

Unit 5 Summary and Pacing Guide

Stability and Change in Chemical Reactions

Standard(s):

Standard 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. (PS1.B)

Standard CHEM.3.3 Plan and carry out an investigation to observe the change in properties of substances in a chemical reaction to relate the macroscopically observed properties to the molecular level changes in bonds and the symbolic notation used in chemistry. Emphasize that the visible macroscopic changes in chemical reactions are a result of changes on the molecular level. Examples of observable properties could include changes in color or the production of a solid or gaseous product. (PS1.B)

Standard CHEM.4.1 Construct an argument from evidence about whether a simple chemical reaction absorbs or releases energy. Emphasize that the overall change in energy is related to the energy absorbed when bonds are broken and the energy released when bonds are formed. Examples could include chemical reactions releasing or absorbing energy to or from the surrounding solution or the metabolism of glucose. (PS1.B, PS3.B)

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Students use fundamental tools in science to compute relationships and interpret results.	PS1.B Chemical Reactions PS3.B Conservation of Energy and Energy Transfer	Stability and Change Students evaluate how and why a natural or constructed system can change or remain stable over time.
Constructing Explanations Students construct explanations about the world using observations that are consistent with current evidence and scientific principles.		

Big Ideas:

- Many substances react chemically with other substances to form new substances with different properties.
- For molecules, collisions can also result in energy transfers through chemical processes, which increase or decrease the total amount of stored energy within a system of atoms; the change in stored energy is always balanced by a change in total kinetic energy—that of the molecules present after the process compared with the kinetic energy of the molecules present before it.

Preceding Grade Bands:	Target Grade Bands:	Following Grade Bands:
	The fact that atoms are	

• In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. • The total number of each type of atom is conserved, and thus the mass does not change. • Some chemical reactions release energy, others store energy.	conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reaction	
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Essential Question:

How can we predict whether atoms or molecules will stay the same or change?

Learning Goals:

Students will be able to:

- **5A** Use the characteristics of chemical reactions to plan an investigation to determine if a chemical reaction has taken place.
- **5B** Analyze data to predict the outcome of a simple chemical reaction.
- **5C** Use evidence to determine if energy is absorbed or released during a chemical reaction and explain where the energy came from and went.

At the end of this unit, students will take the summative assessment. Please complete this [SURVEY](#) to request access to the summative assessments for the JSD High School Science Exemplar Units.

It is recommended that the teacher adjust the assessment to his or her classroom's needs by shortening or lengthening as needed.

Unit 5 Proficiency Scale

4 Advanced	3 Proficient	2 Approaching Proficiency	1 Beginning Proficiency
I can:	I can:	I can:	I can:

Construct an explanation using valid evidence and scientific reasoning predicting whether a group of atoms and/or molecules are likely to stay <u>stable or change</u> through a chemical reaction. AND Apply these ideas to explain a real-world scenario or solve a real-world problem.	Construct an explanation using valid evidence and scientific reasoning predicting whether a group of atoms and/or molecules are likely to stay <u>stable or change</u> through a chemical reaction.	Construct an explanation predicting whether a group of atoms and/or molecules are likely to stay <u>stable or change</u> through a chemical reaction.	Construct an explanation for whether or not atoms or molecules stay <u>stable or change</u> through a chemical reaction.
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Summative Assessment	At the end of this unit, students will complete the assessment: Please complete this SURVEY to request access to the summative assessments for the JSD High School Science Exemplar Units.
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Unit 1 Pacing Guide - (70 minute class periods)	
This should take approximately 8 class periods on a block schedule .	
Day 1	Engage: Anchoring Phenomenon Acid rain Explore: Chemical and Physical Changes Lab (5A)
Day 2	Explain: Signs of a chemical change
Day 3	Explore: Math and chemical equations (5B) Explain: Five Types of chemical reactions
Day 4	Explore: Types of chemical reactions lab (5B) Explain: Lab write-up
Day 7	Explore: Endothermic/Exothermic Lab (5C) Explain: Energy in chemical reactions

Day 8	Assessment
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Teacher's Summary	
Activity Type	Engage
Learning Goal	
Materials	Anchoring Phenomenon: Acid rain (link) Model-making materials: plain paper, colored pencils, etc. Put the Essential Question on the board, or on a student sheet. Let them know that this question will be explained over the course of the unit, but they should try to answer it based on background knowledge and the phenomena video.
Activity Summary & Notes	Essential Question: How can we predict whether atoms or molecules will stay the same or change? Making Models -Prompt students to create models of their thinking. These should be pictures or diagrams with explanations of their thinking. Generating Questions Have students generate questions individually, in groups, or both. Possible questions might include: What makes acid special? Why do some things react with acid rain, and some don't? How can you prevent acid rain from destroying something?
Connection to Anchor Phenomenon	
Formative Assessment	Models and student-generated questions

