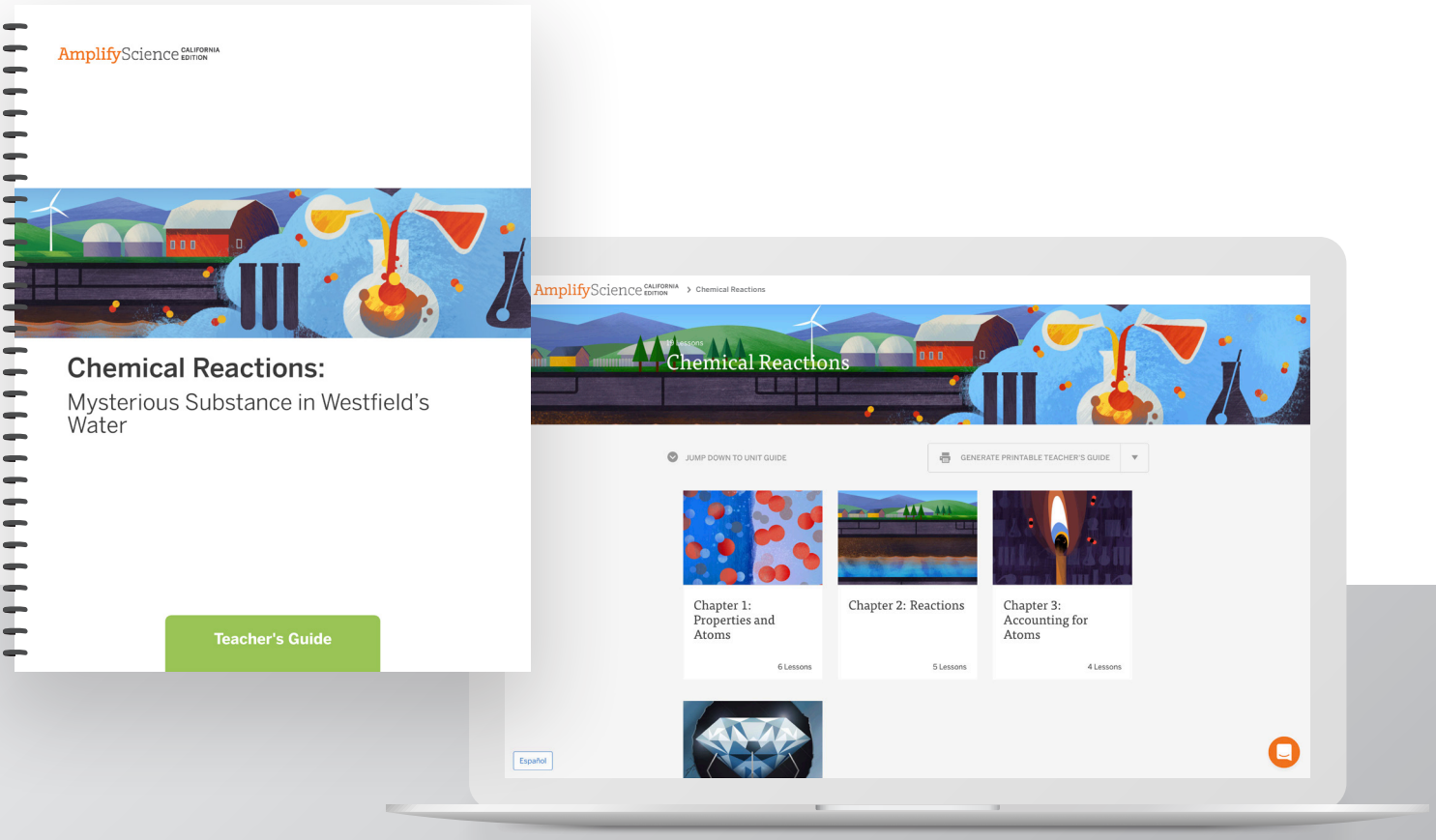
Amplify Science
CALIFORNIA

UNIT GUIDE

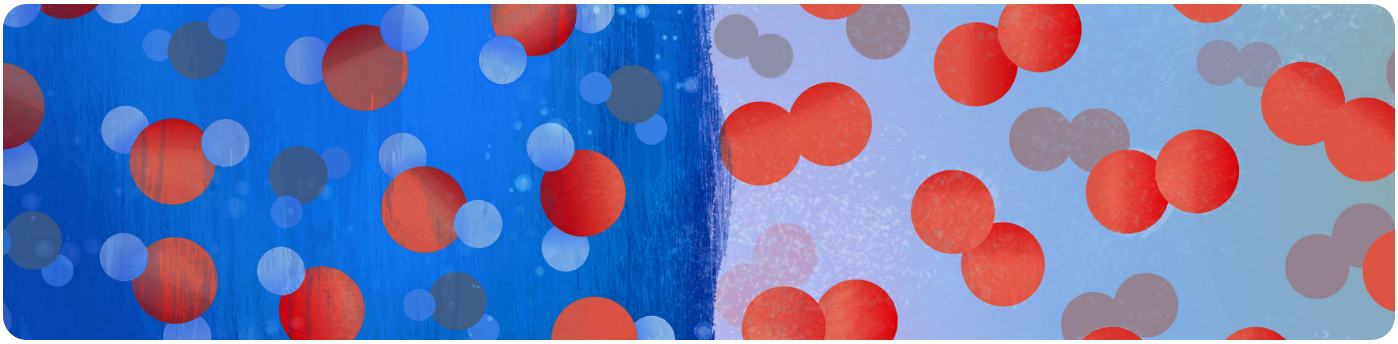
Chemical Reactions



Amplify.

THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY

Table of contents



Welcome to Chemical Reactions

Many curricula present chemical reactions as abstract phenomena that occur only in the context of a laboratory and always involve unfamiliar chemicals. When chemistry content is presented in this manner, students learn to discuss the reactants and products of a chemical reaction without ever considering how these ideas explain the chemical reactions happening all around them. In contrast, Amplify Science California emphasizes realistic and relatable real-world problems in order to encourage students to see chemical reactions as the ubiquitous phenomena that they are.

> Unlike a typical curriculum, Amplify Science California anchors learning by inviting students to take on the role of scientists and engineers.

In this unit, students take on the role of forensic chemists. Their job is to investigate a mysterious reddish-brown substance coming out of the water pipes in Westfield, a rural neighborhood that gets its water from a well. Working