)
Iron element, compound and mixture models

Write the following on the board:

element	compound	mixture	elemental iron	reduced iron
Fe	**Fe_2O_3**			

Hand out the large periodic tables in page protectors.
Ask students: What is the difference between an element, compound, and mixture? (Keep the discussion as simple as possible.)

- **Elements** are the building blocks of matter. Use the periodic table while you discuss elements.
  - Show students the element models. Explain that there is only one kind of atom here.
    - One bag contains only red balls. The **red** balls represent **iron**.
    - The other bag contains only **blue** balls which represent **oxygen**.
  - Show students the placement of iron and oxygen in the periodic table.

- **Compounds** are made up of two or more **<u>elements that are chemically bonded together.</u>**
  - Show students the rust (iron oxide) model. Explain that there are two kinds of atoms here and that they are connected to one another.
    - The red atom is iron and the blue atom is oxygen.
    - Tell students that there are two iron atoms for every three oxygen atoms.
    - Other examples of compounds include water (H_2O), carbon dioxide (CO_2), table sugar ($C_{12}H_{22}O_{11}$), and table salt (NaCl).

Your Notes:

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- **Mixtures** are made up of **<u>two or more different elements or compounds</u>** which can be separated by physical means.
    - Show students the bag of mixed balls. Explain that each differently colored ball represents an element or compound.
        - The balls are not connected, so they are a mixture.
        - Examples of mixtures include salt in water, air, soil, and sand. Mixtures can be made with any combination of phases of matter: solid in solid, (sand), solid in liquid, (salt in water), gas in liquid (carbon dioxide bubbles in water) etc

Tell the students: in today's lesson you will be studying some physical and chemical properties of elemental iron**.**

Give each pair a bag containing:

1 oz sealed wide-mouth bottle of Iron metal
1 oz sealed wide-mouth bottle of iron oxide- Fe_2O_3
1 oz sealed wide-mouth bottle of iron filings
1 oz sealed wide-mouth bottle of sand containing iron
1 white Teflon magnet

Give each student an observation sheet and an instruction sheet.

Tell the students to look at the labels on the bottles.

Ask students:

- How can we tell if a chemical is an **element or a compound**?
- *The formula for an element contains only one atomic symbol, whereas the formula for a compound contains more than one atomic symbol.*
- Which containers have the element? *Fe (Iron Filings)*
- Which container has the compound? *Fe_2O_3 (rust)*
    - Point out to students that iron oxide is a compound because it has two different elements - iron, and oxygen - which are chemically combined. The small numbers give the ratio of elements in the compound.
    - Ask students what happens when an iron shovel is left outside? *When it is left outside, the iron reacts with oxygen to form rust, which is iron oxide.*

Tell the students:

- Every compound has its own properties, which are different from the properties of the elements that make up the compound. In their tests today, the students will study the physical and chemical properties of elemental iron and iron in iron oxide (rust).

III. What are the Physical Properties of Elemental Iron and Iron Oxide?

A. Physical Properties of Elemental Iron and Iron Oxide.

a. Ask students: What are some <u>physical properties</u> of elemental iron?

Iron is a metal. It is hard. It is shiny. It is attracted to magnets.

b. Ask students: What are some physical properties of the compound iron oxide?

Iron oxide is a powder. It is red. It is not attracted to a magnet.

Tell the students to put the magnet on the **outside** of the iron metal and the iron filings container, and to slowly move it up the side or across the vial. What happens?

- Have them repeat this with the iron oxide container.
- Emphasize that the physical properties of elemental iron and iron compounds are not the same.
- Have students check the appropriate blank for Part III on the Observation Sheet.

Your Notes:

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B. Demonstration: Using the magnetic property of iron to separate a mixture.

Materials

1 8 oz jar with sand and a cow magnet

Tell students to look at the sand in their jar.

- Ask students: Is this an example of an element, a compound, or a mixture? *Mixture*
- Why do you think it is a mixture? *Because it contains different kinds of particles.*
    - Tell the students that sand is a collection of fragments of minerals, shells, fossils and organic matter. Sometimes it contains iron in the form of magnetite, which is magnetic.
- Ask students: Do you have any ideas how we can separate the iron from the sand? *With a magnet. Be sure to point out that the iron is magnetic and sand is not. Also be sure to mention that separation by magnetism is a physical means of separation.*

Emphasize that <u>a physical property</u> of iron can be used to separate the mixture.

