Category IV Physical Science Examples

Providing practice

Chemistry That Applies

There are some tasks for students to practice using all of the key ideas, and, in all cases, novel tasks are included. For example, students use

• the idea that substances may combine with other substances to form new substances with different characteristic properties to describe the difference between iron and rust (p. **67s**) and to indicate whether or not a new substance was formed in five chemical and physical changes not observed previously (p. **73s**).

• the idea of mass conservation to (a) explain why the weight does or does not change when an ice cube melts, water boils, sugar is dissolved, and steel wool is spread apart (pp. **23st/24t**); (b) identify their own examples of instances where the weight would and would not change (p. **24st**); and (c) write a letter to a newspaper to refute a recent article entitled "Young chemist discovers substance that continually loses weight" (p. **35st**).

• the idea that atoms combine and recombine in chemical reactions but are not created or destroyed to (a) explain what happens to the atoms and molecules in various reactions (p. **73st**); (b) explain why a rusting shovel will weigh less after the rust has been scraped away (p. 67s, question 3); and (c) explain why the atoms that make up their bodies may have been part of a dinosaur once or could be part of a spaceship some day (p. **80st**).

• the idea that atoms can explain mass conservation to (a) explain (in the baking soda and vinegar reaction) how the same number of reactant and product atoms explains the mass conservation observed (p. **72st**); (b) prepare a video or draw a cartoon strip to show what happens when butane burns—how butane molecules come apart and recombine with oxygen atoms to make the ending substances and why a butane lighter weighs less when it burns but does not change weight if the reaction is carried out under a beaker (p. 75st); and (c) consider whether various changes—compacted steel wool versus teased-apart steel wool, ice cubes melting in a glass, sugar dissolving, water boiling—will cause alterations in weight and explain them in terms of molecules (p. **23st/24t**).

Just as the key ideas move from summaries of observations to abstract explanations, the tasks within the unit increase in complexity. For example, students initially explain four chemical reactions in terms of (observable) mass conservation, then in terms of atoms. Students are coached through the atomic explanation of the first and second reactions (water decomposing and iron rusting); expected to work more independently on the third and fourth reactions (baking soda and vinegar reacting and butane burning); and expected to work without help on the aluminum and copper chloride reaction (as indicated in the *Teacher's Guide*, p. **56t**).

Can you use this discovery to answer the question about weight changes?

Ⓑ I. To write a balanced equation for this reaction, write the correct formula under each kind of molecule. Then show how many molecules of each kind were involved in the reaction, by putting a number in front of the formula for the molecule (for example, 2 Fe).

The balanced equation should look like this, with numbers in front of each molecule:

$$\_\_\ Fe + \_\_\ O_2 \rightarrow \_\_\ Fe_2O_3$$

THINK AND WRITE

1. You have a friend who doesn't know the first thing about chemistry. He thinks that rust just starts somehow and then "eats" away at cars or pipes—sort of like termites eat wood—and this makes holes in the car or the pipe. You must explain to him what is really going on. Tell him what the reactants are and where they come from. Explain what product is formed and how this happens.
2. Is rust just the same thing as iron, only brown? Explain.
3. A friend of yours says that she left a shovel outside during the winter and it got rusty. She says that if you scrape off the rust with a steel brush, the shovel will be as good as new. To test her knowledge of chemical reactions, you ask her if it will weigh the same after the rust is scraped off as when she bought it. She says she's not sure, but it seems like it should—after all, rust just grows on the shovel like moss on a tree or mold on stale bread.

   Do you agree? Explain. Use atoms and molecules in your explanation, too, if you can.
4. Some cars and trucks get so rusty that holes start to form in the metal. How can this happen?

B. Students should write the balanced equation by thinking about their models and looking at the pictures of the models that they drew. If they are having difficulty, remind them to write the correct formula first and then "how many."

QUESTIONS:

1. Students should explain that the iron in the car body combines with oxygen from the air to form the rust. The rust is a reddish-brown color, and is flaky—significantly different in color and texture from the original iron (this is why this unit stresses student observation and description of products early on). The rust can fall away from the car.

