

# Bond Energy

What makes a reaction endothermic or exothermic?

## Why?

Chemical reactions can be a lot like playing with Legos®—you must take apart part of your last creation before you can replace it with something new. For many chemical reactions, we have to first break bonds in the reactants before we can put the atoms back into a new arrangement to form the products. Both of these processes involve changes in energy. The net energy change for a reaction is called the **heat of reaction** or the **change in enthalpy** ( $\Delta H$ ). In this activity we will look at one way energy changes can be approximated for chemical reactions.

## Model 1 – Breaking and Forming Bonds

	Reaction	Change in Energy (kJ/mol <sub>rxn</sub> )		Reaction	Change in Energy (kJ/mol <sub>rxn</sub> )
A)	$\text{PCl}_3(\text{g}) \rightarrow \text{P}(\text{g}) + 3\text{Cl}(\text{g})$	+ 966.7 <i>broken</i>	E)	$\text{P}(\text{g}) + 3\text{Cl}(\text{g}) \rightarrow \text{PCl}_3(\text{g})$	- 966.7 <i>formed</i>
B)	$\text{PCl}_5(\text{g}) \rightarrow \text{P}(\text{g}) + 5\text{Cl}(\text{g})$	+ 1,297.9 <i>broken</i>	F)	$\text{P}(\text{g}) + 5\text{Cl}(\text{g}) \rightarrow \text{PCl}_5(\text{g})$	- 1,297.9 <i>formed</i>
C)	$\text{PF}_3(\text{g}) \rightarrow \text{P}(\text{g}) + 3\text{F}(\text{g})$	+ 1,470.4 <i>broken</i>	G)	$\text{P}(\text{g}) + 3\text{F}(\text{g}) \rightarrow \text{PF}_3(\text{g})$	- 1,470.4 <i>formed</i>
D)	$\text{PF}_5(\text{g}) \rightarrow \text{P}(\text{g}) + 5\text{F}(\text{g})$	+ 2,305.4 <i>broken</i>	H)	$\text{P}(\text{g}) + 5\text{F}(\text{g}) \rightarrow \text{PF}_5(\text{g})$	- 2,305.4 <i>formed</i>

- Identify four reactions in Model 1 where bonds are being broken. Write "broken" in the Change in Energy box in the table for each reaction you identify.
- Identify four reactions in Model 1 where bonds are being formed. Write "formed" in the Change in Energy box in the table for each reaction you identify.
- Circle the correct word to complete each sentence below.
  - When bonds are (broken/formed) there is a positive energy change.
  - Breaking bonds is (endothermic/exothermic).
  - When bonds are (broken/formed) there is a negative energy change.
  - Forming bonds is (endothermic/exothermic).
- Find two reactions in Model 1 that are exact opposites of each other, that is, one reaction is the reverse of the other reaction.
  - How do the changes in energy for the reverse reactions compare?
 

*The changes in energy for these reactions are the same, but opposite in sign.*
  - Explain your answer to part a considering what you learned from Questions 1–3 about bond breaking and bond formation.
 

*If a given amount of energy is required to break a bond, then the same amount of energy will be released when the bond is formed.*

# Bond Energy Pogil

**Richard Bailey**



## **Bond Energy Pogil:**

*Comprehensive Handbook of Chemical Bond Energies* Yu-Ran Luo, 2007-03-09 Understanding the energy it takes to build or break chemical bonds is essential for scientists and engineers in a wide range of innovative fields including catalysis nanomaterials bioengineering environmental chemistry and space science Reflecting the frequent additions and updates of bond dissociation energy BDE data throughout the literature the *Comprehensive Handbook of Chemical Bond Energies* compiles the most recent experimental BDE data for more than 19 600 bonds of 102 elements The author organizes the data by bond type functional group bond order bond degree molecular size and structure for ease of use Data can also be located using the Periodic table The book presents data for organic molecules biochemicals and radicals as well as clusters ions hydrogen and surface bonded species van der Waals complexes isotopic species and halogen clusters complexes It also introduces entirely new data for inorganics and organometallics The final chapter summarizes the heats of formation for atoms inorganic organic radicals and monoatomic ions in the gas phase The *Comprehensive Handbook of Chemical Bond Energies* offers quick access to experimental BDE data in the most inclusive well organized and up to date collection available today     **Organic Chemistry** Suzanne M. Ruder, The POGIL Project, 2015-12-29 ORGANIC CHEMISTRY

