Trend Setters of the Periodic Table: Predicting the Next Big Reaction

Unit	Utah SEEd Standard / NGSS Performance Expectation	Estimated Lesson Time:
Chem 3.2	**Analyze data** to identify patterns that assist in making predictions of the outcomes of simple chemical reactions. Emphasize patterns based on the outermost electrons of atoms, trends in the periodic table, and knowledge of chemical properties. Examples could include reactions between main group elements, combustion reactions, or reactions between Arrhenius acids and bases.	90-110 min

LESSON OVERVIEW

Learning Objective

By the end of the lesson, students will be able to:

- Predict how substances will react based on their location on the periodic table
- Analyze data to identify patterns in metal reactivity
- Write and interpret single-displacement chemical equations
- Use evidence to explain how valence electrons influence metal reactivity

Anchor Phenomenon

Students observe three separate chemical reactions that produce colorless, odorless gases that appear identical to the naked eye. However, when tested with a flame, the gases behave differently: one produces a “pop,” one extinguishes the flame, and one reignites a glowing splint. This discrepancy challenges students to determine the identity of matter based on chemical reactivity rather than physical appearance.

Students will later investigate how metal + acid reactions produce one of these gases, helping them connect reactivity patterns to gas identity.

- If you cannot demonstrate the gas production, show the video located in the slides.

Driving Questions

- If three gases are all colorless, odorless, and look identical, how can we use chemical reactions to determine which is which?
- How can the location of an element on the periodic table help us predict how it will react with other substances?
- How can we use data from simple reactions (like metals with acid) to identify patterns and predict the outcomes of reactions we haven't seen yet?
- What type of gas is produced when an acid (HCl or H2SO4) reacts with a metal?

Lesson Level Performance Expectations

Students analyze data from metal-acid reactions to identify patterns in reactivity and use those patterns to predict the outcomes of similar reactions. They construct explanations using evidence from their investigations and apply their understanding of valence electrons and periodic trends to explain differences in reactivity. Students use patterns and cause-and-effect relationships to connect atomic structure to observable chemical behavior.

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LESSON SNAPSHOT

LESSON SUMMARY:

	Estimated Time	Section Overview	How are students answering the driving question or meeting the learning objectives? (Highlight SEPs, DCIs, and CCCs)
Experience the Phenomenon	**10 min**	Review background info and discuss the three gases. Watch a video of burn tests of the three gases.	Students discuss in groups how they could identify 3 unlabeled vials of gas. Students share their ideas with the class and write down any that differ from those in their group.
Investigate the Phenomenon	**35 min**	Students collect data on how reactive metals behave when placed in acids.	Students perform the "Pop" test and observe and compare the rate of chemical reactions of several metals that go down in the same family and across the period. Students **analyze** their data by looking for **patterns** in metal **reactivity** based on their observations and the number of valence electrons each metal has.
Model the Phenomenon	**20 min**	Students use the data they collected to rank the metals by reactivity and justify their rankings with evidence from their data. Students use patterns in their data and periodic trends to predict the reactivity of other metals.	Students will use their data analysis to predict the **reactivity** of untested metals and to predict the products of single displacement reactions

DISCIPLINARY CORE IDEAS	SCIENCE & ENGINEERING PRACTICES	CROSSCUTTING CONCEPTS
NGSS Appendix E (PS1.B): Chemical Reactions Chemical processes can be understood in terms of the rearrangements of atoms into new molecules. The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict the outcomes of chemical reactions.	NGSS Appendix F **Analyzing and Interpreting Data**: Students analyze data for similarities and differences to make predictions of the outcomes of chemical reactions.	NGSS Appendix G Patterns: Using patterns to classify reactions provides a way to make predictions of the outcomes of other reactions.

This lesson could be one in a series of lessons building toward the following Performance Expectation(s):

Writing complete chemical equations with only known reactants and producing correct chemical formulas in the products.

Compare and contrast the formation of ionic (salts: MgCl2, CaCl2, etc.) and covalent (H2) bonds.

