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	*C=O (in CO_2)	799
N≡N	945	C≡C	835	C≡O	1072		
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, $C_2H_6(g)$, forming $H_2O(l)$.

2. Draw Lewis structures for each of the species.

C_2H_6	O_2	CO_2	H_2O

3. Calculate the bond energies of the ***reactants***.

☐ C–H @ _____ kJ/mol = _____

☐ C–C @ _____ kJ/mol = _____

☐ O=O @ _____ kJ/mol = _____

Calculate the bond energies of the ***products***.

☐ C=O @ _____ kJ/mol = _____

☐ O–H @ _____ kJ/mol = _____

Total Bond Energy (***Reactants***) =	Total Bond Energy (***Products***) =

4. $\Delta H_{reaction}$ = Bond Energy$_{(reactants)}$ – Bond Energy$_{(products)}$

What is the $\Delta H_{combustion}$ based on bond energies? _____

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

Standard Enthalpies of Formation (kJ/mol)		
$C_2H_6(g)$	ethane	-84.7
$H_2O(l)$	water	-285.8
$CO_2(g)$	carbon dioxide	-393.5

6. Summarize your calculations:

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

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, $\Delta H°$ (kiloJoules/mol)	Substance	Enthalpy of Combustion, $\Delta H°$ (kiloJoules/mol)
$C_{(s)}$	-393.5	$C_2H_5OH_{(l)}$	-1366.7
$H_{2(g)}$	-285.8	$H_2O_{(l)}$	- -

(a) Write a separate, balanced chemical equation for the combustion of each of the following: $C_{(s)}$, $H_{2(g)}$, and $C_2H_5OH_{(l)}$. Consider the only products to be CO_2 and/or $H_2O_{(l)}$.

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

$$2\ C_{(s)} + 2\ H_{2(g)} + H_2O_{(l)} \rightarrow C_2H_5OH_{(l)}$$

Calculate the standard enthalpy change, $\Delta H°$, for the preparation of ethanol, as shown in the reaction above.