2. No. It's a new substance. This can be seen by its properties—it is quite different from iron.

3. Since rust is a combination of some of the iron from the shovel with oxygen from the air, if the rust is scraped away the shovel loses some of its original iron and therefore wieghs less.

4. Rust starts when iron is exposed to the oxygen in the air and reacts with it. The iron has not disappeared, but is present in a new form in the rust that formed. It has chemically combined with the oxygen to form iron oxide which is rust. Since the iron is actually involved in the reaction (it is reacting to form a new substance), there will eventually be a hole in the original substance.

THINK AND WRITE

Discuss each question below in your group. Then write the answers on the back of your data sheet.

1. Sometimes when you do this reaction, after all the bubbles have popped (and the fizz settles down) you can add more vinegar and start the reaction going again. What does this tell you about the baking soda?
2. Design an experiment to show that carbon dioxide is actually what's inside the bubbles.
3. The change that you observe when baking soda and vinegar are mixed is a chemical reaction. The reaction produces bubbles with carbon dioxide in them. When water boils, bubbles are also produced. Is this a chemical reaction? Explain.
4. a. For each of the following changes, tell if you think new substances formed. Tell why you think as you do.
   1. Hydrogen and oxygen gas are ignited with a spark and explode to form water.
   2. Copper jewelry tarnishes (turns green after being exposed to air and water for a long time).
   3. An iron nail is magnetized by rubbing it against a magnet.
   4. Salt is stirred into water until it all dissolves.
   5. An egg is cooked, turning from a drippy liquid to a rubbery solid.

   b. Which of the above were you unsure of? What information would you need in order to make a correct decision?
5. Think about all the reactions you have done in this cluster, including the mixing you did in Lessons 1 and 2 of common household substances. Write a short paragraph telling what happens when new substances form. Be sure to tell both what you would observe with your eyes and what happens to the atoms and molecules which your eyes cannot see.

You are now ready to explore what happens when butane burns.

2. Yes, because of significant change in color and texture of the tarnish.

3. No, the nail is still the same and can be used as a nail in exactly the same way. Nothing new was seen forming.

4. No, the salt is still there as is evidenced by the taste. Also, the water could be evaporated and you would have salt and water. So they were just mixed together. Students often think that dissolving is a chemical change because the solid "changes into a liquid." They usually know that it did not melt but they do not know what is happening. Tell them to think about the properties of the substance, especially taste. Ask them what would happen if they evaporate the water?

5. Yes, the egg is different in color (the egg white) and taste. Most people don't eat raw eggs. This is confusing because we call both the cooked and the uncooked egg an egg so students often say "it is still an egg." Sometimes students say that it was liquidy and it went to solid as in a physical change but remind them that heat was added to cook the egg and when liquids change to solids (water to ice), the substances must be cooled.

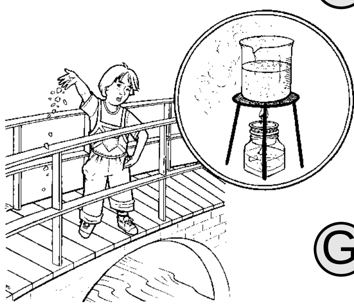
4. b. Answers vary. You need to know the chemical formulas for the reactants and the products to see if they are the same or different.

5. Important points to include are:

• the properties that you can observe with your senses change, usually in an obvious way but sometimes in a less discernible way.

• the reactant molecules come apart and then go back together again in new arrangements.

• the total number of atoms in the reactants and in the products does not change.



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Here's how scientists would explain this. The last experiment—the one with boiling water—was different from the rest because as the water boiled, steam, which is a form of water, left the beaker. As the steam left the beaker, there was less water in the beaker, so it weighed less. It's like standing on a bridge, taking something heavy out of your pocket, and throwing it over the side. You now weigh less than before. As water boils, water molecules are going into the air, thus leaving fewer water molecules behind. Therefore it weighs less than it did before boiling.