Demonstration:

- Tell students that you will use a cow magnet to separate the iron filings from the sand.
- The cow magnet will already be in the jar. Pull it out of the sand, and take it around the class to show the students the iron filings on it.
- *Do not let the students perform this test with the sand or the iron filings in their jars – we want to keep the magnet clean for the test in the cereal. Also, there is a very small amount of the magnetite in the sand, which would make it very difficult to see.*

Collect all the containers but leave the magnet for a later experiment.

Share the following information with the students:

- Cow magnets are used by farmers to protect the cow's stomachs from being punctured by small pieces of baling wire or other bits of wire that cows might eat with hay.
- Cows have four stomachs. The cow magnet is placed in the first stomach to attract bits of wire in order to keep them from entering the other three stomachs.
- Farmers or veterinarians open a cow's mouth and place the cow magnet down its throat into the first stomach.
- Cow magnets are available from farm supply stores, farmer's co-ops and science supply stores.

IV. Chemical properties of Iron – Oxidation (Rusting)

Ask students if they know what **oxidation** means? What are some things that **oxidize**?

*Oxidation usually occurs when an element or compound combines with **oxygen**.*

Iron is oxidizing when it rusts and turns a reddish color. This is a chemical property of iron.

Ask students to name things that rust?

Anything made of iron, that is left outside (in the rain) will rust faster than things kept dry and inside. Examples may include gardening tools, bicycles, anything with exposed iron.

Rust is the common name for a very common compound, iron oxide. Rusting is a very slow process which takes place over several weeks or months.

Your Notes:

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Ask students if they have ever seen iron rust in a few seconds? *Probably not!*

Tell the students they are going to put some chemicals together that will cause rusting in just a few minutes.

Experiment - Rusting of Iron Filings

Hand out the following materials to each pair, and give each student a pair of goggles.

- 1 plate
- 1 ziploc bag containing:
  - 1 1 oz wide-mouth bottle of iron filings
  - 1 1 oz wide-mouth bottle of salt
  - 1 plastic scoop
- 2 1oz cups with cotton balls
- 1 dropper bottle containing water
- 1 dropper bottle containing hydrogen peroxide

Tell students to:

1. Put 1 piece of cotton in each cup. Note – the reason for using the cotton is to make the color change due to rusting more obvious.
2. Sprinkle iron filings on top of the cotton in each cup (a small scattering is all that is needed).

Each piece of cotton will now be treated differently. Tell students to

3. Add a squirt of water on top of the filings in the 1st cup.
4. Add a sprinkle of salt and a squirt of hydrogen peroxide on top of filings in the 2nd cup.

Have the students observe the 2 cups for a few minutes and then ask them what differences they can see. Have students answer the questions in Part IV of the observation sheet. Answers may include:

1. The cotton containing iron and water (cup 1) does not have orange coloring.
2. The cotton containing the hydrogen peroxide and salt (cup 2) will have some orange color (rust).

Set aside to observe again later.

Ask students which of the 2 cups had the best conditions for rusting?

Cup 2, because the hydrogen peroxide could supply more oxygen than just water (as in cup 1), and salt speeds up rusting.

Write the formulas for hydrogen peroxide and water on the board: H_2O and H_2O_2 to show the students that there is more oxygen in the peroxide.

VSVS members should collect all dropper bottles before passing out the cereal. Students should keep the cups with iron filings to observe again at the end of the lesson.

Explanation for VSVS members:

For iron to rust & become iron oxide, 3 things are required: **iron, water and oxygen.**

The equation for oxidation of iron is: $4Fe + 3O_2 \text{ -----› } 2Fe_2O_3$

Hydrogen peroxide is a good source of oxygen.

Iron can rust without salt being present, but it will make rusting even faster (it is a catalyst). Iron objects close to the ocean rust faster. Cars rust faster when we salt the roads in the winter to melt ice.

V. Removing Iron from a Mixture (Cereal)

Materials per pair:

1 ziploc sandwich bag of cereal
1 magnet (from part III)
1 plastic bag containing
- 1 hand lens
- 1 tissue
- 1 laminated piece of paper containing 18mg iron

Ask students: How can we tell something is a mixture? ***It can be separated <u>by physical processes</u>.***

Ask students: How did we separate the iron from the sand? *By using a magnet*
Ask students: Is using a magnet a physical or chemical process? *Physical*

Emphasize that the students are using a physical property of iron to separate the mixture.