Related knowledge and skills from prior grades

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Disciplinary Core Idea: **NGSS Appendix E** Reacting substances rearrange to form different molecules, but the number of atoms is conserved. Some reactions release energy and others absorb energy.	Science and Engineering Practices **NGSS Appendix F** Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. - Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships. - Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships. - Distinguish between causal and correlational relationships in data. - Analyze and interpret data to provide evidence for phenomena. - Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible. - Consider limitations of data analysis (e.g., measurement error), and/or seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials). - Analyze and interpret data to determine similarities and differences in findings. - Analyze data to define an optimal operational range for a proposed object, tool, process or system that best meets criteria for success.	Crosscutting Concept: **NGSS Appendix G** In grades 6-8, students recognize that macroscopic patterns are related to the nature of microscopic and atomic-level structure. They identify patterns in rates of change and other numerical relationships that provide information about natural and human designed systems. They use patterns to identify cause and effect relationships and use graphs and charts to identify patterns in data.

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Materials

Link to all materials on the 3DRST website (3drst.byu.edu): https://3drst.byu.edu/chemistry-3-2-reactivity-trends
Link to all materials on Canvas Commons: https://tinyurl.com/3DRSTchemistry

Student Materials	Teacher Materials	Lab Materials/Other Resources
Student Worksheet	- Teacher Slides - Teacher lab setup instruction slides (includes videos for experiment)	- 2 Beakers (250mL) - Droppers - Test tubes (4-5) per rack - Test tube racks - Goggles - 1M HCl (can use 3-5M if safe in your lab for better reaction rates) - Tweezers - Small amounts of copper, zinc, aluminum, magnesium, and iron - Wooden splint - Matches (Tea Candle optional) - Barbeque Lighter (optional)

LESSON PREPARATION

Material Preparation:
Full lab preparation instructions and how to perform the experiments can be found in the Teacher Lab Setup Instruction Slides Document
Prepare test tube racks (5-6)

Required Previous Knowledge:
This lesson builds on students' prior understanding of the following DCIs developed in previous units:
Chem 1.5 Periodic Table - (Trends and patterns of the periodic table)
Chem 2.2 Structure and Properties - (Structures and properties of elements)

Supports students will need/adaptations: Scaffolding for SPED on the equations. Possible sentence starters for students.

Vocabulary Definitions: Reactants, Products, Subscript, Coefficient, Ionic bond, Chemical Reaction, Valence Electrons, families or groups/columns, Periods

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EXPERIENCE THE PHENOMENON/PROBLEM (ENGAGE)

What Students Are Doing	Teacher Tips
Students follow along with the presentation and fill out their worksheets where indicated. During the brainstorm, students discuss in a group how to distinguish between the clear gases. Students come up with answers to probing questions.	Prepare the reactions while students are discussing how to distinguish the gases.

What Teachers Are Doing	Teacher Tips
Teachers present the slides. Read the title (slide 1) and lesson objective (slide 2) with the students. Emphasize the SEP and CCC. Review the background information slides with the students, as needed. Instruct students to write the necessary information on the student worksheet. (**Slides 3-7**) Show the image of 3 clear gases (test tubes with stoppers). Ask the students to brainstorm how to tell the difference between the gases. (**Slide 8**) Ask probing questions, why did they come up with that idea, etc. • **Flask A (Hydrogen - The Pop):** Pre-load 2-3 pieces of Mossy Zinc. Have 10-20mL of 3M-6M HCl ready. • **Flask B (CO2 - The Extinguisher):** Pre-load 1 scoop Sodium Bicarbonate. Have 20mL Vinegar ready. • **Flask C (Oxygen - The Reigniter):** Pre-load a pinch of MnO2 or KI. Have 20mL Hydrogen Peroxide (H2O2) ready. Show the video(s) of burn tests for three gases: CO2, O2, and H2 (**slides 9 or 10**). Have students describe the test results. (**Slide 11**) Optionally, teachers can do 3 reactions to produce the gases for students and perform burn tests for each gas. **See the teacher's lab setup instructions for help setting up these reactions.** Have the students fill in the reactants and products for each burn test on their worksheets. (**Slides 12-14**).	See **Teacher lab set-up instruction slides** for the Metal Reactivity Lab Set-up Make sure to label the containers with the correct chemicals for accurate, timely demonstrations and optimal success. Be sure they are using safe ideas here. Remind the students that lab safety principles should be followed in their ideas!