THINK AND WRITE

Now try to answer the following questions in your journal:

1. What are all substances made up of? Use as much detail as you can.
2. What must happen to the substances involved in order for the weight of the materials to increase? to decrease?
3. Using this same sort of logic, how could you explain why a newly painted car would weigh more?
4. a. Did the steel wool change weight? Why or why not? Use molecules in your explanation. Then draw a picture that shows what is happening to the molecules.
   b. Did the water and ice cube change weight? Why or why not? Use molecules in your explanation. Then draw a picture that shows what is happening to the molecules.
   c. Did the sugar and water change weight? Why or why not? Use molecules in your explanation. Then draw a picture that shows what is happening to the molecules.
   d. Did the boiling water change weight? Why or why not? Use molecules in your explanation. Then draw a picture that shows what is happening to the molecules in your experiment. Include bubbles in your picture and show what's in them.

F. Ask students what they know about steam. See if they know what is inside the bubbles. Many think that the bubbles contain air but they have no explanation for how the air got there. Some think there is nothing in the bubbles. Others simply have no idea of what is in them.

G. When the water heats up, bubbles form in the water. Each bubble contains some molecules of water. As the water gets hotter, the bubbles rise to the top, break and the water molecules fly off into the air.

1. All substances are made of molecules. Students have probably heard of molecules before so take a few minutes to see how their thinking about molecules relates to these substances. If students are not comfortable with the concept of molecules, take some time to discuss the concept. It is sufficient here if students understand that all substances are made up of particles and that these particles are called molecules. The concept of atoms and molecules are developed much more in Cluster 3 so there is no need to go into any detail here—especially, do NOT discuss atomic structure or formulas.

2. Some of the substance must be added to or taken away from the system—like throwing quarters out of your pocket or putting some quarters into your pocket.

3. The paint adds weight to the car.

4. a. No. The number of molecules stayed the same whether the steel wool was stretched or compacted. Nothing left the system when compacting the steel wool. Picture should depict molecules spread out and far apart, possibly lined up in strands. The compacted picture should show the molecules much closer together possibly still in strands. Be sure students show the same number of molecules for each in their pictures.

4. b. No. The number of molecules did not change as the ice melted and changed to water. They simply went into a new arrangement. The water and ice cube picture should show water molecules as random and disordered while the ice cube molecules are neat and orderly floating in the water. When melted, all the molecules should show the same randomness and disorder. Be sure that the number of molecules stays the same in the ice cube

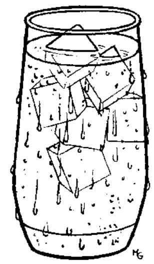
before and after melting. An important point to emphasize is that the ice and water molecules are identical. Be sure that students don’t represent water molecules differently than ice molecules such as squares and circles. They should either be all square or all circles. Do not get into atomic structure here.

4. c. No. The number of molecules stays the same. When the sugar dissolves, the molecules separate and spread throughout the water molecules. The sugar should show a pile of ordered molecules as crystals of sugar (possibly square to show that they are different from water) and the water molecules (possibly round) should be random, disordered molecules in the glass. After dissolving, the sugar molecules (possibly square) should be equally dispersed into the water (round) molecules in the glass. None are lost in the process. Be sure that student drawings show no change in the number of molecules.

4. d. Yes. Bubbles filled with water molecules rise to the surface and burst, releasing some water molecules to the air. In the boiling water, as the water boils some of the molecules are leaving the beaker, spreading out and going into the air as water vapor. Since there are fewer molecules in the beaker, the water now weighs less.

5. a. All four reactions are physical changes.

5. b. Observing the changes reveals no new properties. Steel wool is still steel wool. Melted ice cubes and dissolved sugar taste the same. If you condense steam from boiling water on a spoon or lid of a pot, it is still water. Therefore, these are probably physical changes. Help students understand that observation alone is frequently not enough to tell if a change is physical or chemical.



5. a. Are these changes physical or chemical changes?

   b. How do your observations help you figure this out? Can you be sure?

   c. How do molecules help you figure this out? Why is this a problem?

6. Try these problems:

   a. Predict what would happen to the weight of a cold glass of water on a humid summer day? Explain your prediction.

   b. Predict what would happen to the weight of a car that gets very rusty over several years. Explain your prediction.

7. Can you think of any other examples of a change where weight would stay the same?

8. Can you think of any other examples of change where weight would increase or decrease?

We will use these ideas about weight change to understand more about that other kind of reaction, chemical reactions. The next lesson will give you more insight into chemical reactions as you make predictions about weight changes in some chemical reactions.