Days 1 and 2

Unit 5: Stability and Change in Chemical Reactions

5A: Characteristics of Chemical Reactions

Teacher's Summary	
Activity Type	Explore
Learning Goal	Use the characteristics of chemical reactions to plan an investigation to determine if a chemical reaction has taken place.
Materials	Chemical and Physical Changes Lab -Ice, antacid tablets, play-doh, baking soda, lemon juice, vinegar, milk,

	kool-aid powder -Alternate Lab: Link Wooden splint, copper shavings, sodium chloride, copper (II) nitrate, KSCN, FeCl ₃
Activity Summary & Notes	Students will perform the lab and fill out the data chart. Teacher should move and monitor to help answer questions.
Connection to Anchor Phenomenon	Phenomenon: Acid rain (link) Questions to answer: -What signs of a physical change were there from the acid rain? -What signs of a chemical change were there from the acid rain?
Formative Assessment	There is a formative assessment at the end of the lab assignment

Physical and Chemical Changes

Content Objective: Students will differentiate between chemical and physical changes by conducting a series of experiments.

Materials:

Safety goggles	Play-doh
Graduated cylinders	Baking soda
Small plastic cups	Lemon juice
Small plastic jars	Vinegar
Ice	Milk
Antacid tablets	Kool-Aid powder

Physical and Chemical Change Experiments

Directions: Record all observations on the investigation table. Answer the discussion questions with your group.

Experiment A: Antacid tablet

1. Observe and describe the **antacid tablet** at your table.
2. Break the tablet into small pieces.
 - a. Is this a physical or chemical change?
3. Using a graduated cylinder, measure 50 ml of **water** and add it to a cup. Drop the tablet pieces into the cup.
4. Observe what happens.
 - a. Is this a physical or chemical change?
5. When you are finished, empty the cup, rinse the cup with water and save the cup for experiment B.

Discussion Question - A doctor might tell someone to use an antacid if their stomach produces too much acid. Based on what you observed, how do you think antacids work?
An antacid tablet works by reacting with the liquid inside of a person's stomach. It neutralizes the reaction to help bring the stomach's acidity back into balance.

Experiment B: Ice

1. In the empty cleaned cup from experiment A, place 1 **ice cube** in the cup.
2. Observe and record how the ice looks and feels.
3. Set the cup and ice cube aside until you are finished with the other experiments.

Experiment C: Baking soda and lemon juice

1. With a graduated cylinder, measure 40 ml of **lemon juice** and add it to a larger container. Rinse the graduated cylinder.
2. Add 1 teaspoon of **baking soda** to the lemon juice in the larger container.
3. Observe and record the changes.
 - a. Is this a physical or chemical change?
4. Empty the container, rinse it, and save it for experiment E.

Experiment D: Play-doh

1. Remove the **Play-doh** from its container and describe how it looks, feels, and smells.
2. Break the Play-doh up into many small pieces.
3. Observe and record the change.
 - a. Is this a physical or chemical change?

Experiment E: Baking soda and vinegar

1. Add 1 teaspoon of **baking soda** to the cleaned container from Experiment C
2. Using the graduated cylinder, measure 10 ml of **vinegar**. Add the vinegar to the baking soda container.
3. Observe and record the change.
 - a. Is this a physical or chemical change?
4. Empty the container, rinse the container and graduated cylinder and save them for experiment F.

Experiment F: milk and vinegar

1. Using the graduated cylinder, measure 50 ml of **milk** and add it to the container saved from experiment F.
2. Using the graduated cylinder, measure 30 ml of **vinegar** and add it to the same container.
3. Observe and record the change.
 - a. Is this a physical or chemical change?
4. Rinse the equipment (graduated cylinder and container).

Experiment G: Kool-Aid and water

1. Add 1 teaspoon of **Kool-Aid powder** to a jar.
2. Using the graduated cylinder, add 60 ml of **water** to the same jar.
3. Close the lid of the jar and gently mix by swirling it.
4. Observe and record the change.
 - a. Is this a physical or chemical change?

Revisit B: Ice

1. Look at the cup that held the ice cube from experiment B.
2. Observe and record the change.
 - a. Is this a physical or chemical change?

Exp eri me nt	Original Substance(s)	Description Before Change (Use at least 3 adjectives)	Description During Change	Description After Change (Use at least 3 adjectives)	Is it a physical or chemical change?

