Where Energy Goes

Trace the energy change when chemical bonds form.

CHE.2.b "Construct an explanation of the change in potential energy that occurs when chemical bonds are formed."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline the attraction that causes potential energy to change, then number these events in the passage: atoms approach, potential energy falls, and energy moves to the surroundings.

Energy Inside a Fuel Cell

1 A hydrogen fuel cell can power a bus while producing water instead of the exhaust from burning fuel. Inside the cell, hydrogen and oxygen react, and new oxygen-hydrogen bonds form in water. To understand the energy change, imagine one hydrogen atom and one oxygen atom far apart. Their attraction is weak at that distance. As they approach a suitable distance, the attraction between each atom's nucleus and the other atom's electrons lowers the system's potential energy. At the stable bond distance, the bonded pair has less potential energy than the far-apart atoms. This comparison is about chemical potential energy, not how fast the atoms move.

2 Lower potential energy does not mean energy disappears. When oxygen-hydrogen bonds form, energy leaves the bonding atoms and moves into their surroundings. In a fuel cell, a controlled reaction directs some of the overall released energy into an electric circuit, and some becomes heat. If you wanted to pull a bonded oxygen atom and hydrogen atom apart again, you would need to supply energy. Separating them raises their potential energy toward the level they had when far apart. Thus, forming a bond releases energy, while breaking that same bond requires energy.

3 The fuel cell does not begin with separate atoms. It begins with hydrogen molecules, H_2, and oxygen molecules, O_2. Breaking bonds in these starting molecules requires energy. New bonds form in water molecules, H_2O, releasing energy. In this reaction, forming the new bonds releases more energy than breaking the old bonds requires. That difference can leave the cell as electrical energy and heat. A common mistake is to say that breaking the bonds in fuel is what releases energy. To explain the cell's energy output, compare the energy required to break old bonds with the energy released when new ones form.

2 ANSWER WITH EVIDENCE

Use the passage

1. As a hydrogen atom and an oxygen atom approach a stable bond distance, what happens to their chemical potential energy? Explain the cause.

2. When oxygen-hydrogen bonds form in the fuel cell, where does the released energy go? Name two forms the cell's overall energy output can take.

3. Why must energy be supplied to pull a bonded hydrogen atom and oxygen atom apart?

4. Why can the fuel-cell reaction release energy overall even though breaking bonds in H_2 and O_2 requires energy?

3 YOUR TURN

Your own words

Two separate fluorine atoms form an F_2 molecule. In three or four sentences, explain what causes their chemical potential energy to change, where the released energy goes, and what would be required to separate the atoms again.

Where Energy Goes

PART 1 · READ AND MARK

Underline the attraction that causes potential energy to change, then number these events in the passage: atoms approach, potential energy falls, and energy moves to the surroundings. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	As a hydrogen atom and an oxygen atom approach a stable bond distance, what happens to their chemical potential energy? Explain the cause.	**Their chemical potential energy decreases because attraction between each nucleus and the other atom's electrons lowers the energy of the bonded pair.**
2	When oxygen-hydrogen bonds form in the fuel cell, where does the released energy go? Name two forms the cell's overall energy output can take.	**Energy moves to the surroundings. The cell's overall energy output can take the form of electrical energy and heat.**
3	Why must energy be supplied to pull a bonded hydrogen atom and oxygen atom apart?	**Pulling the atoms apart raises their chemical potential energy, so the separation requires an energy input.**
4	Why can the fuel-cell reaction release energy overall even though breaking bonds in H_2 and O_2 requires energy?	**Forming the new bonds in water releases more energy than breaking the bonds in H_2 and O_2 requires.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

As two fluorine atoms approach a stable bond distance, attractions involving their nuclei and electrons lower their chemical potential energy. The energy difference is released to the surroundings, such as through increased thermal energy. Separating the atoms again requires an energy input because their chemical potential energy rises as the bond breaks.

Accept explanations that connect bond formation to a decrease in chemical potential energy caused by attraction, with energy transferred to the surroundings. For the overall fuel-cell reaction, students must compare energy released by forming bonds with energy required to break bonds.