together, they determine that the reddish-brown substance is rust, and could have formed only from a chemical reaction between the iron pipes and the fertilizer. The unit concludes with a Science Seminar, in which students use what they have learned about substances, atoms, and chemical reactions to assist in a police investigation of a robbery that involved the use of an unknown substance to steal a rare and expensive diamond.

Unit Type: Core

Student Role: Forensic Chemists

Phenomenon: A mysterious brown substance has been detected in the tap water of Westfield.

Core Concepts: Understanding the relationship among properties, groups of repeating atoms, and how substances are formed during chemical reactions

Target Performance Expectations:

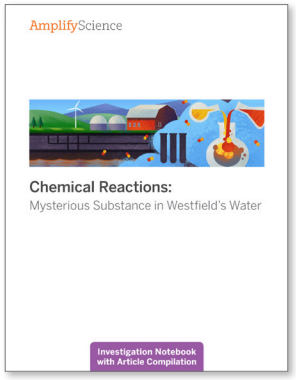
- PS1-1: Atomic Theory/Molecules
- PS1-2: Chemical Reactions
- PS1-3: Synthetic Materials
- PS1-5: Atoms Conserved
- PS1-6: Thermal Energy and Chemical Processes

Related Performance Expectations:

- LS1-6: Photosynthesis
- LS1-7: Cellular Respiration
- ESS3-1: Distribution of Natural Resources
- ESS3-3: Designs to Minimize Impact

Students figure out the unit phenomenon through the use of a variety of resources.