A	Antacid crushed	White, solid, round		Powder, white, solid	Physical
A	Antacid in Water	White, solid, round	Fizzing, bubbles	Bubbles, disappeared,	Chemical
B	Ice	Cold, solid, clear/white	melting	Cold, liquid, clear	Physical
C	Baking Soda & Lemon Juice	White powder, yellow liquid, sour smell	Fizzing, bubbles, warm?		Chemical
D	Play-doh broken into bits	Color, soft, solid	Stretching, breaking	Small pieces, same color, rough edges	Physical
E	Baking Soda & Vinegar	White powder, clear liquid, odor	Fizzing, bubbles	Clear solution	Chemical
F	Milk & Vinegar	White liquid, Clear liquid		Liquid and solid separating, Solid produced	Chemical
G	Kool-aid & Water	Colored powder, clear liquid	Dissolving	Red transparent liquid	Physical

Analysis

1. What was the indication that you used to decide if a chemical change had occurred? What MUST happen in a chemical change? **If something new has formed.**
2. What are the signs/observations of a chemical change? **Bubbles, temperature change**
3. What can you see that can indicate a chemical or physical change? **A color change.**

Teacher's Summary	
Activity Type	Explain
Learning Goal	Use the characteristics of chemical reactions to plan an investigation to determine if a chemical reaction has taken place.
Materials	Youtube Video: Introduction to Chemical Reactions (link)
Activity Summary & Notes	Discuss the evidence from the physical and chemical changes lab. What signs of a chemical reaction did you see? Review Signs of a chemical change. Be sure to talk about state changes and the idea of 'reversible' these are the two places students get most confused.
Connection to Anchor Phenomenon	Revisit anchor phenomena: What questions did we answer? What new questions do you have? Revise initial models based on the new evidence we have gathered and the information we have learned.
Formative Assessment	CER Paragraph: How can you tell if a chemical reaction has occurred? Use evidence from the phenomena and from the lab to back up your claim.

Explain

Watch the video on chemical reactions. Discuss with students what they saw in the lab and whether each reaction was chemical and physical and why.

Have students complete a worksheet or quizizz to see if they can identify physical and chemical changes .

Formative Assessment: Write a CER

Possible CER summary - Students could talk about many of the different experiments they did in the lab, and/ or the acid rain phenomena.

How can we tell if a chemical reaction has occurred?

Claim: A chemical reaction or chemical change occurs when a new substance is formed.

Evidence: In the station lab I saw bubbles formed when I combined lemon juice and vinegar. The bubbles told me that a new substance was being formed. When I combined baking soda and vinegar the solution got colder.

Reasoning: The bubbles that were produced from baking soda and vinegar were carbon dioxide bubbles that weren't one of the starting materials. The baking soda and vinegar got colder when combined, this shows that there was a change of energy which indicates a new substance.

In this experiment I saw the cross cutting concept of stability and change. When certain substances are combined they go through changes. If a new substance is formed then the change is a chemical change.

CER Paragraph Rubric

	4	2	0
Claim	Makes an accurate and	Makes an accurate but	Does not make a claim,

	complete claim that answers the question.	vague or incomplete claim.	or makes an inaccurate claim.
Evidence	Provides appropriate and sufficient evidence to support the claim.	Provides appropriate but insufficient evidence to support the claim. May include some inappropriate evidence.	Does not provide evidence, or only provides inappropriate evidence. Evidence does not support the claim.
Reasoning	Provides accurate and complete reasoning that links the evidence to the claim	Repeats the evidence and links it to some scientific principles, but not sufficient.	Does not provide reasoning, or only provides reasoning that does not link evidence to claim.

Day 3

Teacher's Summary	
Activity Type	Explore
Learning Goal	Analyze data to predict the outcome of a simple chemical reaction.
Materials	List of digital or physical materials that can be used for this lesson
Activity Summary & Notes	Starter: (students should know how to form neutral ionic compounds) Write the unit formula for the following ionic compounds: $\text{Mg}+\text{Cl}$, $\text{Rb}+\text{P}$, $\text{Al}+\text{Br}$ If Magnesium burns in the presence of oxygen gas what is produced? Write an equation with reactants and products. Math and Chem Equations Challenge Students will first find patterns with math problems, then find patterns with chemical equations. Teacher Notes (link) Student Worksheets (link) Can have students cut out the equations and put them into baggies, or have them cut and ready when class starts.
Connection to Anchor Phenomenon	Phenomenon: Acid rain (link) Questions to answer: -Can we predict the products formed when acid rain reacts with statues and plants? -Given the equation for acid rain, what type of reaction is taking place?
Formative Assessment	Lab questions from "Math and Chem Equations Challenge"

Teacher's Summary	
Activity Type	Explain
Learning Goal	Analyze data to predict the outcome of a simple chemical reaction.
Materials	Five Major Types of Chemical Reactions Video (link) Types of Reactions Video (link)
Activity Summary & Notes	Direct instruction of the 5 Major Types of Chemical reactions
Connection to Anchor Phenomenon	Discussion Questions: -Predict the products of acid rain on a metal statue. (webpage article on this: www.thehistoryblog.com/archives/27474)



-What could be done to help prevent the acid rain from corroding the statues?

