X: What is Chemistry?

Unit: Introduction
Standard:• NGSS: Introduction to Chemistry.
• TEKS: §112.43(c)(1) — ask questions, plan and safely conduct investigations, use appropriate safety equipment and tools (Safety Data Sheets, balances, glassware), collect data using SI units, and organize qualitative and quantitative data.

Lesson Objective: You will explain what chemistry is and why it's called the central science. You will also classify matter into pure substances and mixtures, and analyze how chemists observe, measure, and model the world around them safely.

Chemistry: The Central Science Hiding in Your Everyday Life

1. What Chemistry Really Is

Chemistry is the study of matter, including its composition, its properties, and the changes it undergoes. Because matter connects the physical and living worlds, chemistry bridges physics and biology and earns the nickname "the central science."

2. Classifying Matter

Everything physical sorts into pure substances, like elements and compounds, or mixtures, like homogeneous and heterogeneous combinations. Learning this system also means telling a physical change, like ice melting, apart from a chemical change, like iron rusting.

3. How Chemists Work

Chemists rely on the scientific method, careful observation, and precise measurement in SI units to investigate matter reliably. Safety practices and tools like balances and glassware keep that investigation both safe and trustworthy.

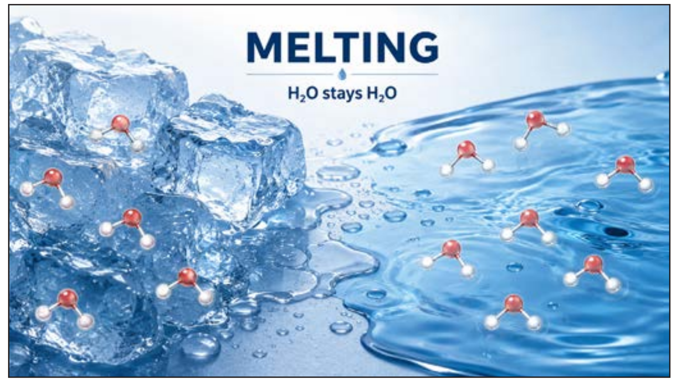
Why It Matters

Chemistry shapes your health, the products you rely on, and the environment around you, whether you notice it or not. Learning to classify matter and investigate it carefully builds scientific literacy you'll use for the rest of your life.

Every object around you, from your phone to your breakfast, is chemistry at work. You just haven't looked closely yet.

Chemistry: The Central Science Hiding in Your Everyday Life

The metal in your phone conducts electricity because of how its atoms are arranged. The bread in your sandwich turned golden brown from a chemical reaction between sugars and proteins. The water in your glass keeps you alive because of a molecule made of two elements bonded together. None of that is an accident. It's chemistry, running quietly in the background of nearly everything you touch, eat, and use.



Ice begins to melt into liquid water, a physical change that keeps its chemical identity as H_2O throughout.

What Chemistry Really Is

Chemistry is the study of **matter**: what it's made of, what properties it has, and how it changes under different conditions. Matter is anything that takes up space and has mass, built from tiny particles called **atoms**. That definition covers almost everything physical around you, from the air filling your lungs to the phone in your hand.

Chemists examine matter closely at the atomic level. They describe its **composition**, meaning what it's built from, its **properties**, meaning how it looks, feels, and behaves, and the **changes** it goes through when heat, pressure, or other substances get involved. Even a small shift in one of these factors can completely change how a material acts. Take an apple sitting on your desk: its composition includes sugars and water, its properties include its color and crunch, and leaving it out too long shows you a change in real time.

Because matter connects the physical world to the living world, chemistry has earned a nickname: the **central science**. Spotting those same qualities in an apple is a small preview of a much bigger pattern. It bridges **physics**, which explains the energy and forces behind matter's behavior, and **biology**, which explains how matter organizes itself into living things like you.

