Periodic Table of the Elements
Transition Metals III
Teacher's Guide

Grade Level: 9–12 | **Curriculum Focus**: Physical Science | **Lesson Duration:** Two class periods

Program Description

The diversity of transition metals provides versatility in their practical applications. Vanadium provides strength and flexibility on a major U.S. aircraft carrier. Zirconium's unique properties make it ideal for use in nuclear reactors. And mercury maintains happy mouths through its use in dental fillings.

Lesson Summary

Students identify the transition elements on the periodic table of the elements and discuss their key characteristics before conducting an experiment that shows what happens when iron reacts with oxygen in air and water: An exothermic reaction takes place, and heat is released. Salt acting as a catalyst helps the reaction take place faster, and vermiculite helps hold in the heat.

Onscreen Questions

Part 1, "Exploring Transition Metals," "Vanadium: Strengthening Steel," "Zirconium: Nuclear Necessity," "and "Mercury: Weather Wizard"

- What properties do the transition metals share?
- How does a nuclear reactor generate electricity?

Part 2, "Extreme Machine: Oil Rig"

- How does oil form?
- What makes the *Erik Raude* different from a traditional oil rig?

Lesson Plan

Student Objectives

- Identify the transition metals on the periodic table of the elements and describe their characteristics.
- Predict what will happen when one transition metal is mixed with water and sealed in a bag.

- Describe the results of the investigation and explain how it illustrated a property of one of the transition metals.

Materials

- *Transition Metals II* program
- Newsprint and markers
- Copy of the periodic table of the elements

For each group

- 1 tablespoon iron filings
- ¼ teaspoon salt
- 1 tablespoon vermiculite (available in garden shops)
- 1 teaspoon tap water
- 1 resealable plastic bag
- Measuring spoons

Procedures

1. Prior to the start of the class, decide how to handle the distribution of the materials for the investigation. One student from each group can come up to a central area to collect the materials, or hand out the materials to each group.
2. Begin the lesson by having students watch the program *Transition Metals II.* Ask them to pay close attention to the transition metals highlighted in the program and why each is important. Have them write the names of transition metals they are familiar with and how the metals are used. If students are not familiar with any transition metals or their uses, tell them not to worry about it. Then ask them to put the piece of paper away until the end of the lesson.
3. Direct students' attention to the periodic table of the elements in a book or on a class chart. Point out the transition metals. As a class, make a list of some elements in this group, where on the periodic table they are located, and two characteristics of the group. The chart will include the information below.

Elements in the Transition Metals Group

The transition metals include all the elements in groups 3 through 12 on the periodic table. Listed below are common transition metals.

- zirconium (Group 4)
- vanadium (Group 5)
- iron (Group 8)

- cobalt (Group 9)
- nickel (Group 10)
- copper (Group 11)
- mercury (Group 12)

Characteristics of the Group

- fairly stable; react slowly; some do not react at all with air and water.
- hard and strong
- good conductors of heat and electricity
- high melting and boiling points
- form colored compounds and ions in solution

Now that students have some background information, tell them they are going to conduct an investigation using iron. Before giving directions to the class, divide them into groups of three.

4. Tell students that they are going to make a homemade hand warmer. Each group should follow the directions listed below. First have each group write a prediction of what will happen when these materials are mixed together.
   - Pour 1 tablespoon iron filings into the resealable plastic bag. Add ¼ teaspoon salt.
   - Add 1 tablespoon vermiculite to the bag and seal it. Shake the bag well.
   - Open the bag, add 1 teaspoon water, and quickly reseal it.
   - Squeeze the bag. What happens? Write your observations.
   - Continue squeezing the bag. Write any additional observations.
5. Tell the students to put their predictions aside to complete the investigation. Remind them to record their observations as the investigation progresses. Make sure that each group cleans up before the class period ends.
6. During the next class period, discuss the results of the investigation. Ask students to explain why the bag turned warm. If students have trouble, go back to the sheet that identifies the characteristics of transition metals. Ask if they think any of the characteristics listed there could explain what happened. If necessary, point out that some transition metals give off heat when mixed with oxygen.
7. Work with the class to explain the results of the experiment. Ask students, "What happened when iron and oxygen were combined?" *(A chemical reaction took place between the iron and the oxygen in the water and in the air. When mixed with oxygen, the iron oxidized and gave off heat.)* Then ask, "What kind of chemical reaction is this?" *(an exothermic reaction)*

8. Discuss the roles that salt and vermiculite play in the investigation. Make sure students know that the salt acts as a catalyst in the reaction, and the vermiculite helps hold in heat.
9. Conclude the lesson by asking students to revisit the notes they recorded at the beginning of the lesson. Ask students to complete the list or add to it, based on what they have learned. Ask them to list as many transition metals as possible and why each one is important.

Assessment

Use the following three-point rubric to evaluate students' work during this lesson.

