Lesson 2.5: Solve the Case

Task	Page(s)	Learning Target
1	2-3	I can evaluate observational evidence in order to identify an unknown substance.
2	4-5	I can draw atomic-scale models to show if available reactants can be used to make a specific product.
3	6-7	I can analyze evidence in order to support a claim.

Task 1 Learning Target: I can evaluate observational evidence in order to identify an unknown substance.

In our society, scientists are sometimes asked to use their knowledge to help police collect and analyze evidence from a crime scene. In other cases, if a trial involves scientific evidence or ideas, a scientist may be called in as an expert witness. This can involve explaining a difficult science concept to the nonexperts who make up the jury. Although the criminal justice system sometimes relies on the expertise of scientists, it is important to remember that scientists only play an advisory role in this process. Scientists are not responsible for making judgments of innocence or guilt.

To: Student Chemists
From: Dr. Samara Yung, Lead Chemist
Subject: Someone Stole the Lavoisier Diamond!

There's been a robbery at the Westfield Museum! This morning, the museum staff discovered the rare and expensive Lavoisier Diamond was missing. When police arrived, they found a hole had been made in the glass display case where the diamond was stored. Next to the display case, they found a plastic container that was half full with an unknown substance. Police think that the thief may have used some of the substance to make a hole in the glass and may have accidentally left the rest of the substance behind.

The chief of police has asked me to help them identify this unknown substance and determine who could have used it to steal the Lavoisier Diamond. As you have recent experience in working with the community of Westfield, I am turning the case over to you. I hope you remember what you have learned so far about chemical reactions. I think you will need to use your knowledge to help the police crack this case!

Fortunately, four police officers observed the unknown substance and recorded their observations, so we have some evidence that might help us determine what this substance could be. Before we can use these observations to identify the unknown substance, however, we need to make sure that the evidence is strong.

A. Sort the Unknown Substance Evidence Cards from stronger to less strong. Which officer provided the strongest evidence? Write an explanation of why some of the observations are stronger than others.

Officer Hodges's observation: "To me, it looked like water but a little different."	**Officer Lee's observation:** "At room temperature, it was a liquid, and it smelled awful."
Officer Diaz's observation: "It was a colorless liquid with a strong, irritating odor."	**Officer Williams's observation:** "I saw a clear liquid that seemed to be dangerous."

The police have made a short list of substances they think could have been used to make a hole in the glass. All of these substances are corrosive, which means they can cause damage when they come in contact with substances such as glass. Examine the table below. Then, use the strongest evidence from the officers' observations to help you determine which substance was used to make a hole in the glass.

Substance name	**Properties**
hydrobromic acid	• faint yellow color • strong, irritating odor • liquid at room temperature
hydrofluoric acid	• colorless • strong, irritating odor • liquid at room temperature
iodine monochloride	• dark red color • strong, irritating odor • liquid at room temperature
perchloric acid	• colorless • odorless • liquid at room temperature

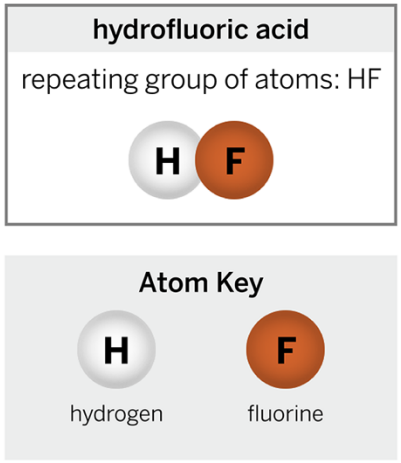
B. Which of the substances do you think is the unknown substance the criminal used to make a hole in the glass? Explain.

Task 2 Learning Target: I can draw atomic-scale models to show if available reactants can be used to make a specific product.

To: Student Chemists
From: Dr. Samara Yung, Lead Chemist
Subject: Hydrofluoric Acid

You did a great job at using properties to identify the substance found at the crime scene as hydrofluoric acid. We're lucky that at least one of the police officers provided detailed observations!

Here is some additional information about hydrofluoric acid at the atomic scale. This may help you as you continue to investigate this case.



Now that the police know that hydrofluoric acid was used at the crime scene, they have been looking for suspects who could have made hydrofluoric acid. The police contacted a local chemical supply company to see whether or not anyone had purchased hydrofluoric acid recently. When the company told the police that they do not sell hydrofluoric acid, the police asked whether or not anyone had purchased substances that might have been used to make hydrofluoric acid. In response, the company released information about three suspicious orders.

Name	Job	Substances ordered
Pat	sculptor	• sulfuric acid • calcium fluoride
Alex	gardener	• sulfuric acid • magnesium chloride
Tracy	chemist	• purified water • fluorine

A. Answer the following questions:

1. At this point, can you tell whether or not any of these suspects could have made hydrofluoric acid using the substances they ordered? Why or why not?
2. To help you determine whether or not any of these suspects could have made the hydrofluoric acid, what additional information would you need to know about hydrofluoric acid? What additional information would you need to know about the substances listed in the table?

