Category II Summaries for Physical Science Examples

Addressing commonly held ideas

Chemistry That Applies
An attempt is made to address most of the important commonly held student ideas. Sometimes misconceptions are addressed by challenging students to compare their observations to predictions based on a widely held idea. For example, after asking them to predict how the weights of teased-apart versus compacted steel wool compare, teams of students carry out the experiments and consider whether their results helped to prove or disprove their predictions. Then, the whole class is to answer the question: “What must happen during any change for the weight of the materials to increase or decrease?” If they are having trouble answering, the following questions are provided to help: “In which of the experiments did the weight decrease significantly? What was different about that experiment from the others where there was no weight change?” (p. **22s**).
This same strategy is used in other lessons—for example, to address confusions about weight versus density (pp. **26–27s**) and misconceptions about gases (pp. 33s, 40–43s).
However, the strategy is not used very effectively to address student misconceptions.

Throughout the text, sidebars convey the notion that if students are given time to explain their predictions and compare them to what happens, then the issues will be clarified (e.g., pp. **26t**, 28t, **41t**). No specific guidance is given to teachers about how to structure discussions that will help to bridge student ideas with scientific ideas. For example, in the reaction between calcium chloride and potassium carbonate, students may predict that the weight will increase because solids weigh more than liquids. However, after they test the prediction, they are never asked explicitly whether they still believe the reasons they gave initially. The sidebar on page 26t suggests that students should become aware of any discrepancies in their thinking. It does not indicate what the discrepancies are likely to be, suggest what teachers should do after students become aware of them, or give teachers suggestions for how they can help students to resolve them.

In addition, students’ commonly held ideas are addressed by prompting them to contrast their ideas with the scientifically correct ideas and to resolve the differences between them. Students respond to questions like: “Why might your little brother think that matter was created in this experiment [steel wool weighs more after rusting than before]?” (p. **41s**) and “Why might your little sister think that butane just burned up and disappeared in this reaction?” (p. **43s**), and they are asked to write a letter to the editor refuting a newspaper article that claims that a chemist has discovered a new substance that loses weight continually (p. **35s**).

The widely held misconception that chemical changes result from the disappearance of the original substances and the appearance of new substances (which is why students do not expect weight to always be conserved) is addressed in lessons 12 through 16. Students are given the model of combining and recombining atoms to account for the conservation of mass observed in situations where the system was closed. Students work with molecular models and then with chemical formulas and equations to account for mass conservation by counting atoms for each of the chemical reactions encountered previously—water decomposing, baking soda and vinegar reacting, iron rusting, and butane burning (pp. 56–77s). However, students are never asked to explain how the idea of atoms combining and recombining can explain mass conservation, even when substances seem to “disappear.” For example, they are never asked to use models to show why mass is not conserved in those situations where the system is open.

The idea that oxygen is an “enabler” of burning (probably a result of the often-used expression “oxygen supports combustion”) is not addressed. For instance, students are not asked to explain how an “enabler” role for oxygen is not consistent with their observations about mass changes in open systems and mass conservation in closed systems (i.e., why should the weight change in one case but not the other?), nor are they asked how they might respond to a sibling who held this view.

EXPERIMENT 2: How does the weight of a glass of water with an ice cube in it change as the ice cube melts and eventually disappears?

EXPERIMENT 3: How does the weight of a teaspoon of sugar and a glass of warm water before they are mixed compare to the weight after stirring the sugar into the warm water until it has all dissolved?

EXPERIMENT 4: How does the weight change if you boil a beaker of water for 5 minutes?

After you have collected all the needed data, your group should prepare to present your findings to the class. Be sure to include the following points in your presentation:

B
- Whether your results helped to prove or disprove your predictions.
- If your group still believes in the reasons you gave for your prediction.

After all the experiments have been done and reported to the class, try as a class to answer to following question:

C
- What must happen during any change for the weight of the materials to increase or decrease?

If you're having trouble coming to a good answer to this question, think about these questions:

D
- In which of the experiments did the weight decrease significantly?

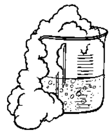
E
- What was different about that experiment from the others where there was no weight change?

B. If students predicted that the weights would decrease, they should have some lively discussions as they try to construct explanations that account for their observations. Through the class discussion, students should construct a molecular picture of what is going on that would cause the observed results. Students find it very difficult to change their thinking from their original misconceptions. Allow plenty of discussion time while they construct new ideas.

C. • Something must be gained or lost—like putting quarters into your pocket or tossing them out.

D. • The weight of the boiled water decreased.

E. • Some of the water actually left the beaker and went into the air.



TRY THIS

YOU WILL NEED

- 2 stoppered test tubes containing solutions to be combined
- 100 ml beaker and stirring rod
- balance

A. Obtain two stoppered test tubes that contain each of the solutions to be mixed. Examine the properties of each of the solutions and write them in your journal. Save your solutions for later use.

A

B. Your teacher will combine solutions of the two substances together and stir for several minutes. Watch carefully and write any observations in your journal.

C. Your teacher will give each group a small portion of the product to examine. Examine the properties and record your observations in your journal. Compare these properties to those you observed before the reaction. Record whether you think a new substance was formed, and why you think so.

B

D. Make a prediction. Did the weight increase, decrease or remain the same during this reaction? Write your prediction in your journal. Then write all the reasons why you think this.

How can you verify your predictions for this reaction?