- 3 points: Students identified several transition metals on the periodic table of the elements and accurately described several characteristics of these elements; demonstrated a clear understanding of how the investigation illustrated a property of one transition metal; and could explain clearly and accurately the results of the experiment.
- 2 points: Students identified two transition metals on the periodic table of the elements and satisfactorily described at least two characteristics of these elements; demonstrated a satisfactory understanding of how the investigation illustrated a property of one transition metal; and could explain satisfactorily the results of the experiment.
- 1 point: Students had difficulty identifying any transition metals on the periodic table of the elements and could not describe any characteristics of these elements; demonstrated a weak understanding of how the investigation illustrated a property of one transition metal; and had difficulty explaining the results of the experiment.

Vocabulary

catalyst

Definition: A material that helps increase the rate of a chemical reaction but is not changed by the reaction

Context: Salt acts as a catalyst in the chemical reaction between iron and oxygen.

exothermic reaction

Definition: A chemical reaction that releases energy in the form of heat

Context: Oxygen and iron produce an exothermic reaction and release heat.

iron

Definition: A transition metal in group 8 of the periodic table of the elements

Context: A common metal, iron is found inside the human body as part of a hemoglobin molecule.

Academic Standards

Mid-continent Research for Education and Learning (McREL)

McREL's Content Knowledge: A Compendium of Standards and Benchmarks for K–12 Education addresses 14 content areas. To view the standards and benchmarks, visit http://www.mcrel.org/.

This lesson plan addresses the following national standards:

- Physical Sciences: Understands the structure and property of matter
- Language Arts—Viewing: Uses viewing skills and strategies to understand and interpret visual media

National Academy of Sciences

The National Academy of Sciences provides guidelines for teaching science in grades K–12 to promote scientific literacy. To view the standards, visit this Web site: http://books.nap.edu/html/nses/html/overview.html#content.

This lesson plan addresses the following national standards:

- Physical Science: Chemical reactions
- Physical Science: Structure and properties of matter

Support Materials

Develop custom worksheets, educational puzzles, online quizzes, and more with the free teaching tools offered on the Discoveryschool.com Web site. Create and print support materials, or save them to a Custom Classroom account for future use. To learn more, visit

- http://school.discovery.com/teachingtools/teachingtools.html

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DVD Content

This program is available in an interactive DVD format. The following information and activities are specific to the DVD version.

How To Use the DVD

The DVD starting screen has the following options:

Play Video—This plays the video from start to finish. There are no programmed stops, except by using a remote control. With a computer, depending on the particular software player, a pause button is included with the other video controls.

Video Index—Here the video is divided into sections indicated by video thumbnail icons; brief descriptions are noted for each one. Watching all parts in sequence is similar to watching the video from start to finish. To play a particular segment, press Enter on the remote for TV playback; on a computer, click once to highlight a thumbnail and read the accompanying text description and click again to start the video.

Curriculum Units—These are specially edited video segments pulled from different sections of the video (see below). These nonlinear segments align with key ideas in the unit of instruction. They include onscreen pre- and post-viewing questions, reproduced below in this Teacher's Guide. Total running times for these segments are noted. To play a particular segment, press Enter on the TV remote or click once on the Curriculum Unit title on a computer.

Standards Link—Selecting this option displays a single screen that lists the national academic standards the video addresses.

Teacher Resources—This screen gives the technical support number and Web site address.

Video Index

I. Exploring Transition Metals (5 min.)
Transition metals are the largest group of elements on the periodic table. Learn about the common traits and unique properties of these elements.

II. Vanadium: Strengthening Steel (6 min.)
Vanadium is a corrosive-resistant, silvery-white metal that is soft and pliable. Examine the element and learn why it is useful in the making of steel alloys.

III. Zirconium: Nuclear Necessity (6 min.)
A hard, gray-white metal, zirconium is highly resistant to corrosion and is commonly used as an insulator in nuclear reactors.

IV. Mercury: Weather Wizard (6 min.)
The only common liquid metal at room temperature, mercury is used in amalgams and thermometers. Discover what makes mercury an ideal substance for the accurate measurement of temperature.

V. Extreme Machines: Oil Rig (23 min.)
More structurally sound and technologically advanced than its predecessors, the *Eirik Raude* represents a new generation of oil rigs, thanks to transition metals.

Curriculum Units

1. Transition Metals: Traits and Properties
Pre-viewing question
Q: What are some important transition metals? Explain your answer.
A: Answers will vary.

Post-viewing question
Q: What is a d orbital and how does it set transition metals apart from other elements?
A: For most groups on the periodic table, the number of valence electrons an element has corresponds with the element's position on the periodic table. But transition metals have valence electrons in two shells instead of one. They have valence electrons in their outermost shell, but they also have valence electrons in an interior shell called a d orbital, which holds between one and 10 additional valence electrons. When a transition metal reacts with other metals, the d orbitals determine how the elements will interact.

