Bond Enthalpy Practice Name: **ANSWER KEY**

Chemistry Date: _____ Hour: _____

Read (and annotate) this! Feel free to use the space at the bottom of the page to take additional notes from the EdPuzzle video.

In a chemical reaction the reactant molecules are chemically converted into product molecules. The chemical bond(s) in the reactant molecule(s) are broken and new bond(s) are formed in the product(s). Energy must be absorbed to break a chemical bond (ΔH is positive) and energy is released (ΔH is negative) when bonds are formed. The enthalpy change (ΔH) for a chemical reaction can be calculated by looking at the difference in the sum of (Σ) the bond energies (BE) of the broken reactant bonds and the formed product bonds.

$$\Delta H = \sum BE_{broken} - \sum BE_{formed}$$

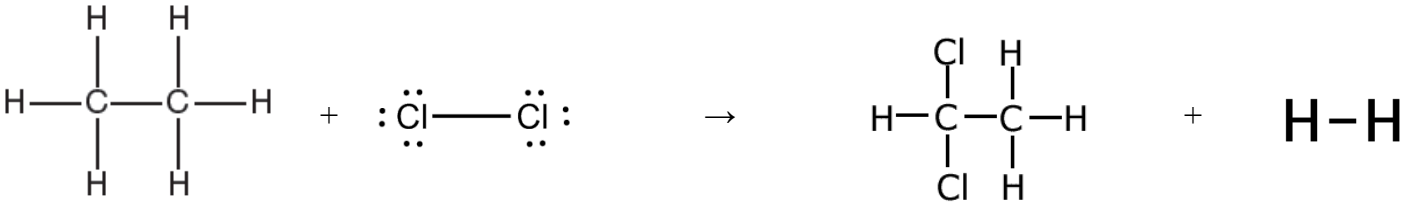
Bond Energies

Bond	Energy (kJ/mol)	Bond	Energy (kJ/mol)
H—H	432	N—N	160
C—H	411	N=O	631
N—H	386	N≡N	941
H—Cl	431	N—O	201
C—C	346	Cl—Cl	243
C—O	358	F—F	158
C—N	305	O—H	464
C—Cl	327	O—Cl	269
C=C	602	O—O	204
C=O	745	C—F	552
O=O	494	C—S	259

Reaction #1 -- Ethane and chlorine gas react as shown in the balanced chemical equation:

$$C_2H_{6(g)} + Cl_{2(g)} \rightarrow C_2H_4Cl_{2(g)} + H_{2(g)} + \mathbf{21kJ}$$

The Lewis dot structures of the products and reactants are shown below.



1) a) The sum (Σ) of the bond energies broken is…

C–H 6 x (411 kJ/mol) = 2466 kJ
C–C 1 x (346 kJ/mol) = 346 kJ
Cl–Cl 1 x (243 kJ/mol) = 243 kJ
Σ BE_{broken} = 3055 kJ/mol

b) The sum (Σ) of the bond energies formed is…

C–H 4 x (411 kJ/mol) = 1644 kJ
C–Cl 2 x (327 kJ/mol) = 654 kJ
C–C 1 x (346 kJ/mol) = 346 kJ
H–H 1x (432 kJ/mol) = 432 kJ
Σ BE_{formed} = 3076 kJ/mol

c) The enthalpy change (ΔH) for the reaction is…

ΔH = (3055 kJ/mol) - (3076 kJ/mol) = -21 kJ/mol

2) Use your answer from #1c to update the thermochemical equation found at the top of the section.

3) Is this reaction **exothermic** or endothermic? _____

Reaction #2: The combustion of hydrogen, H_2 to produce water. $2H_2(g)+O_2(g)\rightarrow 2H_2O(g)+498\ kJ$

4) **DRAW** the chemical reaction below. Use an arrow → to separate the products from the reactants.

5) a) The sum (Σ) of the bond energies broken is…

H–H 2 x (432 kJ/mol) = 864 kJ
O=O 1 x (494 kJ/mol) = 494 kJ
Σ BE_{broken} = 1358 kJ/mol

b) The sum (Σ) of the bond energies formed is…

H–O 4 x (464 kJ/mol) = 1856 kJ/mol
Σ BE_{formed} = 1856 kJ/mol

c) The enthalpy change (ΔH) for the reaction is…

ΔH = (1358 kJ/mol) - (1856 kJ/mol) = -498 kJ/mol

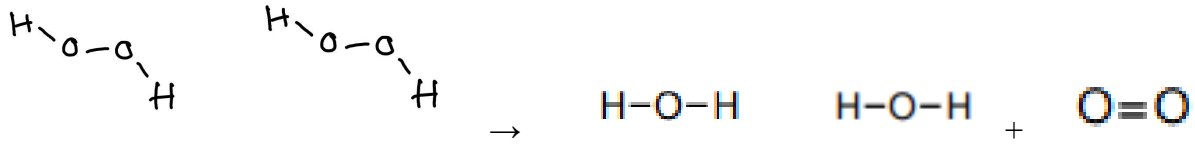
6) Use your answer from #2c to update the thermochemical equation found at the top of the section.