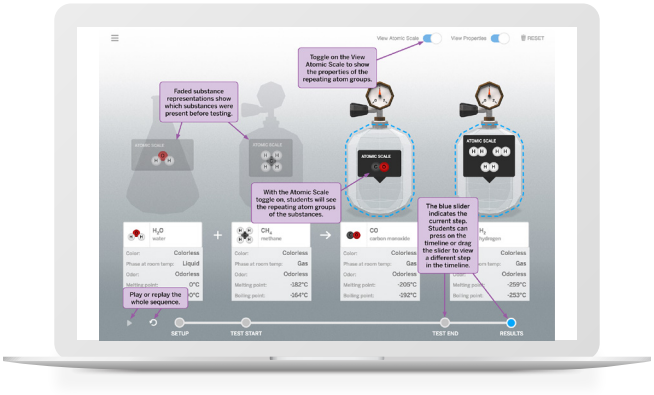
Student Investigation Notebook



Hands-On Kit

Videos

Digital Tools



About technology in this unit:
All Amplify Science California lessons were designed with device sharing in mind, and never assume that every student has a separate device.

In this grade, student-facing technology includes Practice Tools and digital Simulations. When the use of a digital tool is called for in a lesson, teachers have several implementation options:

If limited student devices are available—teachers can have students do activities in pairs or small groups.

If no student devices are available—teachers can project the digital tool to the class and either "drive" the digital tool themself or invite students to "drive" by using their device.

If internet access is unavailable—teachers can "pre-load" the digital tool on their device for use offline.

Chapter 1:
The storyline begins

What students investigate:

What is the reddish-brown substance in the water?

What students figure out:

The reddish-brown substance is different from the pipe substance (Fe) and from the contaminant of the water supply ($NaNO_3$). Evidence for this is that each of their properties (color and texture) is so different. In addition, the groups of atoms that make them up are different. The pipe substance is made of Fe; the contaminant is made of $NaNO_3$; and the reddish-brown substance is made of Fe_2O_3.

How they figure it out:

- Making careful observations of various substances
- Reading an article about why different substances have different properties
- Gathering evidence in the Sim about the atoms of substances found in the Westfield water

KEY


CLASS


HANDS-ON


HOMEWORK


MODELING


READING


SIM


SORTING


STUDENT-TO-STUDENT DISCUSSION


TEACHER


TEACHER-LED DISCUSSION


WARM-UP


WRITING

DAY 1 | LESSON 1.1

Pre-Unit Assessment

- Multiple-Choice Questions (25 min)
- Written-Response Question #1 (10 min)
- Written-Response Question #2 (10 min)

Pre-Unit Assessment

DAY 2 | LESSON 1.2

A Water Mystery in Westfield

- Warm-Up (5 min)
- Video: Using Chemistry to Keep Water Safe (5 min)
- Investigating a Mysterious Substance (15 min)
- Observing Substances (20 min)

DAY 3 | LESSON 1.3

Analyzing Substances and Properties

- Warm-Up (5 min)
- Making Detailed Observations (5 min)
- Investigating Substances (20 min)
- Evaluating Evidence (15 min)
- Homework

Optional Flextension: *Identifying Substances*

On-the-Fly Assessment

DAY 4 | LESSON 1.4

"Atomic Zoom-In"

- Warm-Up (5 min)
- Playing Everything Is Made of Atoms (10 min)
- Reading "Atomic Zoom-In" (25 min)
- Discussing Annotations (10 min)
- Homework

On-the-Fly Assessment

DAY 5 | LESSON 1.5

Investigating Atoms and Properties

- Warm-Up (5 min)
- Investigating Substances in the Sim (15 min)
- Rereading "Atomic Zoom-In" (20 min)
- Explaining the Homework Assignment (5 min)
- Homework
- Family Homework Experience (Optional)

DAY 6 | LESSON 1.6

Identifying the Reddish-Brown Substance

- Warm-Up (5 min)
- Word Relationships (15 min)
- Identifying the Reddish-Brown Substance (25 min)
- Homework
- Self-Assessment (Optional)

Self-Assessment

Chapter 2:
The storyline builds

What students investigate:

How did the rust form?