B. Create atomic-scale models that show whether or not each of the suspects could have produced hydrofluoric acid.

Do:

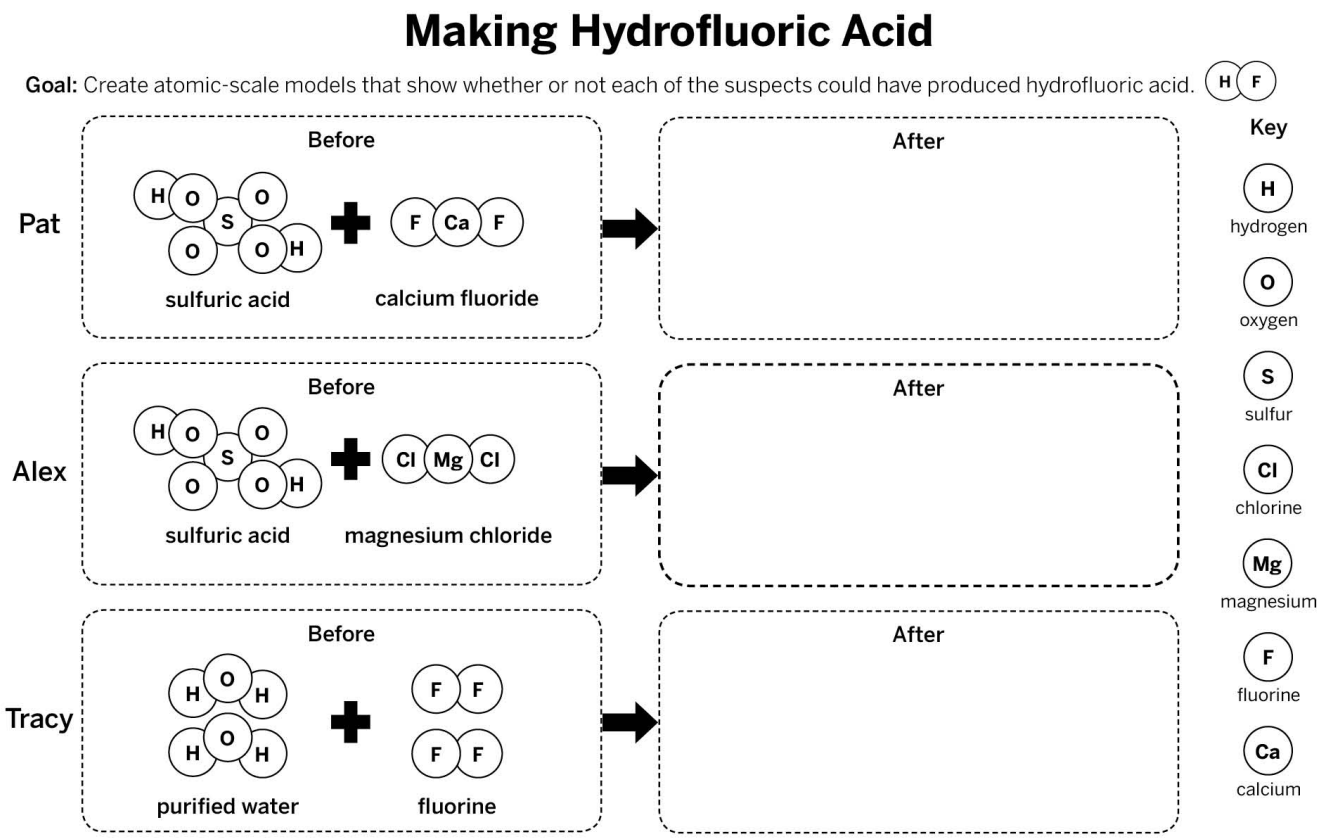
-In the Before space, color in the atoms of each substance using the key at the bottom of the Substance Reference Guide.