A biologist studying how your cells use oxygen relies on chemistry to explain that process. A physicist studying why a metal conducts heat efficiently relies on chemistry too, since the arrangement of atoms inside that metal determines the answer. Chemistry sits in the middle, giving both fields a shared language.

That bridge shows up far outside the classroom. The fabric in your clothes, the medicine in your cabinet, and the fuel powering a car all trace back to someone who understood matter well enough to shape it on purpose. Careers in medicine, pharmacy, environmental science, forensics, and materials engineering all start with this same foundation. Even a chef relies on this same science, since cooking is chemistry you can taste.

A single glass of water hides two elements locked together in a bond, and that's just the beginning of chemistry.

Sorting Out the Stuff Around You

Now that you know what matter is, the next step is learning how chemists sort it. Chemists divide matter into two broad categories: **pure substances** and **mixtures**. A pure substance has a fixed composition, meaning every sample of it contains the same atoms combined in the same way. Table salt, for example, is a compound with the same sodium-to-chlorine ratio in every grain, no matter where it came from.

Iron exposed to air and moisture gradually forms iron oxide, a chemical change that creates an entirely new compound.

Pure substances split further into **elements**, like the oxygen (O_2) you breathe, and **compounds**, like water (H_2O), where two or more elements bond together in a fixed ratio. A compound's properties are often completely different from the elements that make it up. Hydrogen and oxygen are both gases at room temperature, but combined in the right ratio, they form a liquid you drink every day. That difference matters, since a pure substance always behaves the same way, while a mixture depends on what's in it.

Mixtures work differently. A mixture combines substances that keep their own identities and can be physically separated again, since no new bonds ever formed between them. Even the air around you is a mixture of gases like nitrogen and oxygen, each one keeping its own identity as it mixes with the rest. Figuring out whether a mixture looks uniform is usually the fastest way to sort it further.

Some mixtures, called **homogeneous mixtures**, look uniform throughout, like saltwater or clean air. Others, called **heterogeneous mixtures**, show visibly different parts, like a salad or sand mixed with gravel. You could pick the gravel out by hand, or let the saltwater evaporate to leave the salt behind, and neither substance would be changed in the process.

This sorting system connects to another key idea: the difference between a **physical change** and a **chemical change**. When ice melts into water, its form changes, but it's still H_2O. That's a physical change, and it's easy to reverse by simply refreezing it. When iron rusts, the iron atoms combine with oxygen in the air to form an entirely new compound, iron oxide. That's a chemical change, and there's no simple way to reverse it by physical means alone.

How Chemists Turn Observation Into Understanding

Sorting matter only helps if you can investigate it reliably, and that's where the **scientific method** comes in. Chemists ask a question, form a hypothesis, design an investigation, and collect data, then use that data to support or revise their thinking. None of those steps mean much without observations you can trust.

Along the way, they rely on two types of observation. **Qualitative observations** describe qualities, like color, smell, or texture, without assigning a number. **Quantitative observations** use

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Saltwater looks completely uniform because it's a homogeneous mixture, with salt dissolved evenly throughout the water.

measurement instead, recording exact values like mass, volume, or temperature in standard **SI units**, so results can be compared reliably from one lab to another. For example, calling a lemon sour and yellow is a qualitative observation, while recording its mass as 84 grams (3 ounces) on a balance is a quantitative one. Both kinds of observation work together, since a measurement still needs context to make sense.

Atoms and molecules are far too small to see, even under most microscopes, so chemists rely on **models** to represent them. A model might be a simple ball-and-stick sketch showing how atoms in water connect, or a computer simulation showing how atoms rearrange during a reaction. A good model doesn't have to be perfectly accurate to be useful. It just has to capture the behavior chemists need to understand and predict. Once chemists have a reliable model and solid data, the next responsibility is handling the real substance safely.

Measurement and safety go hand in hand in real chemistry work. **Safety Data Sheets** tell chemists how to handle a substance responsibly, while tools like balances and glassware let them record matter's properties precisely rather than guessing. That responsibility becomes clear once it's ignored.