What students figure out:

A chemical reaction occurred between the iron on the inside of the pipes and the sodium nitrate that was mixed in with the water flowing through the pipes. During this reaction, atoms from the pipes and sodium nitrate rearranged to form new groups of atoms, resulting in the new reddish-brown substance. It has iron atoms just like the pipes, and oxygen atoms just like the contaminant, but the properties of the reddish-brown substance are different from both because the way that the atoms are grouped is different. This is true even though the iron and sodium nitrate were the substances that combined to produce the reddish-brown substance.

How they figure it out:

- Conducting chemical reactions and observing reactants and products both in hands-on tests and using the Sim
- Gathering evidence from a token-based physical model of a chemical reaction
- Reading an article about how synthetic materials developed by scientists and engineers are often designed at the atomic scale to mimic substances discovered in nature

KEY


CLASS


HANDS-ON


HOMEWORK


MODELING


READING


SIM


SORTING


STUDENT-TO-STUDENT DISCUSSION


TEACHER


TEACHER-LED DISCUSSION


WARM-UP


WRITING

DAY 7 | LESSON 2.1

Investigating Substance Changes

- Warm-Up (5 min)
- Investigating Substance Changes (20 min)
- Mixing Substances in the Sim (15 min)
- Reflecting on the Investigation Question (5 min)
- Homework

On-the-Fly Assessment

DAY 8 | LESSON 2.2

Explaining Chemical Reactions

- Warm-Up (5 min)
- Finding Chemical Reactions (20 min)
- Explaining Chemical Reactions (15 min)
- Homework

On-the-Fly Assessment

DAY 9 | LESSON 2.3

Explaining How the Rust Formed

- Warm-Up (5 min)
- Testing the Claims (15 min)
- Modeling How the Rust Formed (15 min)
- Writing to Westfield (10 min)
- Homework

On-the-Fly Assessment

Optional Flextension: *Investigating Mixtures*

DAY 10 | LESSON 2.4

Critical Juncture Assessment

- Multiple-Choice Questions (25 min)
- Written-Response Question #1 (10 min)
- Written-Response Question #2 (10 min)

Critical Juncture Assessment

DAY 11 | LESSON 2.5

Reflecting on Chemical Reactions

- Warm-Up (5 min)
- Playing Sodium and Hydrogen Chloride (10 min)
- Analyzing the Results of the Experiment (25 min)
- Sharing Ideas (5 min)
- Homework
- Self-Assessment (Optional)

Self-Assessment

Chapter 3:
The storyline goes deeper

What students investigate:

What was produced during the reaction between the iron pipes and the fertilizer?

What students figure out:

The reddish-brown substance (Fe_2O_3) is in the water because it was formed in the reaction, but it can be filtered out. The substance $NaNO_3$ was used up in the reaction, but its atoms couldn't have been destroyed. So, another substance ($NaNO_2$) must be left behind. The NaCN can't be in the water because there were no carbon atoms in the water or the pipes, and atoms can't change types during chemical reactions.

How they figure it out:

- Reading an article about what happens to atoms during a chemical reaction
- Gathering related evidence by analyzing reactions in the Sim
- Exploring the token physical model further
- Analyzing evidence from Westfield
- Creating a visual model

KEY

- CLASS
- HANDS-ON
- HOMEWORK
- MODELING
- READING
- SIM
- SORTING
- STUDENT-TO-STUDENT DISCUSSION
- TEACHER
- TEACHER-LED DISCUSSION
- WARM-UP
- WRITING

DAY 12 | LESSON 3.1

"What Happens When Fuels Burn?"

- Warm-Up (10 min)
- Introducing Questions and Claims (5 min)
- Playing Burning Paper (5 min)
- Reading "What Happens When Fuels Burn?" (20 min)
- Discussing Annotations (10 min)

On-the-Fly Assessment

DAY 13 | LESSON 3.2

Burning at the Atomic Scale

- Warm-Up (5 min)
- Burning Fuel in the Sim (20 min)
- Rereading "What Happens When Fuels Burn?" (15 min)
- Sharing Evidence and Discussing Claims (5 min)
- Homework

On-the-Fly Assessment

DAY 14 | LESSON 3.3

Investigating How Products Form

- Warm-Up (5 min)
- Investigating Jessie's Claim (20 min)
- Word Relationships (20 min)
- Homework

On-the-Fly Assessment

DAY 15 | LESSON 3.4

What's in Westfield's Water?