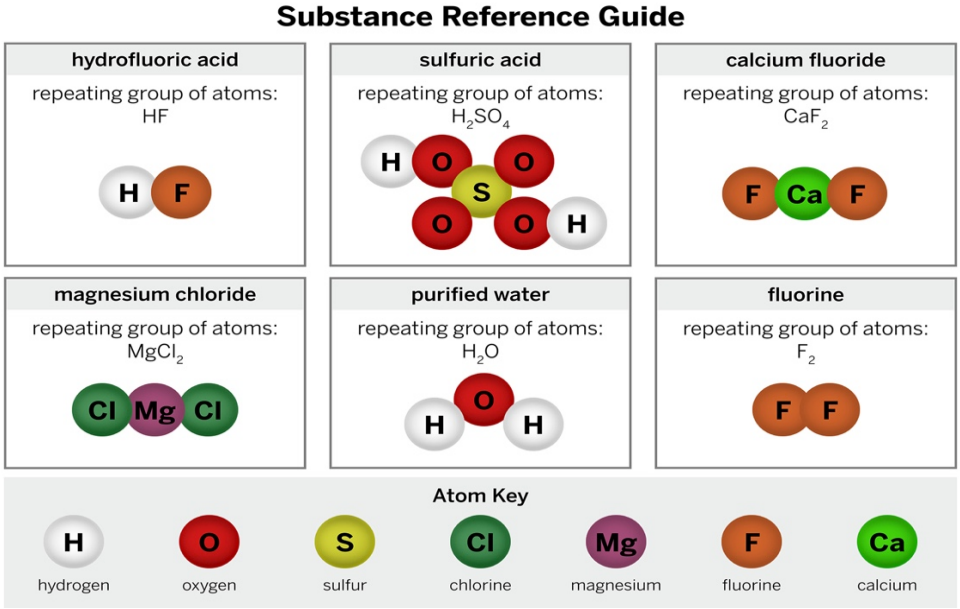
-Use the atoms to determine whether or not each suspect's substances could have produced hydrofluoric acid.

-If you think a suspect could produce hydrofluoric acid, draw an atomic-scale model of hydrofluoric acid in the After space. If there are enough atoms, draw more than one repeating group. Also, draw any other atoms that were involved in this chemical reaction and color them in.

-If you think a suspect could not produce hydrofluoric acid, write an explanation of why this is the case in the After space.

Tips: In the Before space, you have been provided with atomic-scale models of each suspect's substances. These atomic-scale models are also provided in the Substance Reference Guide.





C. Based on your models, which of the suspects could have produced the hydrofluoric acid?

Task 3 Learning Target: I can analyze evidence in order to support a claim.

Now that we know both Pat and Tracy could have made hydrofluoric acid, the police want to know whether or not either suspect is more likely to have done so. The police have collected new evidence from Pat and Tracy's houses. They would like you to examine this evidence.

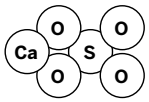
A. Copy the table below. List the evidence statements in the grid boxes that they best belong.

Evidence Sorting Grid

Evidence Pat made the hydrofluoric acid:	Evidence Tracy made the hydrofluoric acid:
Evidence Pat did **not** make the hydrofluoric acid:	Evidence Tracy did **not** make the hydrofluoric acid:

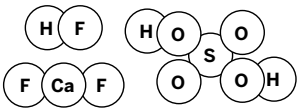
Evidence Card A

When the police searched Pat's house, they found some calcium sulfate ($CaSO_4$).



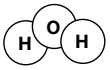
Evidence Card B

The police did **not** find hydrofluoric acid (HF), sulfuric acid (H_2SO_4), or calcium fluoride (CaF_2) in Pat's house.



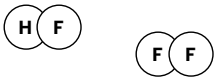
Evidence Card C

When the police searched Tracy's house, they found some purified water (H_2O).



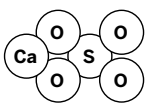
Evidence Card D

The police did **not** find hydrofluoric acid (HF), fluorine (F_2), or any other unusual substances in Tracy's house.



Evidence Card E

According to Dr. Yung, calcium sulfate ($CaSO_4$) is a substance commonly used in sculpting.

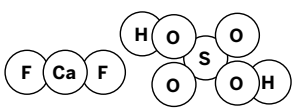


Evidence Card F

According to Dr. Yung, oxygen (O_2) is a colorless, odorless gas that is commonly found in air.

Evidence Card G

The chemical supply company confirmed the delivery of sulfuric acid (H_2SO_4) and calcium fluoride (CaF_2) to Pat's house.



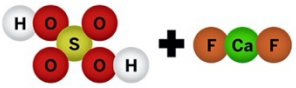
Evidence Card H

The chemical supply company confirmed the delivery of purified water (H_2O) and fluorine (F_2) to Tracy's house.

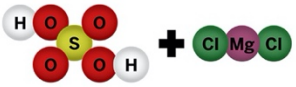
B. Based on what you know, which suspect do you think is most likely to have made the hydrofluoric acid? Explain your answer using at least one piece of evidence from your Suspect Evidence Cards.

Question: Which suspect is most likely to have made the hydrofluoric acid? 

Claim 1: Pat is most likely to have made the hydrofluoric acid by using sulfuric acid and calcium fluoride.



Claim 2: Alex is most likely to have made the hydrofluoric acid by using sulfuric acid and magnesium chloride.



Claim 3: Tracy is most likely to have made the hydrofluoric acid by using purified water and fluorine.

Atom Key