Tell students to:

1. Make sure the Ziploc bag of cereal is closed. Crush the cereal in the bag. Caution students to be careful not to tear holes in the bag as they crush the cereal.
2. Wipe off the white magnet with a tissue and examine it with the hand lens to make sure there are no iron filings on it. **This is important since any residual iron filings will affect the observation in step 3.**
3. Take the white magnet and stir the cereal with it. Students may need to hold the magnet in the bag and mash the cereal around it to collect more iron filings.
4. Pull the magnet out of the cereal and look at the end of the magnet. Then they should use the hand lens to look for small iron filings on the end of the magnet. <u>Make sure they move the hand lens away from the end of the magnet until they have maximum magnification.</u>
5. Look at the white magnet to see if any iron is on the magnet. (There should be tiny black dots and slivers. These are the iron filings that have been added to the cereal.)
6. Record observations on Part V on the Observation Sheet.
7. VSVS members should circulate around the room and make sure the students are seeing small particles of iron. Take enough time to do this. If no black dots or slivers of iron are on the magnet, have the students put the magnet back into the bag and dig around the bottom and in the corners for the iron.

Ask students: Is the iron collected on the magnet and element or compound? *Elemental*
Ask students: Is cereal an example of an element, mixture, or compound? *mixtur*

Your Notes:

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Clean up: **Return the hand lens, the chemical scoops, and the magnets to the Ziploc bag.**
Two VSVS team members should collect the Ziploc bags, making sure that the magnet is in the bag. Another VSVS team member should take the large trash bag around and collect all of the sandwich bags containing used 1-oz cups and tissues and the bags containing the crushed cereal. **Return the trash bag with the kit to the VSVS lab.**

VI. Review

Ask students: Why do we have to have iron in our diet?

- *Hemoglobin, an iron compound, is a very important protein that carries oxygen from the lungs to the rest of the body. Oxygen is very important for life.*
- Our body does not make iron, so we have to get it from our diet. Having too little iron (called anemia) can cause tiredness, make it easier to get sick, and cause faster heart rate and breathing.
- Have the students look at the piece of laminated paper with 18 mg of iron. Explain that this is the amount of iron needed every day.
- We can get iron from lots of different sources in our diet. It is in red meat, egg yolks, leafy green vegetables (like spinach), and shellfish (like crabs or shrimp). In these foods, iron is in a compound form.
- Iron is also added to certain foods. Cereal makers use elemental iron as their source of iron. Some snack foods that add iron use iron compounds instead of elemental iron. Tell students to look at the labels of cereals and snacks that they eat to see what form of iron has been added.

Explanation of Source of Iron in Cereals

Ask the students: How can we tell if iron has been added to cereal as an element or a compound? *Use a magnet. If iron is added as an element, it will be attracted to the magnet.*
Explain that many cereal labels will say "reduced iron" which is another way of saying "elemental iron". This means the iron is present in the cereal as iron metal (an element) and is added in the form of small iron filings. If a snack food label says ferric phosphate, then this product contains an iron compound.

Tell the students to look at the cereal box "Nutrition Facts" tables to answer the following questions on the Observation Sheet.

- What percent of the daily requirement of iron is provided by one serving?
- Look at the ingredients list: How is iron added? What is it called?
- Is iron added as an element or as a compound?
- Tell the students to look at the Ingredient table for an iron dietary supplement and determine if the iron used in pills is a compound or element.
- **Explain Question 6 on the Observation Sheet,** the supplement label uses the name of ferrous sulfate – point out that this is another iron compound.

Ask the students: Do you think our bodies can use the solid iron filings or do the filings need to be changed? *No. Iron filings must be chemically changed to a compound of iron. Our bodies cannot use iron metal.*
Review the vocabulary words and the responses to the questions on the Observation Sheet.

- Iron (Fe) is an essential element in our diet, which means that our body does not make it, so we have to get it from our food.
- Food grade iron filings are added to cereals as a food supplement. This iron is elemental iron, and is magnetic. In the stomach, this metallic iron is changed to iron compounds.

Lesson written by: Dr. Melvin Joesten, Department of Chemistry, Vanderbilt University
Pat Tellinghuisen, Director of VSVS, Vanderbilt University
Heather Day, Program Assistant for VSVS, Vanderbilt University

Iron in Cereal
OBSERVATION SHEET

NAME _____

VOCABULARY WORDS:
element, compound, mixture, elemental iron, reduced iron

III A. Test for Elemental Iron Using a Magnet – a physical property

Are the **elemental** iron filings and iron metal magnetic?	____ Yes	____ No
Is the **compound** iron oxide magnetic?	____ Yes	____ No
Is magnetism a physical or chemical property (circle the answer)?	Physical	Chemical

III B. Removing Iron from a Mixture (sand)

What happened?_____

IV. Rusting – a chemical property of Iron

What happened in cup 1? _____

What happened in cup 2? _____

V. Removing Iron from Cereal

What happened? _____

Questions:

1. Are iron filings.....a (n) ____ element, ____ compound, or ____ mixture?
2. Is iron oxide.....a (n) ____ element, ____ compound, or ____ mixture?
3. Is the cereal you tested today a(an) ___ element, ___ compound, or ___ mixture?