7) Is this reaction **exothermic** or endothermic? _____

Reaction #3: The decomposition of hydrogen peroxide, H_2O_2. $2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g) + 86kJ$

VIDEO WALK-THROUGH $2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$ $\Delta H = 186$ kJ/mol

8) **DRAW** the chemical reaction below. Use an arrow → to separate the products from the reactants.



9) a) The sum (Σ) of the bond energies broken is…

H–O 4 (464 kJ/mol) = 1856
O–O 2 (204 kJ/mol) = 408
Σ BE_{broken} = 2264 kJ/mol

b) The sum (Σ) of the bond energies formed is…

H–O 4 (464 kJ/mol) = 1856
O=O 1 (494 kJ/mol) = 494
Σ BE_{formed} = 2350 kJ/mol

c) The enthalpy change (ΔH) for the reaction is…

ΔH = (2264 kJ/mol) - (2350 kJ/mol) = -86 kJ/mol

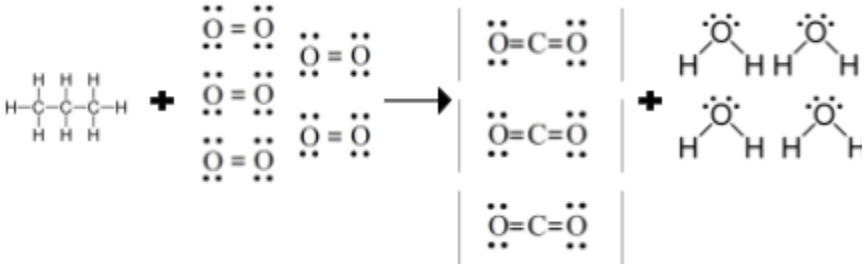
10) Use your answer from #6c to update the thermochemical equation found at the top of the section.

11) Is this reaction exothermic or endothermic? _____

Reaction #4 -- The combustion of propane is shown in the balanced chemical equation:

$$C_3H_{8(g)} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(g)} + \mathbf{1732\ kJ}$$

12) **DRAW** the chemical reaction below (lewis structures). Use an arrow → to separate the products from the reactants. **VIDEO WALK-THROUGH**



13) a) The sum (Σ) of the bond energies broken is…

H–C (8)(411 kJ/mol) = 3288 kJ
C–C (2)(346 kJ/mol) = 692 kJ
O=O (5)(494 kJ/mol)= 2470 kJ
Σ BE_{broken} = 6450 kJ/mol

b) The sum (Σ) of the bond energies formed is…

C=O (6)(745 kJ/mol) = 4470 kJ
H–O (8)(464 kJ/mol) = 3712 kJ
Σ BE_{formed} = 8182 kJ/mol

c) The enthalpy change (ΔH) for the reaction is…

ΔH = (6450 kJ/mol) - (8182 kJ/mol) = -1732 kJ/mol

14) Use your answer from #16c to update the thermochemical equation found at the top of the section.

15) Is this reaction **exothermic** or endothermic? _____

Reaction #5 -- The following balanced thermochemical equation represents a hypothetical reaction between A_2 and B_2 producing the molecule AB. Use the given information to calculate the energy for the A__B bond. VIDEO WALK-THROUGH

$$A_2 + B_2 \rightarrow 2AB + 549kJ$$

The following bond energies are known:

Bond	Bond Energy (kJ/mol)
A__A	327
B__B	432
A__B	???

16) Calculate the A__B bond energy.

We know that $\Delta H = \sum BE_{broken} - \sum BE_{formed}$. *Based on the information provided, we have* ΔH *&* $\sum BE_{broken}$.

$\Delta H = -549\ kJ$

$\sum BE_{broken} = (1)$(A__A) + (1)(B__B) = (1)(327 kJ/mol) + (1)(432 kJ/mol) = 759 kJ/mol

So, we'll plug this known information into the equation $\Delta H = \sum BE_{broken} - \sum BE_{formed}$

$-549\ kJ = 759\ kJ - \sum BE_{formed}$

$\sum BE_{formed} = 1308\ kJ$

But there are 2 bonds being formed, so the energy of one A__B bond is (1308÷2) **654 kJ**

Answer the following questions by circling the correct answer that completes the sentence.
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17) For an exothermic reaction the…
   a) symbol for enthalpy change (ΔH) is [*positive* / ***negative***].
   b) bond energies of the reactants is [*greater than* / ***less than***] the bond energies of the products, while the enthalpy diagram shows the reactants [***higher*** / *lower*] than the products.

18) For an endothermic reaction the…
   a) symbol for enthalpy change (ΔH) is [***positive*** / *negative*].
   b) bond energies of the reactants is [***greater than*** / *less than*] the bond energies of the products, while the enthalpy diagram shows the reactants [*higher* / ***lower***] than the products.