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5. c. At the molecular level, the molecules are still the same kind of molecule. But since you can’t see individual molecules, this is not a practical way to detect physical changes. You need sophisticated instrumentation to figure out whether the molecules have changed or not.

6. a. It becomes very moist on the outside of the glass as it picks up water vapor from the air. It has added more matter so it will weigh more. Students have difficulty with this question. Some think that the water seeps through the glass. That doesn’t make much sense to them, but they do not have a better explanation.

6. b. There are several plausible answers for this—the car gets lighter because metal rusts and falls off; the car gets heavier because the iron combines with oxygen from the air and forms a heavier molecule; there is no change in weight since rust is just the same iron discolored. Accept any reasonable explanation. Do not give answers here as this reaction is explored in lessons that follow.

7. Examples are chocolate melting, water freezing, bending metal, etc.

8. Answers will vary.

before and after melting. An important point to emphasize is that the ice and water molecules are identical. Be sure that students don't represent water molecules differently than ice molecules such as squares and circles. They should either be all square or all circles. Do not get into atomic structure here.

4. c. No. The number of molecules stays the same. When the sugar dissolves, the molecules separate and spread throughout the water molecules. The sugar should show a pile of ordered molecules as crystals of sugar (possibly square to show that they are different from water) and the water molecules (possibly round) should be random, disordered molecules in the glass. After dissolving, the sugar molecules (possibly square) should be equally dispersed into the water (round) molecules in the glass. None are lost in the process. Be sure that student drawings show no change in the number of molecules.

4. d. Yes. Bubbles filled with water molecules rise to the surface and burst, releasing some water molecules to the air. In the boiling water, as the water boils some of the molecules are leaving the beaker, spreading out and going into the air as water vapor. Since there are fewer molecules in the beaker, the water now weighs less.

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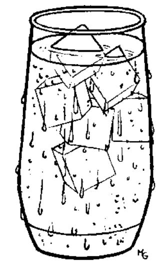

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5. c. At the molecular level, the molecules are still the same kind of molecule. But since you can't see individual molecules, this is not a practical way to detect physical changes. You need sophisticated instrumentation to figure out whether the molecules have changed or not.

6. a. It becomes very moist on the outside of the glass as it picks up water vapor from the air. It has added more matter so it will weigh more. Students have difficulty with this question. Some think that the water seeps through the glass. That doesn't make much sense to them, but they do not have a better explanation.

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7. Examples are chocolate melting, water freezing, bending metal, etc.

8. Answers will vary.

6. Write a paragraph in your journal telling how this law can explain the result of the demonstration you observed today.
7. For all reactions involving physical or chemical changes, how does the weight of the products formed compare to the weight of the reactants you started with? Remember that the reactants are ALL the substances you started with including any invisible gases and the products are ALL the substances that were formed, including any invisible gases. Write the answer in your journal.
8. A newspaper headline recently read: “Young chemist discovers substance that continually loses weight.” Use your scientific knowledge to write a letter to the newspaper editor refuting the article.

In the next lesson you will explore another variation on this law.

6. Important points to include are:

• In every case, the weight of the products formed was exactly equal to the weight of the reactants.

• The system weighed less in the first two reactions because the gas which formed was leaving the bottle and going into the air. It was not included in the weight. It is like throwing quarters out of your pockets. You weight less, but no matter was lost. It was just being put into a different place. So it is with the gas particles. When they leave the bottle, the bottle weighs less because the gas particles are just being put into a different place.

7. The weight of the products is always exactly equal to the weight of the reactants. Just in case a student asks—in a nuclear reaction like an A-bomb, an H-bomb, or the reaction of the sun, small amounts of matter are changed into very large amounts of energy. Don’t bring this up at this time unless students ask about it. Then it is best to acknowledge this fact but don’t dwell on it or discuss it.

8. As part of their letter, students should include the following points: nothing ever disintegrates since matter is always conserved. Probably invisible gases are formed constantly and escape into the air. The weight of the system is, therefore, slowly but continuously decreasing.

