

Bond Energy

Chem Worksheet 16-2

Name _____

Bond energy is defined as the amount of energy required to break a bond. These values are positive, indicating that bond breaking is endothermic. Bond energies are reported in kilojoules per mole (kJ/mol). The energy for breaking a hydrogen-hydrogen bond is 436 kJ/mol so when a hydrogen-hydrogen bond is formed the process releases 436 kJ/mol.

In a chemical reaction several bonds are broken and formed. For example in the reaction below a hydrogen-hydrogen bond is broken and a fluorine-fluorine bond is broken. Two hydrogen-fluorine bonds are formed. The overall energy change for this process is calculated below.

example



$$\begin{aligned}\Delta H_{\text{rxn}} &= [\text{energy used for breaking bonds}] - [\text{energy formed in making bonds}] \\ &= [436 \text{ kJ/mol} + 155 \text{ kJ/mol}] - [2(567 \text{ kJ/mol})] \\ &= -543 \text{ kJ/mol}\end{aligned}$$



Bond energy: 436 kJ/mol



Bond Energy: 155 kJ/mol



Bond Energy: 567 kJ/mol

Average Bond Energies (kJ/mol)

H-H	436 kJ/mol	C-H	413 kJ/mol	C=C	614 kJ/mol
H-Cl	431 kJ/mol	C-C	348 kJ/mol	C≡C	839 kJ/mol
H-F	567 kJ/mol	C-N	293 kJ/mol	C=O	799 kJ/mol
N-H	391 kJ/mol	C-O	358 kJ/mol	O=O	495 kJ/mol
N-O	201 kJ/mol	C-F	485 kJ/mol	C=O	1072 kJ/mol
O-H	463 kJ/mol	C-Cl	328 kJ/mol	C=N	615 kJ/mol
O-O	146 kJ/mol	C-S	259 kJ/mol	N=N	418 kJ/mol
F-F	155 kJ/mol	Cl-Cl	242 kJ/mol	N≡N	941 kJ/mol
				C≡N	891 kJ/mol

Estimate the enthalpy change (ΔH_{rxn}) of the following reactions using the bond energies above.

- $\text{H}-\text{H} + \text{Cl}-\text{Cl} \rightarrow \text{H}-\text{Cl} + \text{H}-\text{Cl}$
- $\begin{array}{c} \text{H} & & \text{H} \\ & \backslash & / \\ & \text{C}=\text{C} \\ & / & \backslash \\ \text{H} & & \text{H} \end{array} + \text{F}-\text{F} \rightarrow \begin{array}{c} \text{H} & \text{H} \\ | & | \\ \text{H}-\text{C}-\text{C}-\text{H} \\ | & | \\ \text{F} & \text{F} \end{array}$
- $\begin{array}{c} \text{H} \\ | \\ \text{H}-\text{C}-\text{O}-\text{H} \\ | \\ \text{H} \end{array} + \begin{array}{c} \text{H} \\ | \\ \text{H}-\text{C}-\text{O}-\text{H} \\ | \\ \text{H} \end{array} \rightarrow \begin{array}{c} \text{H} & \text{H} \\ | & | \\ \text{H}-\text{C}-\text{O}-\text{C}-\text{H} \\ | & | \\ \text{H} & \text{H} \end{array} + \text{H}-\text{O}-\text{H}$
- $\begin{array}{c} \text{Cl} \\ | \\ \text{H}-\text{C}-\text{Cl} \\ | \\ \text{Cl} \end{array} + \text{O} \rightarrow \begin{array}{c} \text{O} \\ || \\ \text{C}-\text{Cl} \\ | \\ \text{Cl} \end{array} + \text{H}-\text{Cl}$
- $\begin{array}{c} \text{H} \\ | \\ \text{H}-\text{C}-\text{H} \\ | \\ \text{H} \end{array} + \begin{array}{c} \text{O}=\text{O} \\ \text{O}=\text{O} \end{array} \rightarrow \text{O}=\text{C}=\text{O} + \begin{array}{c} \text{H}-\text{O}-\text{H} \\ \text{H}-\text{O}-\text{H} \end{array}$

Draw Lewis structures for reactants and products. Estimate the enthalpy change (ΔH_{rxn}) for the reactions using bond energies.

- $\text{H}_2(\text{g}) + \text{CO}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{g}) + \text{CO}(\text{g})$
- $2\text{H}_2\text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{g}) + \text{O}_2(\text{g})$
- $\text{CO}(\text{g}) + 2\text{H}_2(\text{g}) \rightarrow \text{CH}_3\text{OH}(\text{g})$
- $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$
- $\text{H}_2(\text{g}) + \text{C}_2\text{H}_4(\text{g}) \rightarrow \text{C}_2\text{H}_6(\text{g})$
- $2\text{C}_2\text{H}_6(\text{g}) + 7\text{O}_2(\text{g}) \rightarrow 4\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{g})$
- $\text{CH}_4(\text{g}) + 3\text{Cl}_2(\text{g}) \rightarrow \text{CHCl}_3(\text{g}) + 3\text{HCl}(\text{g})$
- $\text{HCN}(\text{g}) + 2\text{H}_2(\text{g}) \rightarrow \text{CH}_3\text{NH}_2(\text{g})$

Bond Energy Extension Questions Key

Brendan G. Carr

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Table of Contents Bond Energy Extension Questions Key

1. Understanding the eBook Bond Energy Extension Questions Key
 - The Rise of Digital Reading Bond Energy Extension Questions Key
 - Advantages of eBooks Over Traditional Books
2. Identifying Bond Energy Extension Questions Key
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Bond Energy Extension Questions Key
 - User-Friendly Interface
4. Exploring eBook Recommendations from Bond Energy Extension Questions Key
 - Personalized Recommendations
 - Bond Energy Extension Questions Key User Reviews and Ratings
 - Bond Energy Extension Questions Key and Bestseller Lists
5. Accessing Bond Energy Extension Questions Key Free and Paid eBooks
 - Bond Energy Extension Questions Key Public Domain eBooks
 - Bond Energy Extension Questions Key eBook Subscription Services
 - Bond Energy Extension Questions Key Budget-Friendly Options
6. Navigating Bond Energy Extension Questions Key eBook Formats
 - ePub, PDF, MOBI, and More
 - Bond Energy Extension Questions Key Compatibility with Devices
 - Bond Energy Extension Questions Key Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Bond Energy Extension Questions Key
 - Highlighting and Note-Taking Bond Energy Extension Questions Key
 - Interactive Elements Bond Energy Extension Questions Key

8. Staying Engaged with Bond Energy Extension Questions Key
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Bond Energy Extension Questions Key
9. Balancing eBooks and Physical Books Bond Energy Extension Questions Key
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Bond Energy Extension Questions Key
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Bond Energy Extension Questions Key
 - Setting Reading Goals Bond Energy Extension Questions Key
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Bond Energy Extension Questions Key
 - Fact-Checking eBook Content of Bond Energy Extension Questions Key
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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