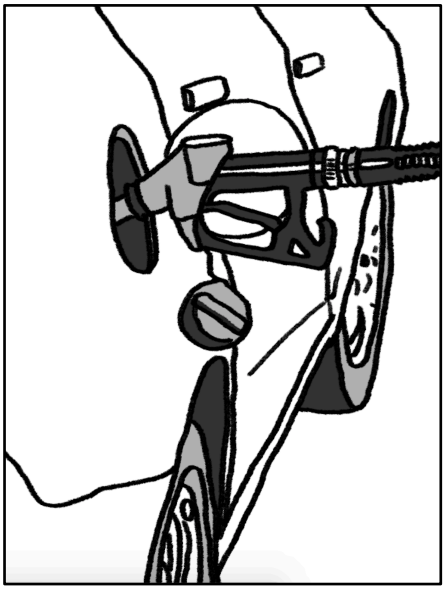
Name _____ Teacher _____ Date _____

Assessing the Big Idea Probe: Fill 'Er Up

As we have explained in "Using Big Idea Probes in Carbon TIME," we are thinking of this probe as an interesting way to gauge where your class is as a whole. There is a suggestion for having students "vote" several times through the course of the unit by putting their preferred choices on sticky notes and arranging the sticky notes on a poster to make a bar chart showing votes for each idea. However you do this, we think that the voting and discussion are important. Three times that would be useful to use this probe include right before Activity 1.2, after Lesson 4, and right before the unit posttest.



Luis's family stopped at the gas station on the way home one day. Luis's mom filled up the tank with 12 gallons of gasoline. Luis realized that his mom had to fill up the tank every week. He knew that 12 gallons was a pretty big amount. It would take him about 3 months to drink 12 gallons of milk! Where did all that gasoline go?

The family started talking about what happens to the gasoline when you drive a car. Here's what they thought…

We are especially interested in whether students use the Laws of Conservation of Matter and Energy when they are reasoning about chemical changes in systems —in this case combustion is the chemical change of interest. Combustion is a process in which hydrocarbon molecules (in this case in gasoline) react with oxygen to produce carbon dioxide and water, which are released from the car's tail pipe. Energy in the form of work/movement and heat is released in the process.

It is important for students to know that they can vote for more than one explanation. Comments on what a vote for each explanation may mean in terms of student thinking are below.

Luis: I think some of the gasoline turns into energy that makes the car go. So, you start with gasoline and you end up with motion and some heat. *This answer violates the Laws of Conservation of Matter and Energy: Matter does not turn into energy during chemical changes. But it is a very attractive option to students reasoning at learning progression Levels 2 and 3. They are not making the distinction between "Energy is released when we burn fuel as an energy source" and "Fuel is turned into energy." Students who choose Luis's answer could benefit from some continuing focus on reasoning with the Three Questions. It might also help them to explain how the two statements above are different and have different implications. For example, "fuel is turned into energy" implies that, since fuel is made of atoms, the atoms that were in the fuel have disappeared, while the first statement implies that something is happening to the energy in the fuel and something different is happening to atoms in the fuel.*

David: I think some of the gasoline turns into carbon dioxide. *This is a correct answer. The main products of combustion are carbon dioxide and water. However, David does not also indicate that water is a product of combustion. So, David only has a partial story of what happens to the fuel. Also, David does not trace the energy from chemical energy in the gasoline to work/motion and heat after combustion. It could be useful for students who choose David's response to account for all of the elements in the reaction, not just carbon.*

Tracing unseen energy is more difficult for students. It may be useful to ask what the indicators are that energy was involved (there was noise and heat, and the engine moved) and investigate the history of this energy.

Elena: I think some of the gasoline ends up as water that goes into the air. *This is a correct answer. The main products of combustion are carbon dioxide and water. However, Elena does not also indicate that carbon dioxide is a product of combustion. So Elena only has a partial story of what happens to the fuel. Also, Elena does not trace the energy from chemical energy in the gasoline to work/motion and heat after combustion. The same instructional hints for students who choose David's answer apply for students who choose Elena's response.*

Mom: I think the gasoline evaporates and becomes fumes that pollute the air. *While a small amount of gasoline may evaporate and leave the car as a vapor, Mom is not tracing the bulk of the gasoline and is not tracing the fuel through the process of combustion and into the products of combustion. If students choose Mom's answer, you may want to ask them, if the gasoline mostly evaporates, then how does the car get energy to move?*

Dad: I think some of the gasoline just burns up and disappears. *Dad is correct that the gasoline burns (in the process of combustion), but he seems to be thinking of this process as something that violates the Laws of Conservation of Matter and Energy. When something burns, the matter from the initial materials (gasoline and oxygen) doesn't disappear. It needs to be traced to products of water and carbon dioxide. Students who choose Dad's answer could also benefit from some continuing focus on reasoning with the Three Questions.*

Who do you agree with and why? It's ok to pick more than one person. Explain your thinking.

One thing to notice when you read students' explanations or listen to their arguments is where their ideas are coming from.

- *Are they trying to trace matter and energy through a system—a core goal in the Next Generation Science Standards—OR*
- *Are they relying on ideas from the media and popular culture or on everyday experiences of gases as invisible: Fuel gets "burned up" and the matter is gone, or fuel IS ENERGY rather than fuel IS MATTER that contains chemical energy.*

Pay special attention to the numbers of students who say they agree with Luis, Mom, or Dad. When students learn to reject those ideas, they are shifting from "popular culture thinking" to scientific reasoning about matter and energy.