THINK AND WRITE

Discuss each question below in your group. Then write the answers on the back of your data sheet.

1. Sometimes when you do this reaction, after all the bubbles have popped (and the fizz settles down) you can add more vinegar and start the reaction going again. What does this tell you about the baking soda?
2. Design an experiment to show that carbon dioxide is actually what's inside the bubbles.
3. The change that you observe when baking soda and vinegar are mixed is a chemical reaction. The reaction produces bubbles with carbon dioxide in them. When water boils, bubbles are also produced. Is this a chemical reaction? Explain.
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    2. Copper jewelry tarnishes (turns green after being exposed to air and water for a long time).
    3. An iron nail is magnetized by rubbing it against a magnet.
    4. Salt is stirred into water until it all dissolves.
    5. An egg is cooked, turning from a drippy liquid to a rubbery solid.

   b. Which of the above were you unsure of? What information would you need in order to make a correct decision?
5. Think about all the reactions you have done in this cluster, including the mixing you did in Lessons 1 and 2 of common household substances. Write a short paragraph telling what happens when new substances form. Be sure to tell both what you would observe with your eyes and what happens to the atoms and molecules which your eyes cannot see.

You are now ready to explore what happens when butane burns.

2. Yes, because of significant change in color and texture of the tarnish.

3. No, the nail is still the same and can be used as a nail in exactly the same way. Nothing new was seen forming.

4. No, the salt is still there as is evidenced by the taste. Also, the water could be evaporated and you would have salt and water. So they were just mixed together. Students often think that dissolving is a chemical change because the solid "changes into a liquid." They usually know that it did not melt but they do not know what is happening. Tell them to think about the properties of the substance, especially taste. Ask them what would happen if they evaporate the water?

5. Yes, the egg is different in color (the egg white) and taste. Most people don't eat raw eggs. This is confusing because we call both the cooked and the uncooked egg an egg so students often say "it is still an egg." Sometimes students say that it was liquidy and it went to solid as in a physical change but remind them that heat was added to cook the egg and when liquids change to solids (water to ice), the substances must be cooled.

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5. Important points to include are:

- the properties that you can observe with your senses change, usually in an obvious way but sometimes in a less discernible way.
- the reactant molecules come apart and then go back together again in new arrangements.
- the total number of atoms in the reactants and in the products does not change.

4. From the earth, either from copper nuggets or from ore or various rock forms. Ores that contain copper, such as copper sulfate, are chemically changed to form copper metal. This is often done in solutions using electrolysis. The metal is then melted and formed into useful materials.

5. Copper nuggets or copper statues have the characteristic copper metal color. But they can also have a blue or blue-green tarnish on their surface, from being exposed to oxygen in the air and water. This is a new form of copper formed when the copper in the statue or monument reacted with oxygen and/or water vapor in the air to form a new substance.

6. When you throw away materials made of copper, the copper will eventually react with air, water and other substances in contact with it and go into a different chemical form that does not at all resemble copper metal. It may then be dissolved in water and carried away to rivers, lakes and oceans, where it becomes available again to form copper metal under the right conditions.

6. What happens to copper wires, pots, jewelry, etc. when you throw them away?

7. Almost everyday you hear that you should recycle such things as aluminum, copper, paper, etc. Do you think this is important? Use what you have learned in this unit to explain why you think this.

   As you thought about the Law of the Conservation of Matter, you wondered if it could possibly apply to this situation. What do you think?

8. Now what do you think about the KEY QUESTIONS for this lesson? Here they are again:

   Could it be true that the atoms that make up my body may have once been part of a dinosaur?

   Could it be possible that some atoms that are part of me could someday be part of a spaceship that travels to distant galaxies?

   And would it be true that the materials we throw in landfills don't just rot into nothingness?

   Explain your thinking about each question.

In this cluster, you have learned where new substances come from and how they form. As you continue your research in the next lesson, think about atoms and molecules, and how new substances are formed.