- Warm-Up (5 min)
- Identifying the Other Product (15 min)
- Modeling the Products of the Reaction (10 min)
- Writing to Westfield (10 min)
- Homework
- Self-Assessment (Optional)

On-the-Fly Assessment
Self-Assessment

Chapter 4:
Application to a new storyline

What students investigate:

The Lavoisier Diamond has been stolen from Westfield Museum, but by whom? More importantly, what was the unknown substance discovered at the crime scene that was used to make a hole in the glass protecting the jewel?

What students figure out:

Scientists must communicate how their claims and evidence are supported with reasoning in a convincing scientific argument. In order to convince its reader, a written scientific argument needs to state a claim, describe specific evidence, and explain how the evidence supports the claim. A claim can sometimes be supported more effectively if you consider the combination of several different pieces of evidence.

How they figure it out:

- Reviewing available evidence to make an argument
- Engaging in oral argumentation in a student-led discourse routine called a Science Seminar
- Writing final arguments

KEY


CLASS


HANDS-ON


HOMEWORK


MODELING


READING


SIM


SORTING


STUDENT-TO-STUDENT DISCUSSION


TEACHER


TEACHER-LED DISCUSSION


WARM-UP


WRITING

DAY 16 | LESSON 4.1

Chemistry at the Crime Scene

- Warm-Up (5 min)
- Identifying an Unknown Substance (25 min)
- Discussing New Evidence (15 min)

DAY 17 | LESSON 4.2

Analyzing Claims and Evidence

- Warm-Up (5 min)
- Making Possible Reactions (20 min)
- Analyzing New Evidence (15 min)
- Identifying the Primary Suspect (5 min)

On-the-Fly Assessment

DAY 18 | LESSON 4.3

Science Seminar

- Warm-Up (5 min)
- Preparing for the Science Seminar (10 min)
- Introducing the Science Seminar (5 min)
- Participating in the Science Seminar (20 min)
- Introducing the Homework Assignment (20 min)
- Homework
- Self-Assessment (Optional)

On-the-Fly Assessment
Self-Assessment

DAY 19 | LESSON 4.4

End-of-Unit Assessment

- Multiple-Choice Questions (25 min)
- Written-Response Question #1 (10 min)
- Written-Response Question #2 (10 min)

End-of-Unit Assessment

All students. All standards.

Rather than treating the standards simply as a list of topics to cover, we designed Amplify Science California to allow for truly in-depth and integrated coverage of the disciplinary core ideas (DCIs), science and engineering practices (SEPs), and crosscutting concepts (CCCs). Unlike other programs, however, ours makes the NGSS' vision of "all students, all standards" a reality by creating a unit-specific learning progression for every unit called a Progress Build.

Each Progress Build defines several levels of understanding of the unit's anchoring phenomenon, with each level integrating and building upon the knowledge and skills from lower levels. In this way, each Progress Build provides a clear roadmap for how students' understanding of the phenomenon is expected to deepen and develop with each successive chapter and lesson.

What's more, the program's system of assessments is also tied to these Progress Builds. This carefully crafted integration provides teachers with credible, actionable, and timely diagnostic information about student progress toward the unit's learning goals and grade-level performance expectations. Armed with this powerful data, teachers have the ultimate flexibility to decide when to move on and when to slow down and dive deeper.

Chemical Reactions Progress Build

The Progress Build in this unit consists of three levels of understanding. At each level, students add new ideas and integrate them into a progressively deeper understanding of the relationship among properties, groups of repeating atoms, and the way substances are formed during chemical reactions.

Progress Build Level 1:

Different substances have different properties. This is because every substance is made of a unique group of a certain type and number of atoms. This group repeats to make up the substance.

Progress Build Level 2:

During chemical reactions, atoms that make up the starting substance(s) rearrange to form different groups of atoms that repeat, resulting in different substances(s).