2. Vanadium: Properties and Uses
Pre-viewing question
Q: What metallic elements do you know?
A: Answers will vary.

Post-viewing question
Q: What are some common uses of vanadium?
A: Vanadium added to iron alloys and steel makes axles, car gears, and jet engines. Vanadium compounds are also used to permanently fix dye to fabric and create highly conductive magnets.

3. Vanadium in Steel Alloys
Pre-viewing question
Q: What everyday appliances, gadgets, and other items contain iron or steel alloys?
A: Answers will vary.

Post-viewing question
Q: Why is vanadium added to steel?
A: Adding vanadium to steel creates an alloy that resists metal fatigue, or repeated pressure that gradually forces metal to stretch out of shape. Because it helps metal hold its shape, vanadium goes into crankshafts, gears, and jet engines, where very high strength and abrasion-resistance are critical.

4. Zirconium: Properties and Uses

Pre-viewing question
Q: What do you know about zirconium and its uses?
A: Answers will vary.

Post-viewing question
Q: What are some common uses of zirconium?
A: From the 1960s through the 1980s, most photographic flashbulbs contained zirconium. It resists corrosion, so it is commonly used in high-performance pumps and valves and as an alloy agent in steel. Because it does not readily absorb neutrons, it is widely used as an insulator in nuclear reactors. Zircon is a zirconium compound that is often used in jewelry because it can take on the appearance of diamonds. The compound zirconium carbonate is added to lotions for treating poison ivy.

5. Zirconium in Nuclear Reactors
Pre-viewing question
Q: What are some uses of nuclear power?
A: Answers will vary.

Post-viewing question
Q: How and why is zirconium used as an insulator in nuclear reactors?
A: Nuclear-reactor fuel rods are made of zircolloy, a zirconium alloy that is at least 98 percent zirconium. Zirconium is an ideal insulator for the rods because it will not melt in the heat generated by uranium fission. Because it does not absorb neutrons, it will not interfere with the chain reaction in nuclear reactors.

6. Mercury: Properties and Uses
Pre-viewing question
Q: How is mercury used in your home or classroom?
A: Answers will vary.

Post-viewing question
Q: What are some industrial uses of mercury?
A: Mercury easily forms alloys with other metals called amalgams, which are used to extract gold from its ores, create dental fillings, and extend the life of dry-cell batteries. Mercury is especially useful in thermometers, barometers, and other scientific instruments because it is liquid at room temperature.

7. Mercury Thermometers
Pre-viewing question
Q: What do you know about how mercury thermometers work?
A: Answers will vary.

Post-viewing question
Q: What makes mercury an ideal substance for measuring temperature?

A: It expands and contracts uniformly with temperature change: Liquid at room temperature, mercury melts at -39° Celsius and boils at 357° Celsius.

8. New Offshore Oil Rigs
Pre-viewing question
Q: Where does most of our oil originate?
A: Answers will vary.
Post-viewing question
Q: Why does the oil rig *Eirik Raude* float?
A: The *Eirik Raude* floats on two massive, submerged pontoons so it can work in water as deep as 10,000 feet. (Most other rigs drill in water up to 4,000 feet and are attached to the ocean floor.)

9. Geologists Search for Fossil Fuels
Pre-viewing question
Q: What safety issues might arise on an oil rig?
A: Answers will vary.

Post-viewing question
Q: How do geologists find oil and gas beneath the sea?
A: Geologists first identify the most likely rock formations several miles underground that could contain fossil fuels. They analyze rocks below the seabed with a seismic survey; they fire shockwaves through the sea that are reflected off layers of rock deep in the Earth's crust.

10. Drilling for Oil
Pre-viewing question
Q: How does a drill work?
A: Answers will vary.

Post-viewing question
Q: Why are transition metals well suited for making drill bits for oil rigs?
A: Drill bits made from transition metals and alloys are extra durable, have a longer lasting fit and improved temperature resistance. These properties are important for oil-rig drills that must go through icy open temperatures through the hot rock inside the Earth.

11. Bad Weather on the Rig
Pre-viewing question
Q: What traits does it take to work on an oil rig?
A: Answers will vary.

Post-viewing question
Q: What happens aboard the *Eirik Raude* during severe winter weather?
A: The *Eirik Raude* is fully winterized and can keep drilling 98 percent of the time in winds up to 70 miles an hour and waves as high as 60 feet. Beyond that, drilling must stop. Occasionally the drill

strings must be pulled up so the rig can float away and ride out the storm. In an emergency the pipe can be cut in less than 40 seconds.

12. Finishing the Exploratory Well
Pre-viewing question
Q: Do you think oil rigs always find oil?
A: Answers will vary.
Post-viewing question
Q: Is the money and energy necessary to drill for inaccessible oil worth the costs?
A: Answers will vary.