7. The earth's supplies of ores that contain many of the metals we use everyday is getting very depleted. When there is no more ore from which to obtain various metals, the only way to get them is to recycle them. The same is true of paper which is made from trees. We are cutting down trees faster than the new ones can grow. When we run out of trees, either substitutes must be found for paper as we know it today, or paper must be made from recycled paper. When the materials we use are just buried in large dumps with all our other trash, it is doubtful that the useful substances could ever be sorted out and refined in order to use them again. Hence, we must "sort" our trash before it is thrown out and recycle the useful materials so they will be around for future generations.

8. Yes, the atoms that made up dinosaurs now make up some portions of plants, animals, or non-living substances on the earth. When a dinosaur died—like any living thing—the matter that made up its body was recycled into other materials, by the processes of decomposition and growth of new plant material. Some of the matter that made up some dinosaurs changed into the fossil fuels we use today. Some of the atoms that make up the minerals in our bodies—minerals like calcium, potassium, zinc, iron, etc.—will return to the soil when we decompose, and be picked up in plants, which will be eaten by animals, including humans, etc. But some will also be mined and possibly used in spaceships. The materials we throw into landfills do not just "rot into nothingness."

B. You may either ask students to verbally explain this to the class, or ask them first to write this explanation in their journals and then add to it after a class discussion. The connection we want them to make here is that if all of the atoms that made up the starting substances are present in the ending substances, then no weight was lost or gained, since it is the atoms themselves that make up the weight of any substance.

These questions should be used for discussion in small groups to allow students to express their ideas and find any discrepancies. After group discussions, students should write answers in their journals.

1. There is more baking soda in the beaker that has not yet reacted with vinegar.

2. Use BTB after trapping the gas in some way. BTB turns yellow when carbon dioxide is present.

3. No, since the bubbles produced from boiling water have water vapor in them, which is not a new substance—it is the same molecule as makes up liquid water. If no new molecules are produced, then no new substances are produced, and no chemical change has occurred.

4. Students answers may vary on these. Remember, they are going on visual descriptions now and may or may not know the formulas which are needed to be sure if a chemical change occurred. As long as their explanations make sense, they should be accepted as feasible answers. We are trying to get away from teachers always having the correct answers and jumping in whenever there is doubt.

1. Yes: Water, which is a transparent liquid, has very different properties from the invisible gases hydrogen and oxygen.

CONSERVATION OF MATTER and THE CHEMICAL EQUATION

I. Check the kinds of atoms and number of each kind in both reactants and products and fill in the ACCOUNTING FOR ATOMS IN THE REACTANTS AND PRODUCTS portion of your data sheet.

Are there as many atoms of carbon in the reactants as in the products?

Are there as many atoms of oxygen in the reactants as in the products?

Are there as many atoms of hydrogen in the reactants as in the products?

Are there as many atoms of sodium in the reactants as in the products?

B *Explain how this proves that if you trapped all the gas given off in this reaction, the weight of the original baking soda and vinegar would be the same as the weight of all the products after the reaction.*

J. To write a balanced equation for this reaction, write the correct formula under each kind of molecule. Then show how many molecules of each kind were involved in the reaction, by putting a number in front of the formula for the molecule (for example, 1 $NaHCO_3$).

The balanced equation should look like this, with numbers in front of each molecule:

__ $NaHCO_3$	+	__ CH_3COOH	➜	__ CH_3COONa	+	__ CO_2	+	__ H_2O
BAKING SODA	+	VINEGAR	PRODUCES	SODIUM ACETATE	+	CAR. DIOX.	+	WATER

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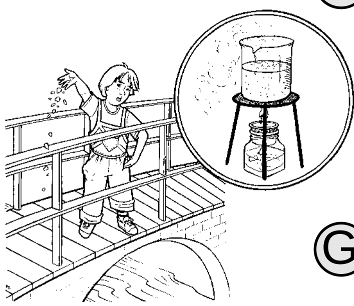

Here's how scientists would explain this. The last experiment—the one with boiling water—was different from the rest because as the water boiled, steam, which is a form of water, left the beaker. As the steam left the beaker, there was less water in the beaker, so it weighed less. It's like standing on a bridge, taking something heavy out of your pocket, and throwing it over the side. You now weigh less than before. As water boils, water molecules are going into the air, thus leaving fewer water molecules behind. Therefore it weighs less than it did before boiling.