Progress Build Level 3:

During chemical reactions, the ending substances are formed from the same type and number of atoms that made up the starting substances because atoms cannot be created or destroyed.

Examples of differentiation in this unit

In addition to providing unit-specific Progress Builds that break learning goals into smaller, more achievable levels of understanding, Amplify Science California makes learning accessible for all students through a variety of scaffolds, supports, and differentiation strategies for every lesson. **For a complete list of strategies, see the Differentiation section of every Lesson Brief**.

Below are a few examples of strategies embedded in this unit.

For English learners:

Additional sentence starters (Example from Lesson 2.2)
English learners may benefit from the support of sentence starters in order to participate more fully in the partner discussions. You could write the following prompts on the board or distribute them on paper to students you think would benefit from having them.

- I notice ...
- I observe ...
- I think that this is _____, and my evidence is _____.

For students needing more support:

Whole-class work instead of partner work (Example from Lesson 1.3)
You may want to support students in learning to make observations by doing at least one part of the lesson as a whole group. For example, you could do the first hands-on activity together and then have students do the Sorting Tool activity individually or with a partner.

For students ready for a challenge:

Considering and addressing refutational evidence (Example from Lesson 3.4)
Sophisticated argumentation includes not only supporting a claim with the strongest, most convincing evidence available, but also includes explaining why some evidence eliminates other possible claims. It can be quite challenging to consider both supports and refutation at the same time, but if some or all of your students are ready for the challenge, you may want to ask them to write about why the water did not contain potassium chromate. Ask students to cite key concepts from the unit as they write.

3-D Statements

In order to help teachers recognize the three-dimensional structure of every unit, chapter, and lesson, each unit contains a 3-D Statement document that makes the integration clear.

Making the 3-D statement document all the more effective, the three dimensions are color-coded for easy recognition.

Chemical Reactions 3-D Coverage

SEPs
Science and Engineering Practices

DCIs
Disciplinary Core Ideas

CCCs
Cross-Cutting Concepts

Unit Level

To identify a mysterious reddish-brown substance appearing in the pipes of a fictional town, students use digital and physical models and hands-on observations to investigate how atoms are rearranged into different patterns to form new substances during chemical reactions (scale, proportion, and quantity; patterns). Students apply their understanding to construct explanations about how the reddish-brown substance formed as a result of a chemical reaction between the pipes and fertilizer in the water supply.

Chapter Level

Chapter 1: Properties and Atoms

Students begin to investigate a mysterious reddish-brown substance discovered coming out of the water pipes in a fictional community. They first observe substances at the macroscale and then use the digital model (a simulation) to observe substances at the atomic scale to figure out that observable differences between different substances are the result of differences at the atomic scale (scale, proportion, and quantity).

Chapter 2: Reactions

In order to construct explanations about how the rust in Westfield's water formed, students gather evidence from hands-on activities, a physical model, and the digital simulation to investigate whether or not it is possible for substances to change into different substances (scale proportion, and quantity; cause and effect). Then students construct visual models of how atoms are rearranged during a chemical reaction (patterns).