This kind of disciplined chemical analysis has exposed public health problems, like contaminated drinking water in a community's pipes, and led to solutions that protected people's health. A single overlooked reading can mean the difference between a discovery that helps people and one that harms them.

A materials engineer inspects a new alloy, relying on chemistry to predict how the metal's atoms will behave under stress.

Matter is everywhere, and once you can name it, sort it, and observe it with care, the chemistry running quietly beneath your everyday life starts to come into focus.

How to Apply This

- **Spot matter around you:** Notice that everything physical, from air to metal, is matter chemists can study.
- **Sort what you see:** Decide whether something is a pure substance or a mixture, and whether it's homogeneous or heterogeneous.
- **Tell changes apart:** Ask whether a change is physical, meaning the same substance in a new form, or chemical, meaning a whole new substance formed.
- **Observe like a chemist:** Separate what you notice, which is qualitative, from what you can measure, which is quantitative.
- **Trust careful measurement:** Precise, honest measurement is what protects people in real-world chemistry.

Safety Data Sheets guide chemists in handling substances responsibly, protecting both the scientist and the people around them.

X: What is Chemistry? - Guided Notes

Three Most Important Concepts

As you read the article, jot down the three biggest ideas in your own words.

Concept 1: ____

Concept 2: ____

Concept 3: ____

Main Concept Overview

Fill in each blank using a word from the word bank below.

Word Bank: models, composition, matter, chemical, central

1. Chemistry is the study of ______________, including what it's made of, its properties, and the changes it undergoes.
2. Because matter connects the physical and living world, chemistry is nicknamed the ______________ science.
3. A pure substance has a fixed ______________, meaning every sample contains the same atoms combined the same way.
4. When iron rusts and forms iron oxide, that is an example of a ______________ change.
5. Since atoms are too small to see, chemists use ______________ to represent them, like a ball-and-stick sketch.

Matching Section

Write the correct letter next to each term.

_____ 1. Element	A. A substance made of two or more elements bonded together in a fixed ratio
_____ 2. Compound	B. A mixture that looks uniform throughout, like saltwater
_____ 3. Homogeneous Mixture	C. A pure substance that cannot be broken down into simpler substances
_____ 4. Heterogeneous Mixture	D. A change in form that does not create a new substance, like ice melting
_____ 5. Physical Change	E. A mixture with visibly different parts, like a salad

X: What is Chemistry? - Guided Notes

True or False

Write T or F next to each statement.

_____ 1. Chemistry is called “the central science” because it connects physics and biology.

_____ 2. A compound is a type of mixture.

_____ 3. Ice melting into water is an example of a chemical change.

_____ 4. Chemists use qualitative observations to describe things like color, smell, or texture.

_____ 5. Because atoms are too small to see directly, chemists often use models to represent them.

Fill in the Table

Using what you learned about classifying matter, fill in an example of each type mentioned in the article.

Type of Matter	Example From the Article
Element	
Compound	
Homogeneous Mixture	
Heterogeneous Mixture	

Application Questions

1. Explain why water is considered a compound rather than a mixture, using what the article says about fixed ratios and bonding.

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2. Describe one way a chemist might use a model to study something too small to see, and explain why models are useful even if they aren’t perfectly accurate.

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The Flint, Michigan Water Crisis

In 2014, the city of Flint, Michigan switched its water source to save money, and the new water proved more corrosive than officials expected. That corrosive water reacted chemically with old lead pipes beneath the city, leaching lead, a toxic metal, into the drinking water supply. For months, the water still looked clear and smelled normal, so a simple qualitative observation missed the danger. Some residents reported discolored water and health symptoms, but officials dismissed these concerns without visual proof of a problem. It took quantitative testing and precise measurement, well above the accepted safety limit, for independent scientists to confirm the danger. That measured evidence, not appearance, finally forced officials to replace the corroded pipes and warn the public. The case shows how an invisible chemical reaction between water and metal became a public health crisis until disciplined measurement exposed it.