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INVESTIGATE THE PHENOMENON (EXPLORE)

What Students Are Doing

Listening to the instructions on lab safety and how to carry out the squeaky pop tests.

Students collect data on gas production when metals react with acid by following the lab instructions on their student worksheet.

Students use patterns in their data to make predictions about reactivity.

They record their observations in the student worksheet's data table.

What Teachers Are Doing	Teacher Tips
Review the general reaction type that the students will perform in the lab. (**Slide 15**). Have students practice writing a metal reaction on their worksheet. Review lab safety. (**Slides 16-17**) Review lab directions. (**Slide 18**) Have student groups perform the lab. Monitor for lab safety. Make sure the students follow the instructions given. Have the students record their observations in the data table on the student worksheet. Use slides 19 and 20 to help them fill out the data table. (**Slides 19-20**) If lab supplies are unavailable, use the videos on the slides to help students gather information about the reactivity of various metals. (**Slides 21-22**) Review instructions: • ***Step 1:*** Add HCl to cover the metal (approx. 1cm depth). • ***Step 2:*** Invert an empty tube over the reaction tube to catch gas. • ***Step 3:*** Observe bubbles (rate of reaction). • ***Step 4:*** Test the gas with a burning splint (listen for the "pop" of H2). **Slides 23 and 24** are intended to help students fill in the data table. Build consensus with the general order that calcium and magnesium are the highest. Instruct students to clean their lab stations and dispose of any leftover products appropriately. (See the teacher lab setup instruction page and disposal information as needed.)	Reiterate with students that hydrogen gas (H2) and a salt (XCl) will be produced. Remind students that aluminum is delayed when using foil. Tell them to wait until they see the bubbles, then collect the gas. If time permits, you can have students share their rankings aloud to notice differences with other groups. Prompts for students: - What pattern do you notice in how different metals react? - Is the gas different, or is the rate of production different?

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MODEL THE PHENOMENON (EXPLAIN)

What Students Are Doing

Students should complete the Chemical data table and the Explain section of the student handout.

Communicating the Phenomenon

Students use their data to explain:

- Reactivity trends
- Predictions of new reactions using evidence and patterns

What Teachers Are Doing

When students are done with the lab, have them fill in the chemical data table on the student worksheet. Use the family slide to help them remember which groups each element belongs to. (**Slide 24**)

Instruct the students to put the reactivity numbers from their data tables on the periodic table (question 1 in the explain portion of the worksheet).

Then, the students will need to decide on the order of reactivity for the elements used. After students create their initial rankings, use **Slide 26** to support or refine their thinking if students are struggling, or to compare their data with accepted data using more controlled variables (same metal sizes, same amounts, etc.).

After the students have decided on the order and given their reasoning in question 3, show them the reactivity chart on **Slide 27**. Have the students compare their order to the chart and put their answers in question 5 of the student worksheet.

Have the students predict the reactivity of strontium (question 4). Then, show them the reactivity trends using **slides 28-30**. Have them add to their explanation, as needed.

Use the video in **slide 28** to help emphasize the CCC of patterns in reactivity. Discuss with students how the reactivity of metals varies according to periodic trends.

Student Prompts:

- What rule can you create to explain the pattern you observed in metal reactivity?

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Possible Extensions/Alternative Adaptations

Some students struggle to write equations. You might need to give them examples or fill in part of the equation for them. If you make a scaffold of equations for the students, be sure to allow them to still use patterns (CCC) to complete the task.

Extensions could include making more predictions based on patterns on the periodic table.

This lesson was created by Rachel Trujillo, Jamie Carling, Mike Sandersen, and Anna Lewin

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