Formative Assessment

Predicting Products of Chemical Reactions ([link](#))

Day 4

Teacher's Summary	
Activity Type	Explore/Explain
Learning Goal	Analyze data to predict the outcome of a simple chemical reaction.
Materials	Materials: per lab group: evaporation dish scoopula test tubes 4 mini test tube (culture tube) test tube holder right angle glass tubing with rubber stopper small piece of steel wool 00 or 000 2 g copper (II) carbonate 5 mL limewater (saturated solution of $\text{Ca}(\text{OH})_2$) 1 piece Mossy zinc 5 mL 6 M HCl (513 ml/1 L) 5 ml 0.2 M Sodium sulfate (28.4 g/L) 1 mL 0.2 M Barium nitrate (32.8g/L) methanol candle (emergency candle) - 1 per class lighter or matches - 1 per class
Activity Summary & Notes	Starter: (link) Students will predict products during the lab based on the 5 Major types of chemical reactions Student Lab Online guide: (link) In class version of the lab: (link)
Connection to Anchor Phenomenon	Phenomenon: Acid rain (link) Questions to answer: -Can we predict the products formed when acid rain reacts with statues and plants?
Formative Assessment	Lab questions from “Types of Chemical Reactions” Lab Optional extra practice: (link) CER: How can we predict the outcome of a simple chemical reaction?

Teacher's Summary	
Activity Type	Explore
Learning Goal	Use evidence to determine if energy is absorbed or released during a chemical reaction and explain where the energy came from and went
Materials	Endothermic/Exothermic Lab -baking soda, acetic acid, HCl solution, zinc metal, magnesium sulfate, calcium chloride, water, glassware, lab supplies etc.
Activity Summary & Notes	Starter: A container of melted paraffin wax is allowed to stand at room temperature until the wax solidifies. What is the direction of heat flow as the liquid wax solidifies? Is the process exothermic or endothermic? Endothermic/Exothermic Lab (link)
Connection to Anchor Phenomenon	Does the reaction of acid rain on limestone require energy or release energy? Where does the energy go in the chemical equation?
Formative Assessment	Lab questions Discussion questions: -How can you tell if a reaction absorbs or releases energy? (Reboiling hand warmers)

Teacher's Summary	
Activity Type	Explain
Learning Goal	Use evidence to determine if energy is absorbed or released during a chemical reaction and explain where the energy came from and went
Materials	CrashCourse Energy in Chemical Reactions (link) Exothermic vs Endothermic Reactions video (link)
Activity Summary & Notes	Direct instruction on energy within chemical reactions.
Connection to Anchor Phenomenon	Draw the energy diagram of the reaction of acid rain and limestone.

Endothermic/Exothermic Lab

PRE-LAB DISCUSSION

All chemical reactions release or absorb energy. Chemical reactions that release energy in the form of heat are called exothermic reactions. Some chemical reactions absorb energy and are called endothermic reactions.

PURPOSE

After examining each reaction in the laboratory, you should be able to classify each reaction as exothermic or endothermic.

SAFETY

The chemicals can be toxic, please treat them with respect and care. Rinse skin immediately upon contact. You MUST wear your goggles at all times. Be sure to rinse and dry your thermometer after each use.

PROCEDURE

In Part I, you will study the reaction between acetic acid and sodium bicarbonate (baking soda). An equation for the reaction is (Is it balanced? If not, try to balance the equation.):



acetic acid + sodium bicarbonate sodium acetate + water + carbon dioxide gas

Step 1: Add approximately 5 ml of acetic acid to a large test tube.

Step 2: Record the temperature of the acetic acid.

Step 3: Add a small scoop of sodium bicarbonate to the acetic acid.

Step 4: Gently stir (with the thermometer) until all sodium bicarbonate has been dissolved. Observe the temperature, record any temperature change and other observations.

Step 5: Discard the solution into the correct area and clean your equipment.

In Part 2, you will study the reaction between hydrochloric acid and zinc metal. An equation for the reaction is (Is it balanced? If not, try to balance the equation.):



hydrochloric acid + zinc metal zinc chloride + hydrogen gas

Step 1: Add approximately 5 ml of hydrochloric acid to a large test tube.