**CHEMICAL BONDS AND BOND ENERGY.** RT. SANDERSON, 1971     *Analytical Chemistry* Juliette Lantz, Renée Cole, The POGIL Project, 2014-12-31 An essential guide to inquiry approach instrumental analysis *Analytical Chemistry* offers an essential guide to inquiry approach instrumental analysis collection The book focuses on more in depth coverage and information about an inquiry approach This authoritative guide reviews the basic principles and techniques Topics covered include method of standard the microscopic view of electrochemistry calculating cell potentials the BerriLambert atomic and molecular absorption processes vibrational modes mass spectra interpretation and much more     **Chemistry** Richard S. Moog, John J. Farrell, 2017-06-26 In the newly updated 7th Edition *Chemistry A Guided Inquiry* continues to follow the underlying principles developed by years of extensive research on how students learn and draws on testing by those using the POGIL methodology This text follows the principles of inquiry based learning and correspondingly emphasizes underlying chemistry concepts and the reasoning behind them This text provides an approach that follows modern cognitive learning principles by having students learn how to create knowledge based on experimental data and how to test that knowledge

*Bond Orders and Energy Components* , 2013     **Bond Orders and Energy Components** István Mayer, 2016-10-14 While modern computational methods can provide us with the wave function of a molecule in numerical form most computer programs lack the sophisticated tools needed to extract chemical concepts from these wave functions Saving researchers vast time and potential confusion this volume collects and organizes those validated tools currently scattered throughout the literature and details their application It provides immediate access for those needing to calculate such critical factors as bond order and valence indices and atomic and diatomic contributions to molecular energy Supporting material is available

for download from the authors continually updated website      **Renewable Energy Finance - Green Bonds** International Renewable Energy Agency IRENA,2020      *Bond-based Corrections to Improve Atomization Energy Calculations* Neelabh Maheshwari,2012      **Energy Refinements to Glass Structure** Patrick Joseph Hood,1985      Renewable energy finance: Green bonds International Renewable Energy Agency IRENA,2020-01-01 Renewables have emerged as a major recipient of green bond proceeds This brief highlights the need for more green bonds to drive sustainable climate safe energy finance

**Main Group Chemistry** ,2013      **Bond Selective Chemistry Beyond the Adiabatic Approximation** ,1993 The adiabatic Born Oppenheimer potential energy surface approximation is not valid for reaction of a wide variety of energetic materials and organic fuels coupling between electronic states of reacting species plays a key role in determining the selectivity of the chemical reactions induced This research program initially studies this coupling in 1 selective C Br bond fission in 1 3 bromiodopropane 2 C S S H bond fission branching in CH<sub>3</sub>SH and 3 competition between bond fission channels and H<sub>2</sub> elimination in CH<sub>3</sub>NH<sub>2</sub>      Energy and Bonding Michael Hudson (chimiste),1969

**Utilizing the Bond Order-bond Length Relationship for Reorganization Energy Prediction of Polyaromatic Hydrocarbons** □□□,2023      **Bond Selective Chemistry Beyond the Adiabatic Approximation . Technical Progress Report, September 15, 1992--June 14, 1993** ,1993 The adiabatic Born Oppenheimer potential energy surface approximation is not valid for reaction of a wide variety of energetic materials and organic fuels coupling between electronic states of reacting species plays a key role in determining the selectivity of the chemical reactions induced This research program initially studies this coupling in 1 selective C Br bond fission in 1 3 bromiodopropane 2 C S S H bond fission branching in CH<sub>3</sub>SH and 3 competition between bond fission channels and H<sub>2</sub> elimination in CH<sub>3</sub>NH<sub>2</sub>      *Bond Orbital Model 2* Stanford University. Microwave Laboratory,1974      *Sustainable Energy Through Green Bonds in India* ,2020

**Bonding and Structures of Light Element Energy Systems Under Extreme Conditions** Yu Lin,2013 This dissertation focuses on investigating the effect of pressure on the structure and bonding of three types of light element energy systems using a suite of synchrotron x ray characterization probes including diffraction spectroscopic and imaging techniques Ammonia borane AB which contains a remarkably high hydrogen content shows rich structural and dihydrogen bonding variations upon compression More strikingly AB is found to be capable of storing a significant amount of extra hydrogen molecules in addition to the hydrogen chemically stored in itself which makes this novel AB H<sub>2</sub> compound one of the most hydrogen rich materials currently known LiMn<sub>2</sub>O<sub>4</sub> a promising cathode material for Li ion batteries is found to be extremely sensitive to deviatoric stress which triggers a cubic to tetragonal phase transition Such a transition during the battery working environment is detrimental to both the performance and lifetime However the nanostructured material can accommodate more stress and strain compared to its bulk counterpart Glassy carbon which has very low density and 100% sp<sup>2</sup> bonding at ambient conditions undergoes a transition to amorphous diamond at high pressure This new carbon allotrope

possesses an amorphous structure with 100% sp<sup>3</sup> bonds and exceptional hardness The property of superhardness if turns out to be isotropic can be advantageous relative to crystalline diamond for which the hardness is highly anisotropic The findings could lead to new classes of ultradense and strong materials that can serve as energy efficient components such as wear resistant parts for all kinds of transportation Bond Graphs for Causal Explanations J. L. Top,1992

## Reviewing **Bond Energy Pogil**: Unlocking the Spellbinding Force of Linguistics

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