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THINK AND WRITE

Now try to answer the following questions in your journal:

1. What are all substances made up of? Use as much detail as you can.
2. What must happen to the substances involved in order for the weight of the materials to increase? to decrease?
3. Using this same sort of logic, how could you explain why a newly painted car would weigh more?
4. a. Did the steel wool change weight? Why or why not? Use molecules in your explanation. Then draw a picture that shows what is happening to the molecules.
   b. Did the water and ice cube change weight? Why or why not? Use molecules in your explanation. Then draw a picture that shows what is happening to the molecules.
   c. Did the sugar and water change weight? Why or why not? Use molecules in your explanation. Then draw a picture that shows what is happening to the molecules.
   d. Did the boiling water change weight? Why or why not? Use molecules in your explanation. Then draw a picture that shows what is happening to the molecules in your experiment. Include bubbles in your picture and show what's in them.

F. Ask students what they know about steam. See if they know what is inside the bubbles. Many think that the bubbles contain air but they have no explanation for how the air got there. Some think there is nothing in the bubbles. Others simply have no idea of what is in them.

G. When the water heats up, bubbles form in the water. Each bubble contains some molecules of water. As the water gets hotter, the bubbles rise to the top, break and the water molecules fly off into the air.

1. All substances are made of molecules. Students have probably heard of molecules before so take a few minutes to see how their thinking about molecules relates to these substances. If students are not comfortable with the concept of molecules, take some time to discuss the concept. It is sufficient here if students understand that all substances are made up of particles and that these particles are called molecules. The concept of atoms and molecules are developed much more in Cluster 3 so there is no need to go into any detail here—especially, do NOT discuss atomic structure or formulas.

2. Some of the substance must be added to or taken away from the system—like throwing quarters out of your pocket or putting some quarters into your pocket.

3. The paint adds weight to the car.

4. a. No. The number of molecules stayed the same whether the steel wool was stretched or compacted. Nothing left the system when compacting the steel wool. Picture should depict molecules spread out and far apart, possibly lined up in strands. The compacted picture should show the molecules much closer together possibly still in strands. Be sure students show the same number of molecules for each in their pictures.

4. b. No. The number of molecules did not change as the ice melted and changed to water. They simply went into a new arrangement. The water and ice cube picture should show water molecules as random and disordered while the ice cube molecules are neat and orderly floating in the water. When melted, all the molecules should show the same randomness and disorder. Be sure that the number of molecules stays the same in the ice cube

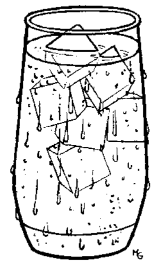
before and after melting. An important point to emphasize is that the ice and water molecules are identical. Be sure that students don't represent water molecules differently than ice molecules such as squares and circles. They should either be all square or all circles. Do not get into atomic structure here.

4. c. No. The number of molecules stays the same. When the sugar dissolves, the molecules separate and spread throughout the water molecules. The sugar should show a pile of ordered molecules as crystals of sugar (possibly square to show that they are different from water) and the water molecules (possibly round) should be random, disordered molecules in the glass. After dissolving, the sugar molecules (possibly square) should be equally dispersed into the water (round) molecules in the glass. None are lost in the process. Be sure that student drawings show no change in the number of molecules.

4. d. Yes. Bubbles filled with water molecules rise to the surface and burst, releasing some water molecules to the air. In the boiling water, as the water boils some of the molecules are leaving the beaker, spreading out and going into the air as water vapor. Since there are fewer molecules in the beaker, the water now weighs less.

5. a. All four reactions are physical changes.

5. b. Observing the changes reveals no new properties. Steel wool is still steel wool. Melted ice cubes and dissolved sugar taste the same. If you condense steam from boiling water on a spoon or lid of a pot, it is still water. Therefore, these are probably physical changes. Help students understand that observation alone is frequently not enough to tell if a change is physical or chemical.



5. a. Are these changes physical or chemical changes?
   b. How do your observations help you figure this out? Can you be sure?
   c. How do molecules help you figure this out? Why is this a problem?
6. Try these problems:
   a. Predict what would happen to the weight of a cold glass of water on a humid summer day? Explain your prediction.
   b. Predict what would happen to the weight of a car that gets very rusty over several years. Explain your prediction.
7. Can you think of any other examples of a change where weight would stay the same?
8. Can you think of any other examples of change where weight would increase or decrease?