E. Before you begin, plan out the experiment carefully, by following these steps for conducting the experiment.

- Plan, as a group, how to conduct your experiment. Write out your plan in steps.
- Think about each measurement you need to make and provide a clearly identified place on your data sheet for it.
- Think carefully about what might happen during your experiment that might make your measurements inaccurate, and plan ways to correct for those possible inaccuracies.

A. Students are allowed to observe the reaction and make predictions about weight change. They design an experiment to test their hypothesis and use their findings to prove or disprove their predictions. Through group discussions, students construct the explanation that no matter entered or left the system. Therefore, the weight did not change.

B. A common misconception is that the weight increases because a solid formed, and solids weigh more that liquids. Many students will be surprised to find that there is no change and will find it hard to accept this fact even after they have done the experiment. In the discussion, they should give reasons why they think what they do, and they should become aware of any discrepancies in their thinking.

- Check your plan with your teacher before starting.

F. Conduct the experiment, making measurements that are as accurate as possible. Record your measurements in your journal.

G. Discuss as a group whether your results help prove or disprove your predictions. Also discuss whether there were any substances that left the reaction or that were added to the reaction.

THINK AND WRITE

After the experiment, answer the following questions:

1. a. How were the ending substances different from the starting substances?

   b. Does this indicate that the change was a physical change or a chemical change? Explain your reasoning.

2. a. Did the weight change during this experiment? If so, how?

   b. How can you explain these results? Think about whether any substances entered or left the beaker during the reaction.

You'll continue your investigation of whether the weight changes during chemical changes in the next lesson.

1. a. The starting substances are transparent or semi-transparent liquids. The ending substance is a white, chunky solid.

   b. This is a probably a chemical change. The properties of the products are different than the properties of the reactants and indicate that a new substance was formed. If some students suggest that this change is "like freezing" because liquid has turned to solid, ask them if they had to cool the two liquids to make the change happen as you do when freezing something. Also, ask if the solid is colder that the liquids. This is not a change of state (physical change) since the solid is not just a frozen form of either of the two liquids.

2. a. There was no change in weight.

   b. No new substances were added to or taken from the system.

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How would scientists explain the steel wool rusting and burning reactions? You may remember that steel wool is a form of iron. When steel wool burns, a chemical reaction occurs that is very similar to the chemical reaction of rusting. Just like a candle or a match or a piece of paper needs oxygen from the air to burn, steel wool needs oxygen from the air to rust or to burn. Candles, matches and paper wouldn't burn on the moon, and neither would steel wool rust or burn on the moon. In both cases, steel wool combines with oxygen from the air to form new substances, both of which are called iron oxide. The reddish, flaky rust is actually a new substance and the jet black, powdery substance left after burning the steel wool is also a new substance. These two new substances are very similar to each other.

6. What do you think happened to the weight of steel wool when it rusted? Explain your answer using the data you collected in the experiment with the balloon: the observation that the balloon was sucked in to the beaker (what does this mean about the air around the steel wool?).
7. Why might your little brother think that matter was created in this experiment?

C

TRY THIS

Here is the final activity of this cluster. You'll use all the new information you learned in this cluster as you predict and write your explanations of what is happening.

YOU WILL NEED

- butane lighter
- aluminum pie tin
- clay or florist's adhesive
- rubber band
- 400 ml beaker

A. Remember the butane lighter? Observe it as you light it and allow it to burn for a minute or two.

6. The weight of the steel wool in the beaker probably increased, since air seems to disappear from the beaker. The air must have attached itself in some way to the steel, making it heavier.

7. If the steel wool gets heavier, without adding anything *that is visible* to it, it might seem that new matter was created.

C. In this activity, students will try to use all the information about invisible reactants and products and their effect on weight. Usually students are somewhat puzzled about the butane reaction because invisible gases are involved both as reactants and as products. Many times, even though students see the fog collect on the inside of the beaker, they have no idea what this is or where it came from because they do not know what fog is. They may just think it is smoke but butane really burns with a clean flame if it gets enough oxygen. They may know that carbon dioxide is produced when substances burn.

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with the oxygen in the air, and forms two new substances, water and carbon dioxide. The lighter gets lighter. Carbon dioxide is a gas. It floats off into the air. The water formed is hot so it is a gas (water vapor) and it, too, floats off into the air. If the gas hits the cool beaker, it forms a mist of tiny liquid droplets on the side of the beaker. Frequently, you can't see any products in this reaction because both products are gases and they go off into the air.

But in the closed system—when the gases are trapped inside a closed jar—the weight would not change, since the butane and oxygen gas were used to make two new substances, carbon dioxide and water vapor.

9. Review your answers to the last question and use any new information to revise or add to these answers.
10. Do you think this reaction is a physical change or a chemical change? What evidence do you have?
11. Why might your little sister think that the butane just burned up and disappeared in this reaction?
12. Write a paragraph in your journal that explains how the Law of Conservation of Matter applies to this reaction.

In the next cluster, you will see how atoms and molecules can help you understand even more about the Law of Conservation of Matter.

9. Answers vary.

10. It is probably a chemical change since new substances were produced. The properties of the products (invisible gas and water vapor) are totally different from the properties of the reactants (a clear liquid and an invisible gas from the air).

11. Because both products are gases that often are invisible to the naked eye.

12. Points to include are:
    - even through the system appears to weigh less, that is only true if you don't account for ALL of the reactants
    - when the invisible gases of the reactants are accounted for, the products weigh the same as the reactants
    - matter is conserved in all chemical reactions

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.