As you answer the questions below, think back to the article's explanation of physical versus chemical change, and the difference between qualitative and quantitative observation. Those two ideas are the key to understanding what really happened in Flint.

Analysis Questions

a) What change took place between the water and the old pipes, and was it a physical change or a chemical change?

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b) Why did qualitative observation fail to catch the problem in Flint, even though residents were drinking the water every day?

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c) Evaluate the role that quantitative measurement played in finally proving there was a danger. Could the crisis have been solved without it?

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Self-Driving Laboratories

Some research labs now use robotic systems and artificial intelligence to run chemistry experiments around the clock, without a human mixing a single sample by hand. One well-known example, called A-Lab, was built by researchers at UC Berkeley to search for new battery materials faster than any human team could manage alone. These self-driving laboratories still rely on the same scientific method you read about: they form a hypothesis, run a test, and collect quantitative data. Instead of a person reading a measurement, sensors and software record it and decide what experiment to try next.

Before you answer, reread how the article describes qualitative versus quantitative observation, and how models help chemists predict behavior before testing. Use those two ideas to explain what's different, and what stays the same, when a machine runs the experiment instead of a person.

Analysis Questions

a) Application: What kind of observations, qualitative or quantitative, would a robotic lab need to rely on most, and why?

b) Analysis: How does using the scientific method inside a machine change how quickly chemists can test new materials or substances?

c) Evaluation: Why might a model, like a computer simulation, be useful for a self-driving lab trying to predict how atoms will behave before running a real test?

01

Why does honest, careful measurement matter ethically in chemistry?

Think about what could go wrong if a scientist reported inaccurate data about something people rely on, like drinking water.

02

Where do you see chemistry overlapping with biology or physics in your own life?

Think about a process in your body, or a piece of technology you use, and what's really happening inside it.

Manual Lab vs. Autonomous Lab Water Testing

Trial	Manual Lab Reading (µg/L)	Autonomous Lab Reading (µg/L)	Difference (µg/L)
1	4.20	4.10	0.10
2	9.80	9.75	0.05
3	15.60	15.50	0.10
4	22.30	22.10	0.20
5	3.10	3.05	0.05
6	18.90	18.80	0.10

Drinking water can be tested for lead by a human chemist working manually, or by a self-driving lab like the ones described in the Frontier Application. The table above compares six trials testing the same water samples, similar to the kind of testing that exposed the Flint water crisis. You will not need to calculate anything. Just read the table carefully to answer the questions.

Analysis Questions

1. **Basic Interpretation:** What was the manual lab's reading for Trial 4?

2. **Pattern Identification:** Describe how closely the autonomous lab's readings match the manual lab's readings across all six trials.

3. **Application:** Based on the differences shown, would you trust the autonomous lab's readings as much as the manual lab's when checking something as important as drinking water safety? Use evidence from the table to explain your answer.

X: What is Chemistry? - Hypotheticals

Scenario 1: The Boil-Water Notice

You notice your city issued a boil-water notice after tests found unusually high levels of a metal in the tap water supply. The water itself still looks clear and tastes completely normal, which is exactly why the notice catches most residents by surprise.

a) Predict: is the metal likely an element or part of a compound, based on what you know about pure substances?
b) Analyze: why would inspectors need quantitative rather than qualitative observations to detect this problem?
c) Evaluate: why might careful measurement matter more here than a quick visual check of the water?

Scenario 2: Testing a New Shoe Sole

A materials engineer is testing a new running shoe sole and needs to know if it changes physically or chemically after repeated impact. She runs the sole through a machine that simulates thousands of steps in just a few hours, then examines it closely for any sign of wear.

a) Application: what's the difference between a physical change and a chemical change she should look for?
b) Analysis: if the sole cracks but its composition stays the same, which type of change occurred?
c) Prediction: how might a model help her understand what's happening at the atomic level?