We will use these ideas about weight change to understand more about that other kind of reaction, chemical reactions. The next lesson will give you more insight into chemical reactions as you make predictions about weight changes in some chemical reactions.

5. c. At the molecular level, the molecules are still the same kind of molecule. But since you can't see individual molecules, this is not a practical way to detect physical changes. You need sophisticated instrumentation to figure out whether the molecules have changed or not.

6. a. It becomes very moist on the outside of the glass as it picks up water vapor from the air. It has added more matter so it will weigh more. Students have difficulty with this question. Some think that the water seeps through the glass. That doesn't make much sense to them, but they do not have a better explanation.

6. b. There are several plausible answers for this—the car gets lighter because metal rusts and falls off; the car gets heavier because the iron combines with oxygen from the air and forms a heavier molecule; there is no change in weight since rust is just the same iron discolored. Accept any reasonable explanation. Do not give answers here as this reaction is explored in lessons that follow.

7. Examples are chocolate melting, water freezing, bending metal, etc.

8. Answers will vary.

Cluster 3—Lesson 13

A. KEY QUESTION: We've been preparing for this "big idea" for a long time now. Allow students to speculate about answers. This will help you understand their current thinking so you can guide better them through these difficult concepts.

The four reactions that form the backbone of this entire unit are used again in this cluster as a basis for understanding how new substances are formed. Since each reaction has already been done by the students, it will be done here as a teacher demonstration. The purpose of observing the reaction again is to help students make the connection between the actual reactants and products observed in the reaction and the words and symbols they will be using. This is an extremely difficult conceptualization for most students. You need to use every possible visual aid in your presentation. By now, students should be aware that gases can be part of the system of the reactants and/or the products and they should be looking for signs that gases are involved.

In this cluster, the teacher should work with the students, step-by-step through the entire first (and possibly second) reaction. For each successive reaction, the teacher role should diminish gradually and students should begin to work in groups independent of the teacher as much as possible. By the end of the cluster, students should be able to work through the process on their own. Do not expect students to balance dozens of equations. That is not the purpose. Rather, a conceptual understanding of the principles and laws involved, along with the association of the real world context, is much more important.

Lesson 13: ATOMS IN EQUALS ATOMS OUT: Decomposing Water

In Cluster 1, you observed some chemical reactions of common substances and wrote descriptions of what you observed. Then in Cluster 2, you learned one of the most basic laws of nature, the Law of Conservation of Matter. Take a few moments to think about what this law means and share your ideas with the class.

In the first lesson of this cluster, you learned how atoms combine to form molecules. Now you will see how atoms and molecules can explain both the formation of new substances and the Law of Conservation of Matter.

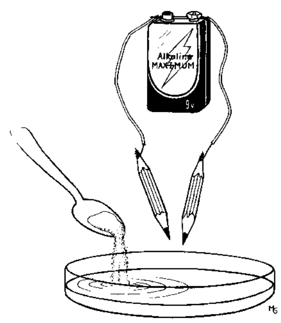
A

KEY QUESTION

How can atoms and molecules be used to explain the formation of new substances? How can they be used to explain the Law of Conservation of Matter?

In an earlier lesson, you used a battery to make bubbles appear under water. The water level went down as the bubbles were formed.

How can atoms and molecules be used to explain the formation of bubbles from water?



LESSON STATEMENT: Students will make models of the molecules involved in the decomposition of water; they will take the water molecule apart and use the atoms to build hydrogen and oxygen molecules. They will draw pictures of the reactant and product molecules, write formulas showing how the atoms have recombined, and consider why mass is conserved in chemical reactions based on the idea that no atoms are created or destroyed, only rearranged to form new molecules.
PURPOSE: To begin to construct a picture of how new substances are formed by observing the decomposition of water reaction and building models to demonstrate how reactants form products; to write balanced equations based on these models; and to consider why mass is conserved in chemical reactions.
APPROX. TIME: 1 class period.