

Name _____

Period ____ Date ____/____/____

8 • Thermochemistry

BOND ENERGIES and ENTHALPY OF COMBUSTION

Table: Some Average Single- and Multiple-Bond Energies (kJ/mol)

	H	C	N	O	F	Si	P	S	Cl	Br	I
H	436	413	391	463	565	318	322	347	432	366	299
C		346	305	358	485			272	339	285	213
N			163	201	283				192		
O				146		452	335		218	201	201
F					155	565	490	284	253	249	278
Si						222		293	381	310	234
P							201		326		184
S								226	255		
Cl									242	216	208
Br										193	175
I											151

Multiple Bonds

N=N	418	C=C	602	C=O*	732	
N≡N	945	C≡C	835	C≡O	1072	*C=O (in CO ₂) 799
O=O (in O ₂)	498	C=N	615	C≡N	887	

1. Write the balanced equation for the combustion of 1 mole of ethane, C₂H₆(g), forming H₂O(l).

2. Draw Lewis structures for each of the species.



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3. Calculate the bond energies of the **reactants**.Calculate the bond energies of the **products**.☐ C-H @ _____ kJ/mol = _____☐ C=O @ _____ kJ/mol = _____☐ C-C @ _____ kJ/mol = _____☐ O-H @ _____ kJ/mol = _____☐ O=O @ _____ kJ/mol = _____Total Bond Energy (**Reactants**) =Total Bond Energy (**Products**) =4. $\Delta H_{\text{reaction}} = \text{Bond Energy}_{(\text{reactants})} - \text{Bond Energy}_{(\text{products})}$ What is the $\Delta H_{\text{combustion}}$ based on bond energies? _____

5. Remember that we also learned a different method of calculating the enthalpy of a reaction. Calculate the $\Delta H_{\text{combustion}}$ of ethane using Hess's Law and the thermochemical data below.

Standard Enthalpies of Formation (kJ/mol)		
$\text{C}_2\text{H}_6(\text{g})$	ethane	-84.7
$\text{H}_2\text{O}(\text{l})$	water	-285.8
$\text{CO}_2(\text{g})$	carbon dioxide	-393.5

6. Summarize your calculations:

	$\Delta H_{\text{combustion}} (\text{kJ} \cdot \text{mol}^{-1})$
Bond Energies	
Hess's Law using $\Delta H_{\text{formation}}$	

Differences may occur because Bond Energies are _____ bond energies that may vary from molecule to molecule.

Notice that in one method, you use **products – reactants** and in the other you use **reactants – products**. Why?

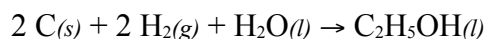
- In **Hess's Law** you use values for the _____ (formation/breaking) of bonds. This occurs in the _____ (reactants/products). You must change the sign for the _____ (products/reactants).

- For **Bond Energies** you use values for the _____ (formation/breaking) of bonds. This occurs in the _____ (reactants/products). You must change the sign for the _____ (products/reactants).

	(reactants-products / products-reactants)
Bond Energies	
Hess's Law	

- 7.
- | Substance | Enthalpy of Combustion, ΔH°
(kJ/mol) | Substance | Enthalpy of Combustion, ΔH°
(kJ/mol) |
|-------------------------|--|---|--|
| $\text{C}_{(\text{s})}$ | -393.5 | $\text{C}_2\text{H}_5\text{OH}(\text{l})$ | -1366.7 |
| $\text{H}_2(\text{g})$ | -285.8 | $\text{H}_2\text{O}(\text{l})$ | - |
- (a) Write a separate, balanced chemical equation for the combustion of each of the following: $\text{C}_{(\text{s})}$, $\text{H}_2(\text{g})$, and $\text{C}_2\text{H}_5\text{OH}(\text{l})$. Consider the only products to be CO_2 and/or $\text{H}_2\text{O}(\text{l})$.

- (b) In principle, ethanol can be prepared by the following reaction:



Calculate the standard enthalpy change, ΔH° , for the preparation of ethanol, as shown in the reaction above.