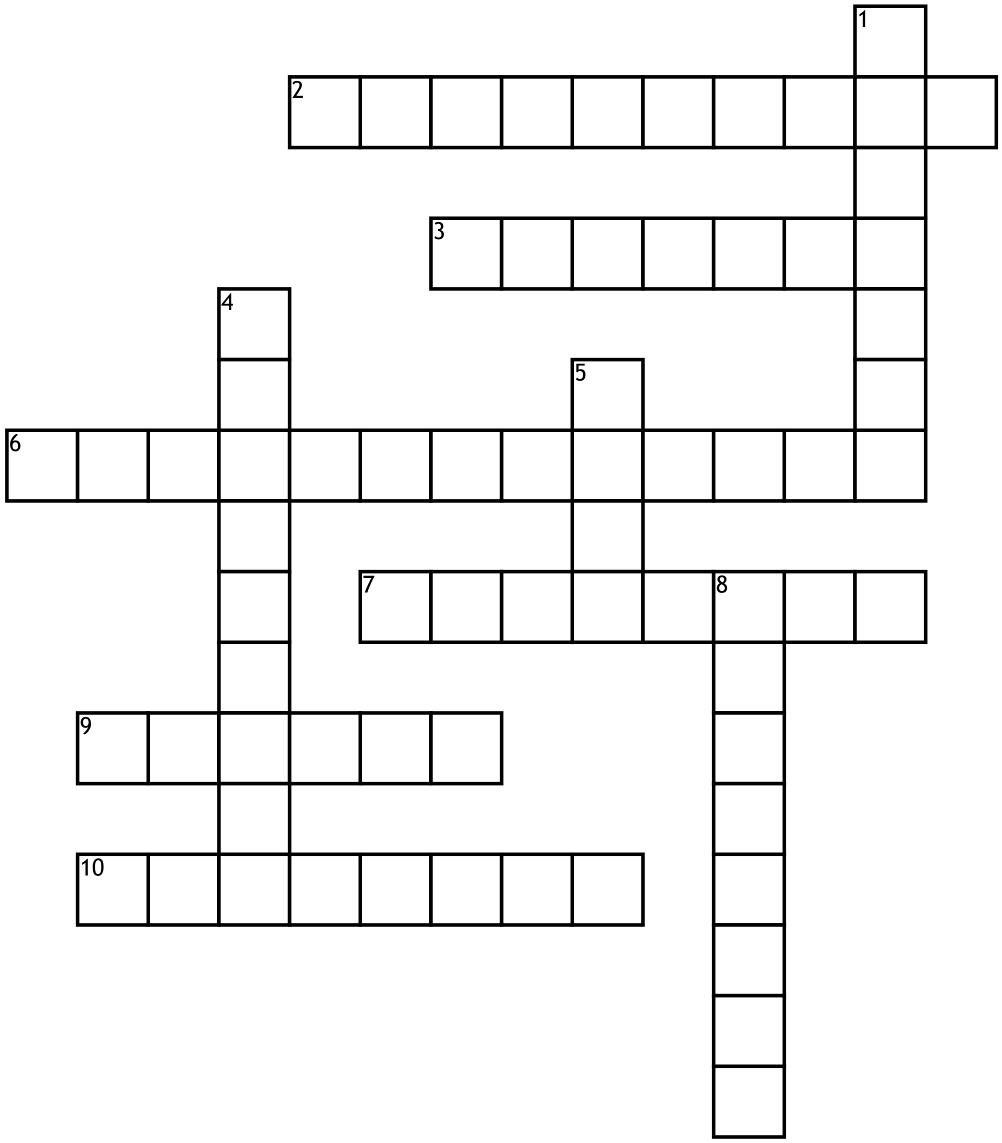
TERM	DEFINITION
Atom	
Chemical Change	
Chemistry	
Compound	
Element	
Matter	
Mixture	
Physical Change	
Pure Substance	
Scientific Method	

What is Chemistry?