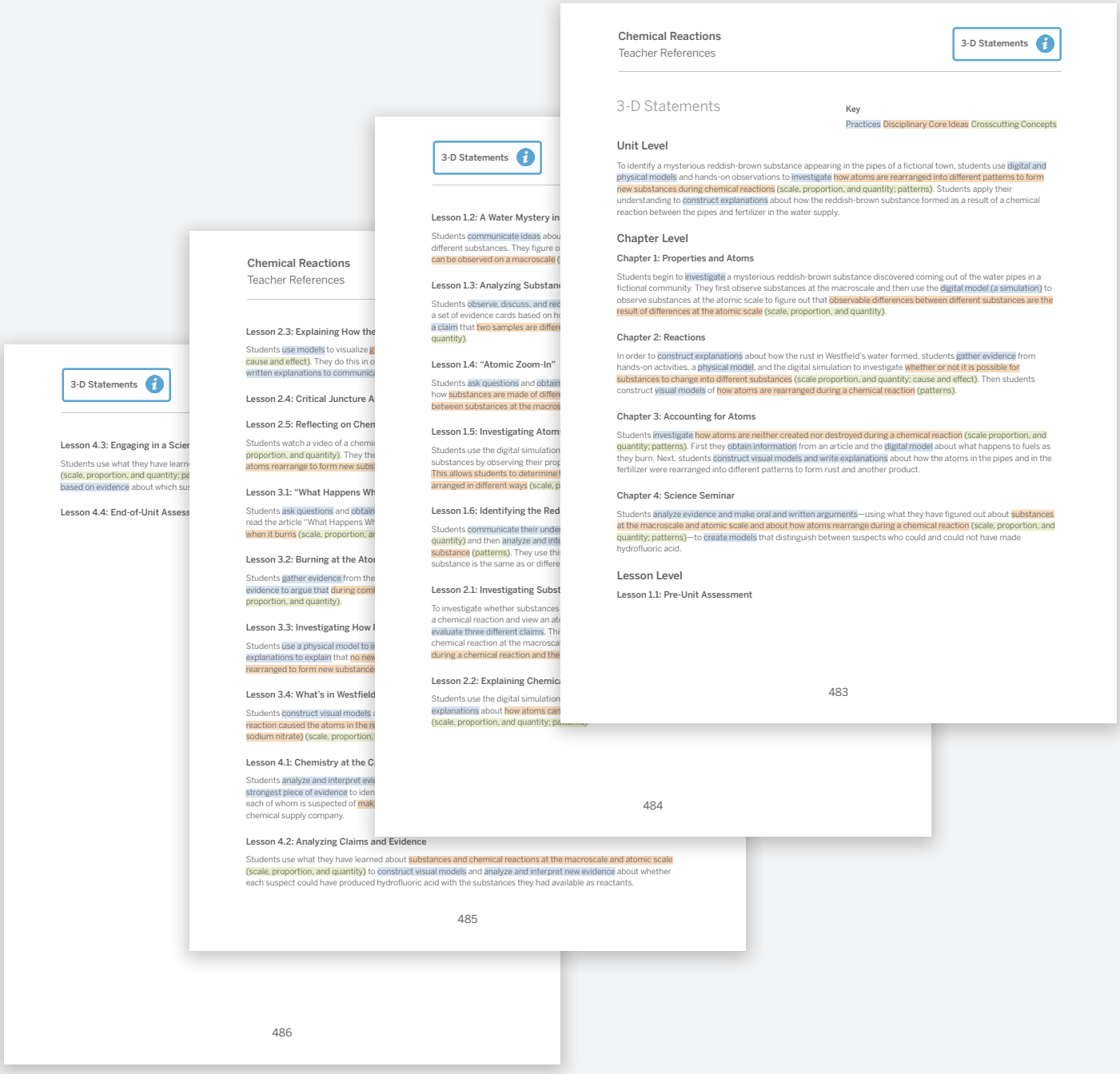
Chapter 3: Accounting for Atoms

Students investigate how atoms are neither created nor destroyed during a chemical reaction (scale proportion, and quantity; patterns). First they obtain information from an article and the digital model about what happens to fuels as they burn. Next, students construct visual models and write explanations about how the atoms in the pipes and in the fertilizer were rearranged into different patterns to form rust and another product.

Chapter 4: Science Seminar

Students analyze evidence and make oral and written arguments—using what they have figured out about substances at the macroscale and atomic scale and about how atoms rearrange during a chemical reaction (scale, proportion, and quantity; patterns)—to create models that distinguish between suspects who could and could not have made hydrofluoric acid.

To review the 3-D Statements at the lesson level, see the Lesson Brief section of every lesson.



Chemical Reactions
Teacher References

3-D Statements

3-D Statements

Key
Practices Disciplinary Core Ideas Crosscutting Concepts

Unit Level

To identify a mysterious reddish-brown substance appearing in the pipes of a fictional town, students use digital and physical models and hands-on observations to investigate how atoms are rearranged into different patterns to form new substances during chemical reactions (scale, proportion, and quantity; patterns). Students apply their understanding to construct explanations about how the reddish-brown substance formed as a result of a chemical reaction between the pipes and fertilizer in the water supply.

