SCIENCE TASK ANNOTATION

ANNOTATION KEY

EQUITY Supporting a wide range of diverse students.

SCENARIOS Information provided to elicit performances.

SEPs Opportunities to demonstrate science and engineering practices.

DCIs Opportunities to demonstrate understanding of disciplinary core ideas.

CCCs Opportunities to demonstrate understanding of crosscutting concepts.

SENSE-MAKING Opportunities for reasoning about phenomena and problems.

ASSESSMENT PURPOSE Highlights how the task features connect to intended assessment use.

UNIT 3: "CONSERVATION OF MATTER"

(Whole task) Questions A and B provide scaffolding for student sense-making in Question C.

SENSE-MAKING | EQUITY

Sandy took a piece of iron wool (Fe(s)) and decided to investigate it. She measured its mass, burned it in the presence of oxygen (O2(g)), and then measured the mass of the product. She was surprised to find that the product had more mass than the iron wool starting material.

This scenario is likely puzzling and intriguing to high school students, as their prior experience has likely involved either equal or less mass after a manipulation has been made to the starting material. It seems a bit contrived, rather than real-world, authentic, and meaningful—students are not told why Sandy decided to burn the iron wool, or why this is a meaningful and relevant investigation. This could be improved if a little more contextual information was provided to help students connect to the scenario.

SCENARIOS | EQUITY

This is a clear way to problematize the phenomenon—to make clear to students what is uncertain and what needs to be explained, creating an opportunity for sense-making in the task.

SCENARIOS | SENSE-MAKING

Before Burning

While Burning

After Burning

The inclusion of real photographs can help students better understand what happened during the reaction.

SCENARIOS | EQUITY

UNIT 3: "CONSERVATION OF MATTER" (CONTINUED)

A. Sandy found out that the chemical formula of the remaining material was Fe2O3, and that it was the only product of the reaction.

Write out a balanced chemical equation that represents this process. Indicate the phase (i.e. solid, liquid or gas) of each reactant and product.

Because students are given the product formula here, and a great deal of information about the reactants (above and below), they can figure out the balanced equation without needing to bring an understanding of the chemical properties of Fe or O to the table throughout the task.

This more closely aligns to the MS DCI PS1.B than the HS-level of sophistication of the DCI, but is clearly revealing student understanding on the way to developing a deep understanding of the DCI at the HS level.

Question A reveals student understanding of parts of a DCI and SEP, and also provides a scaffold for the remaining questions. To correctly produce the balanced equation, students have to:

- know that the number of Fe and O atoms on each side of the equation have to be the same, and
- have some (limited) understanding of how iron and oxygen atoms behave.

This connects most closely with:

- MS DCI PS1.B "...in a chemical process, the atoms that make up the original substances are regrouped into different molecules...the total number of each type of atom is conserved and thus mass does not change."
- MS SEP #5 Using Mathematics and Computational Thinking element "Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems.

This question supports sense-making about the phenomenon (increased mass in the products than the reactants) in Question C. Without part C, this question might conflate understanding the rule that the numbers of atoms have to be equal on both sides of the equation—and the algebra associated with it—with an actual understanding of conservation of matter.

SEPs **DCIs**

Asking students to "balance" the chemical reaction might limit whether students are bringing their understanding of the conservation of mass to the table to respond to the task.

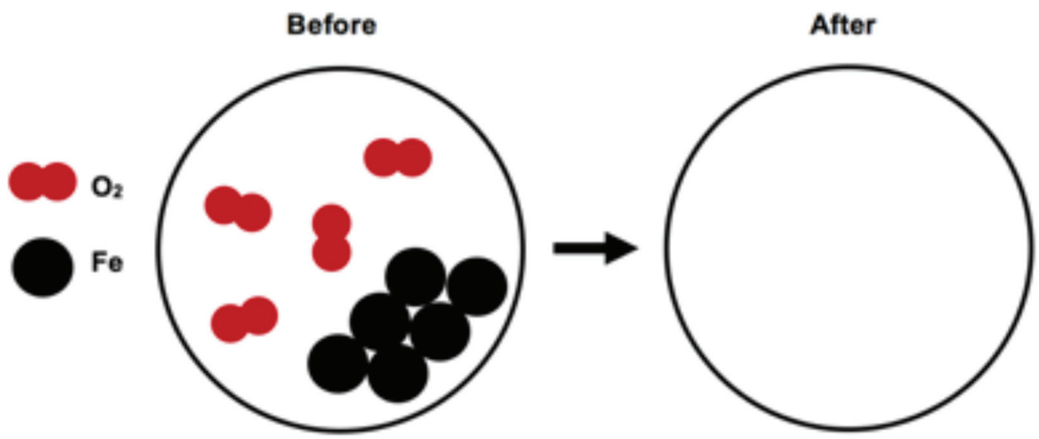
DCIs

UNIT 3: "CONSERVATION OF MATTER" (CONTINUED)

B. Using the balanced equation you constructed in part A, and the particle-level representation below showing a container BEFORE the reaction occurs, draw a representation of the atoms and molecules that will be present AFTER the reaction has occurred in the container provided. Assume the reaction proceeded to the fullest extent possible.

The first part of question B provides students with an alternative way to show the thinking represented in question A. The additional information this question surfaces is whether students know how to draw/represent atoms and molecules. This most closely connects with the skills associated with the SEP Developing and Using Models as well as the same mathematical thinking associated with question A. The DCI surfaced in question A could be surfaced here as well.

SEPs DCIs EQUITY



Justify the number and type of particles you drew in part B above (in the AFTER container). In your explanation, address the relative number of atoms of each element present before and after the reaction.

This part of question B asks students to make their reasoning about the representation and balanced equation explicit. While this does not necessarily reveal additional information about the DCI, it does provide an opportunity to explicitly surface student understanding of DCI HS.PS1.B, and another way for students to make their understanding visible.

DCIs SEPs EQUITY

Achieve

UNIT 3: "CONSERVATION OF MATTER" (CONTINUED)

C. Making use of the formula constructed in part A and/or the particle-level representation constructed in part B, explain why the product obtained from burning iron had a higher mass than the iron wool Sandy started with. In your explanation, discuss the relative atomic mass of starting materials and products.

In this part of question C, students have to connect the DCI and SEP surfaced earlier to make sense of the original phenomenon: why there was more mass in the products than the original iron wool that was burned. To successfully answer this question, students have to recognize that mass is conserved and the additional mass had to come from somewhere, bringing more of the DCI to the foreground. This is a scaffolded example of using multiple dimensions to make sense of the phenomenon.

Because students are given the formula for the only product in the reaction, and most of the information about the reactants, they have to bring minimal understanding of the chemical properties of the elements involved. As a result, this more closely aligns with the MS-level DCI PS1.B "...in a chemical process, the atoms that make up the original substances are regrouped into different molecules...the total number of each type of atom is conserved and thus mass does not change."

This is progressing toward the HS-level understanding and aligns with the LP for the task.

SEPs DCIs SENSE-MAKING

CONNECTION TO ASSESSMENT PURPOSE