Step 2: Record the temperature of the hydrochloric acid.

Step 3: Add a small piece of zinc to the hydrochloric acid.

Step 4: Gently stir (with the thermometer) until all zinc has been dissolved.

Observe the temperature, record any temperature change and other observations.

Step 5: Discard the solution into the correct area and clean your equipment.

In Part 3, you will study the reaction between magnesium sulfate (Epsom salt) and water. An equation for the reaction is (Is it balanced? If not, try to balance the equation.):



magnesium sulfate + water hydrogen gas + oxygen gas

Step 1: Add approximately 10 ml of water to a large test tube.

Step 2: Record the temperature of the water.

Step 3: Add a small scoop of magnesium sulfate to the water.

Step 4: Gently stir (with the thermometer) until all magnesium sulfate has been dissolved.

Observe the temperature, record any temperature change and other observations.

Step 5: Discard the solution into the correct area and clean your equipment.

In Part 4, you will study the reaction between calcium chloride and water. An equation for the reaction is (Is it balanced? If not, try to balance the equation.):



calcium chloride + water calcium chloride + oxygen gas

Step 1: Add approximately 10 ml of water to a large test tube.

Step 2: Record the temperature of the water

Step 3: Add a small piece(s) of calcium chloride to the water.

Step 4: Gently stir (with the thermometer) until all calcium chloride has been dissolved.

Observe the temperature, record any temperature change and other observations.

Step 5: Discard the solution into the correct area and clean your equipment.

Endothermic/Exothermic Lab Name(s):

OBSERVATIONS

Part 1: Initial temperature of acetic acid _____

Temperature after adding sodium bicarbonate to the acetic acid _____

Did you feel a temperature change? **yes**

What did you observe during the reaction?

The temperature went down, the baking soda dissolved in the acid and fizzed/created bubbles

Part 2: Initial temperature of hydrochloric acid _____

Temperature after adding zinc metal to the hydrochloric acid _____

Did you feel a temperature change? **yes**

What did you observe during the reaction?

The temperature went up, the zinc dissolved and created bubbles

Part 3: Initial temperature of water _____

Temperature after adding magnesium sulfate to the water _____

Did you feel a temperature change? yes

What did you observe during the reaction?

The temperature went up, the crystals dissolved

Part 4: Initial temperature of water _____

Temperature after adding calcium chloride to the water _____

Did you feel a temperature change? yes

What did you observe during the reaction?

The temperature went up, the calcium chloride dissolved part-way

ANALYSIS

Part 1: The reaction of sodium bicarbonate and acetic acid is exothermic or endothermic? What evidence do you have?

The reaction is endothermic because the temperature went down.

Part 2: The reaction of zinc metal and hydrochloric acid is exothermic or endothermic? What evidence do you have?

The reaction is exothermic because the temperature went up.

Part 3: The reaction of magnesium sulfate and water is exothermic or endothermic? What evidence do you have?

The reaction is exothermic because the temperature went up.

Part 4: The reaction of calcium chloride and water is exothermic or endothermic? What evidence do you have?

The reaction is exothermic because the temperature went up.

Calcium chloride is as an ice-melting compound on sidewalks and city streets. Explain what is happening (use one of the terms-exothermic or endothermic in your explanation).

The ice melt mixes with the snow and causes an exothermic reaction, so the snow melts.

Does the energy go from the surrounding to the chemicals or from the chemicals to the surroundings in an exothermic reaction?

In an exothermic reaction, the energy goes from the chemicals to the surrounding areas.

GOING FURTHER

Define endothermic and exothermic in your own words.

Endothermic - a reaction absorbs energy and the temperature goes down.

Exothermic - a reaction gives up energy and the temperature goes up

Classify each of the following as an exothermic or endothermic process.

Melting ice cubes _____ exothermic

Burning a candle _____ exothermic

Evaporation of water _____ exothermic

Baking Bread _____ exothermic

Splitting a gas molecule apart _____ exothermic

Formation of snow in clouds _____ **endothermic**

Part 1: Balanced equation... **1** HC₂H₃O₂ + **1** NaHCO₃ → **1** NaC₂H₃O₂ + **1** H₂O + **1** CO₂

Part 2: Balanced equation... **2** HCl + Zn → ZnCl₂ + H₂

Part 3: Balanced equation... MgSO₄ + **2** H₂O → MgSO₄ + **2** H₂ + O₂

Part 4: Balanced equation... CaCl₂ + **2** H₂O → CaCl₂ + **2** H₂ + O₂