K	E	S	J	A	T	H	N	Z	G	N	T	Q	R	G	M	R	O	R	U	J	K	G	O
R	Y	L	W	Q	E	T	X	V	N	H	Q	E	W	A	G	I	R	V	P	G	C	M	R
B	I	U	B	D	Q	V	P	J	Y	T	V	Q	R	X	H	V	I	W	M	A	T	O	M
C	M	S	R	V	L	T	Z	W	I	P	S	O	E	M	P	X	X	R	H	J	Z	G	V
D	F	C	C	Z	W	M	B	K	T	H	C	D	H	P	Y	L	O	Y	L	F	J	L	P
W	P	I	C	U	I	J	Q	D	A	L	U	Z	H	J	E	U	T	V	O	Q	Q	R	H
G	R	E	F	O	G	X	O	V	B	S	Y	H	J	D	U	R	S	O	N	R	Z	I	Y
K	J	N	T	K	L	S	I	B	G	P	L	V	R	A	Z	D	U	S	C	K	W	G	S
U	J	T	H	E	Y	R	C	H	E	M	I	C	A	L	C	H	A	N	G	E	D	Z	I
R	M	I	L	A	L	R	J	B	S	X	S	E	F	N	F	Q	E	E	P	G	L	P	C
K	O	F	K	K	E	E	H	D	G	P	F	J	X	V	N	P	J	G	R	L	K	J	A
M	M	I	P	N	F	M	M	I	Z	A	U	X	X	B	U	W	W	B	P	S	I	K	L
M	V	C	A	H	L	Z	J	E	P	N	O	R	V	N	W	E	V	Z	Z	G	V	T	C
L	B	M	H	T	L	Q	Y	K	N	Z	Q	C	E	R	O	L	V	X	D	T	L	G	H
T	Z	E	H	B	W	W	T	J	M	T	I	L	H	S	Y	D	Q	C	T	Y	N	J	A
T	G	T	D	T	J	G	C	Q	I	B	Q	G	G	E	U	Y	X	G	W	D	N	E	N
V	W	H	I	C	Z	K	K	J	X	P	R	O	B	M	M	B	D	M	S	S	Y	L	G
T	S	O	A	U	O	T	Z	K	T	A	V	I	U	A	I	I	S	B	V	U	O	I	E
J	L	D	C	C	P	M	R	R	U	J	S	B	Z	T	T	Q	S	T	Y	G	O	Y	Q
C	Q	Q	Q	A	I	Q	P	Z	R	N	P	H	A	T	T	G	F	T	A	E	D	I	B
P	C	D	A	P	P	Q	O	O	E	X	I	S	H	E	E	F	K	Y	R	N	I	C	G
S	C	Q	M	T	Y	U	G	R	U	X	W	K	I	R	U	Y	X	T	N	Y	C	R	P
Z	R	L	R	H	G	W	Y	C	S	N	Q	Q	F	R	G	L	B	M	B	E	T	E	R
O	J	R	U	K	V	N	Q	P	Y	B	D	M	M	I	G	D	P	L	B	T	Y	Z	Z

Scientific Method
Physical Change
Chemical Change
Pure Substance
Mixture
Matter
Element
Compound
Chemistry
Atom

What is Chemistry?



Across

2. The step-by-step process of asking a question, forming a hypothesis, investigating, and using data to support or revise an idea. _____ Method

3. A pure substance that cannot be broken down into simpler substances, like oxygen (O_2).

6. Matter with a fixed composition, made up entirely of one element or one compound. (Two words)

7. A change that creates an entirely new substance, like iron rusting into iron oxide. ____ Change

9. Anything that takes up space and has mass; the basic subject chemistry studies.

10. A change in form that does not create a new substance, like ice melting into water. _____ Change

Down

1. A combination of substances that keep their own identities and can be physically separated.

4. The study of matter, including what it's made of, its properties, and the changes it undergoes.

5. The tiny particle that all matter is built from.

8. A pure substance made of two or more elements bonded together in a fixed ratio, like water (H_2O).