Bond Energy Trail

Trace energy through a reaction system model.

HS-PS1-4 "Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy..."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline every phrase that shows energy entering or leaving the reaction system. Circle each sentence that compares the energy needed to break bonds with the energy released when bonds form, because those comparisons determine whether the system releases or absorbs energy.

Following Energy Through Bonds

1. During a chemical reaction, the reacting substances form a system: the atoms and bonds being rearranged. Energy can move between this system and its surroundings, such as a beaker, the air, or your hand. At the molecular level, breaking an existing bond requires an input of energy. Forming a new bond releases energy. A reaction does not release energy simply because a bond breaks, or absorb energy simply because a bond forms. The overall change depends on both processes and on the total energy associated with all bonds changed.

2. In a sealed reaction vessel, hydrogen and chlorine react to form hydrogen chloride. A molecular model could show H-H and Cl-Cl bonds in reactants, then H-Cl bonds in products. In an energy bar diagram, include an arrow into the system for energy needed to separate reactant bonds. Include arrows out for energy released as product bonds form. Compare totals: if energy released during bond formation is greater than energy absorbed during bond breaking, products are lower in energy than reactants. The extra energy leaves the system, so the surroundings warm.

3. A different reaction may absorb energy overall. Its model still shows energy entering to break bonds and energy leaving when new bonds form. If the energy needed for bonds broken is greater than the energy released when bonds form, the products have higher energy than the reactants. The missing energy enters from the surroundings, perhaps as heat, light, or electricity. An energy graph would place products higher than reactants. The reaction system gains exactly the energy that the surroundings lose, showing energy is conserved even though its location changes.

2 ANSWER WITH EVIDENCE

Use the passage

1. According to paragraph 1, what two bond changes must a complete reaction model include, and what happens energetically during each change?

2. Use paragraph 2. Why should the products be placed lower than the reactants on an energy diagram for the hydrogen and chlorine reaction?

3. What relationship between bond breaking and bond formation makes a reaction absorb energy overall? Where would the products appear on an energy graph?

4. How can a reaction model show that energy is conserved when a reaction absorbs energy?

3 YOUR TURN

Your own words

Choose a chemical reaction not named in the reading and make a labeled molecular-level bond sketch plus a relative-energy bar or line graph. Show which bonds break and form, use arrows for energy entering and leaving, then write exactly three sentences that state whether the reaction releases or absorbs energy, compare the total energy of bond changes, and explain conservation of energy.

ANSWER KEY

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HIGH SCHOOL · HS-PS1-4

PART 1 · READ AND MARK

Underline every phrase that shows energy entering or leaving the reaction system. Circle each sentence that compares the energy needed to break bonds with the energy released when bonds form, because those comparisons determine whether the system releases or absorbs energy. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	According to paragraph 1, what two bond changes must a complete reaction model include, and what happens energetically during each change?	**It must include bond breaking, which absorbs energy, and bond formation, which releases energy.**
2	Use paragraph 2. Why should the products be placed lower than the reactants on an energy diagram for the hydrogen and chlorine reaction?	**More energy is released as H-Cl bonds form than is absorbed to break the reactant bonds, so energy leaves the system and the products are lower in energy.**
3	What relationship between bond breaking and bond formation makes a reaction absorb energy overall? Where would the products appear on an energy graph?	**The energy needed to break bonds is greater than the energy released when new bonds form. The products appear higher than the reactants.**
4	How can a reaction model show that energy is conserved when a reaction absorbs energy?	**It can show energy entering the reaction system from the surroundings, with the system gaining exactly the energy the surroundings lose.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

Bond sketch: CH_4 (4 C-H bonds) + 2 O_2 (2 O=O bonds) → CO_2 (2 C=O bonds) + 2 H_2O (4 O-H bonds); arrows enter while C-H and O=O bonds break and leave while C=O and O-H bonds form Relative-energy graph: reactants higher than products; arrow from system to surroundings labeled energy released This reaction releases energy overall. Forming the C=O and O-H bonds releases more total energy than breaking the C-H and O=O bonds absorbs. The reaction system transfers that excess energy to the surroundings, so the energy lost by the system equals the energy gained by the surroundings.

Accept accurate molecular sketches, energy graphs, or bar models that show both bond breaking and bond formation. Do not require numerical bond-energy calculations, but require a correct comparison of total energy absorbed and released and a conservation statement.