Look at the cereal box labels to answer the following questions.

4. What percent of the daily requirement of iron is provided by one serving? _____
5. Look at the ingredients list: How is iron added? _____

   Is iron added as the element or as a compound? _____
6. Look at the dietary supplement label to answer the following question.

   Is iron added as the element or as a compound? _____

Iron in Cereal
ANSWER OBSERVATION SHEET

NAME _____

VOCABULARY WORDS:
element, compound, mixture, elemental iron, reduced iron

III. A. Test for Elemental Iron Using a Magnet – a physical property

Are the **elemental** iron filings and iron metal magnetic? _X_ Yes ____ No
Is the **compound** iron oxide magnetic? ____ Yes _X_ No

Is the property of magnetism a physical or chemical property (circle the answer)?
physical ~~chemical~~

B. Removing Iron from a Mixture (sand)

What happened? **Small pieces of iron filings are on the cow magnet**

IV. Rusting – a chemical property of Iron

What happened in cup 1? Nothing

What happened in cup 2? The iron filings turned orange. They rusted.

V. Removing Iron from Cereal

What happened? **Small pieces of iron filings are on the magnet**

Questions:

1. Are iron filings ……..a (n) __X__ element, ____ compound, or ____ mixture?
2. Is iron (III) sulfate……. a (n) ____ element, __X__ compound, or ____ mixture?
3. Is the cereal you tested today a (an) ___ element, ___ compound, or _X__ mixture?

Look at the cereal box to answer the following questions.

4. What percent of the daily requirement of iron is provided by one serving? **90% (Shredded Wheat), or 70% for Grits.**
5. Look at the ingredients list: How is iron added? **reduced iron**

   Is iron added as the element or as a compound? _____**element**___

6. Look at the dietary supplement label to answer the following question.

   Is iron added as the element or as a compound? **Compound**

Iron in Cereal – Instruction Sheet

I. Elements, Compounds, and Mixtures.

1. Look at the labels on the 4 containers
2. Which containers have the element?
3. Which container has the compound?
4. Which container has the mixture?

III A. Test for Elemental Iron Using a Magnet.

1. Put the magnet on the outside of the iron metal and the iron filings containers.
2. Move the magnet slowly up the side of the container or across the container.
3. Check the appropriate blank for Part IIIA on the Observation Sheet.
4. Repeat with the iron oxide container.

III B. Test for Elemental Iron in a Mixture

1. Look at the sand in the 4th container.
2. Why do you think this is a mixture?
3. How could iron be separated from the sand?

The VSVS team will demonstrate this tests using cow magnet.

4. Write what happened in the demonstration for Part IIIB on the Observation Sheet.

Put the 4 containers back into the plastic bag and return to a VSVS member. Keep the magnet for a later experiment.

IV. Oxidation (Rusting) of Iron

1. Place the 2 cups on a plate.
2. Put 1 piece of cotton into each cup.
3. Sprinkle a small scattering of iron filings on top of the cotton in each cup.

Each piece of cotton will now be treated differently.

4. Add a squirt of water on top of the filings in the 1st cup.
5. Add a sprinkle of salt and a squirt of hydrogen peroxide on top of filings in the 2nd cup.
6. Observe the 2 cups for 1 minute.
7. Record the differences you can see on Part IV on the Observation Sheet.
8. Set aside to observe again later.

Which of the 2 cups had the best conditions for rusting?

Give the cups with cotton ball and iron filings into the bag provided for trash. Return all chemicals to a VSVS member.

VI. Removing Iron from a Mixture (cereal).

1. Make sure the Ziploc bag of cereal is closed. Crush the cereal in the bag. <u>Be careful not to tear holes in the bag as you crush the cereal.</u>
2. While one of you crushes the cereal, the other student should wipe off the white magnet with a tissue and examine it with the hand lens to make sure there are no iron filings on it.
3. Once the cereal is crushed, take the white magnet and stir the cereal with the magnet.
4. Pull the magnet out of the cereal and use the hand lens to see if you see any small iron filings on the magnet.
5. Let other members of the group look at the white magnet to see if any iron filings are on the magnet.
6. Record your observations on Part V of the Observation Sheet.
7. Wipe the iron filings off the magnet and place the tissue in the trash sandwich bag.
8. <u>Return all bottles of chemicals, the hand lens, the chemical scoop, and the magnet to the Ziploc bag. A VSVS team member will collect your bag of cereal.</u>