Chapter Level

Chapter 1: Properties and Atoms

Students begin to investigate a mysterious reddish-brown substance discovered coming out of the water pipes in a fictional community. They first observe substances at the macroscale and then use the digital model (a simulation) to observe substances at the atomic scale to figure out that observable differences between different substances are the result of differences at the atomic scale (scale, proportion, and quantity).

Chapter 2: Reactions

In order to construct explanations about how the rust in Westfield's water formed, students gather evidence from hands-on activities, a physical model, and the digital simulation to investigate whether or not it is possible for substances to change into different substances (scale proportion, and quantity; cause and effect). Then students construct visual models of how atoms are rearranged during a chemical reaction (patterns).

Chapter 3: Accounting for Atoms

Students investigate how atoms are neither created nor destroyed during a chemical reaction (scale proportion, and quantity; patterns). First they obtain information from an article and the digital model about what happens to fuels as they burn. Next, students construct visual models and write explanations about how the atoms in the pipes and in the fertilizer were rearranged into different patterns to form rust and another product.

Chapter 4: Science Seminar

Students analyze evidence and make oral and written arguments—using what they have figured out about substances at the macroscale and atomic scale and about how atoms rearrange during a chemical reaction (scale, proportion, and quantity; patterns)—to create models that distinguish between suspects who could and could not have made hydrofluoric acid.

Lesson Level

Lesson 1.1: Pre-Unit Assessment

483

3-D Statements

Lesson 1.2: A Water Mystery in

Students communicate ideas abou
different substances. They figure o
can be observed on a macroscale (

Lesson 1.3: Analyzing Substanc

Students observe, discuss, and rec
a set of evidence cards based on h
a claim that two samples are differ
quantity).

Lesson 1.4: "Atomic Zoom-In"

Students ask questions and obtain
how substances are made of differ
between substances at the macros

Lesson 1.5: Investigating Atom

Students use the digital simulation
substances by observing their prop
This allows students to determine
arranged in different ways (scale, p

Lesson 1.6: Identifying the Red

Students communicate their under
quantity) and then analyze and inte
substance (patterns). They use thi
substance is the same as or differe

Lesson 2.1: Investigating Subst

To investigate whether substances
a chemical reaction and view an at
evaluate three different claims. Thi
chemical reaction at the macrosca
during a chemical reaction and the

Lesson 2.2: Explaining Chemic

Students use the digital simulation
explanations about how atoms can
(scale, proportion, and quantity; pa

484

Chemical Reactions
Teacher References

Lesson 2.3: Explaining How the

Students use models to visualize g
cause and effect). They do this in o
written explanations to communica

Lesson 2.4: Critical Juncture A

Lesson 2.5: Reflecting on Chen

Students watch a video of a chemic
proportion, and quantity). They the
atoms rearrange to form new subs

Lesson 3.1: "What Happens Wh

Students ask questions and obtain
read the article "What Happens Wh
when it burns (scale, proportion, a

Lesson 3.2: Burning at the Ato

Students gather evidence from the
evidence to argue that during com
proportion, and quantity).

Lesson 3.3: Investigating How

Students use a physical model to i
explanations to explain that no new
rearranged to form new substance

Lesson 3.4: What's in Westfield

Students construct visual models a
reaction caused the atoms in the re
sodium nitrate) (scale, proportion,

Lesson 4.1: Chemistry at the C

Students analyze and interpret evi
strongest piece of evidence to iden
each of whom is suspected of mak
chemical supply company.

Lesson 4.2: Analyzing Claims and Evidence

Students use what they have learned about substances and chemical reactions at the macroscale and atomic scale (scale, proportion, and quantity) to construct visual models and analyze and interpret new evidence about whether each suspect could have produced hydrofluoric acid with the substances they had available as reactants.

485

3-D Statements

Lesson 4.3: Engaging in a Scier

Students use what they have learn
(scale, proportion, and quantity; pa
based on evidence about which sus

Lesson 4.4: End-of-Unit Assess

486

Notes

Notes

For more information on Amplify Science, visit **amplify.com/science/california**.

Amplify.

THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY