Where Energy Goes

Use bond totals and reaction data to explain energy changes.

CHE.10.3 "Enrichment: Analyze and interpret data from energy diagrams and investigations to support claims that the amount of energy released or absorbed during a chemical reaction depends on changes in total bond energy."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline two statements that connect bond-energy totals to whether a reaction releases or absorbs energy. Circle the positive and negative signs in the table's measured energy changes.

Tracking Energy Through Bonds

1. At a research lab, chemists compare reactions by tracking the energy stored in bonds. Pulling atoms apart takes energy; making new bonds releases energy. If bond formation releases more energy than bond breaking requires, a reaction gives off energy overall. If breaking requires more than formation releases, the reaction absorbs energy overall. The difference sets the net energy change.

2. The table compares three gas-phase reactions. Bond-energy totals estimate the energy needed to break all reactant bonds and the energy released when all product bonds form. Investigators measured the net energy change, ΔH, in kilojoules per mole of reaction as written. Small differences between estimates and measurements can arise because tabulated bond energies are averages.

BOND TOTALS AND MEASURED REACTION ENERGY

Gas-phase reaction	Break bonds (kJ/mol)	Form bonds (kJ/mol)	Measured ΔH (kJ/mol)
$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$	2648	3450	−800
$N_2 + O_2 \rightarrow 2NO$	1443	1262	+180
$H_2 + Cl_2 \rightarrow 2HCl$	679	862	−184

3. An energy diagram plots a system's energy as a reaction proceeds. Its reactant and product levels show the net change: lower products mean energy left the system, while higher products mean energy entered it. A hump represents the energy barrier to starting a reaction, not its net energy change. Compare differences with measured values.

2 ANSWER WITH EVIDENCE

Use the passage

1. For the methane reaction, subtract the energy released by forming bonds from the energy needed to break bonds. How does your result compare with the measured ΔH?

2. Use both bond totals and measured ΔH to support a claim about whether the nitrogen monoxide reaction absorbs or releases energy.

3. Which releases more energy per mole of reaction, methane combustion or hydrogen chloride formation? Support your answer with both the bond totals and measured values.

4. On energy diagrams for the nitrogen monoxide and hydrogen chloride reactions, which would have products above reactants? Explain using the table.

3 YOUR TURN

Your own words

A proposed reaction needs 620 kJ/mol to break bonds and releases 755 kJ/mol when new bonds form. Write a claim predicting its ΔH and the product level on an energy diagram. Show your calculation and name one measurement that could test your claim.

Where Energy Goes

PART 1 · READ AND MARK

Underline two statements that connect bond-energy totals to whether a reaction releases or absorbs energy. Circle the positive and negative signs in the table's measured energy changes. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	For the methane reaction, subtract the energy released by forming bonds from the energy needed to break bonds. How does your result compare with the measured ΔH?	**2648 − 3450 = −802 kJ/mol, close to the measured −800 kJ/mol.**
2	Use both bond totals and measured ΔH to support a claim about whether the nitrogen monoxide reaction absorbs or releases energy.	**It absorbs energy. Breaking bonds needs 181 kJ/mol more than forming bonds releases, and measured ΔH is positive, +180 kJ/mol.**
3	Which releases more energy per mole of reaction, methane combustion or hydrogen chloride formation? Support your answer with both the bond totals and measured values.	**Methane combustion releases more. Its bond totals predict a release of 802 kJ/mol, compared with 183 kJ/mol for hydrogen chloride formation. Measurements show releases of about 800 and 184 kJ/mol, respectively.**
4	On energy diagrams for the nitrogen monoxide and hydrogen chloride reactions, which would have products above reactants? Explain using the table.	**The nitrogen monoxide reaction would have products above reactants because breaking bonds takes more energy than forming bonds releases, and ΔH is +180 kJ/mol. Hydrogen chloride formation has products below reactants because its measured ΔH is −184 kJ/mol.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

The predicted ΔH is 620 − 755 = −135 kJ/mol, so the reaction releases energy. Products would be lower than reactants on an energy diagram. A temperature increase in the surrounding water, measured during the reaction, would support the claim that energy was released.

Accept equivalent explanations that treat bond formation as energy released and calculate ΔH as energy needed to break bonds minus energy released by forming bonds. The small differences between calculated and measured values reflect the use of average bond energies.