

Bond Enthalpies

Estimating ΔH from bonds broken and formed

Name _____ Class _____ Date _____

AVERAGE BOND ENTHALPIES (KJ/MOL, GAS PHASE)

H-H 436 · Cl-Cl 242 · H-Cl 431 · Br-Br 193 · H-Br 366 · I-I 151 · F-F 155 · H-F 567

C-H 413 · C-C 348 · C=C 614 · C≡C 839 · C-Cl 328 · O=O 498 · C=O (in CO₂) 799 · O-H 463

$\Delta H \approx \Sigma(\text{bonds broken}) - \Sigma(\text{bonds formed})$

List every bond broken and formed, using the coefficients. Show units in every step.

A. Ideas

1. Define bond enthalpy. Explain why bond breaking is endothermic and bond forming is exothermic.

2. Put C-C, C=C and C≡C in order of increasing bond length and of increasing bond strength. Explain why C=C is not twice as strong as C-C.

B. Estimating ΔH

3. Estimate ΔH for $\text{H}_2(\text{g}) + \text{F}_2(\text{g}) \longrightarrow 2 \text{HF}(\text{g})$.

4. Estimate ΔH for $\text{CH}_4(\text{g}) + \text{Cl}_2(\text{g}) \longrightarrow \text{CH}_3\text{Cl}(\text{g}) + \text{HCl}(\text{g})$. (Only one C-H bond is broken.)

5. Estimate ΔH for the hydrogenation of ethyne: $\text{HC}\equiv\text{CH}(\text{g}) + 2\text{H}_2(\text{g}) \longrightarrow \text{CH}_3\text{CH}_3(\text{g})$.

6. Estimate ΔH for the combustion of ethane: $2\text{C}_2\text{H}_6(\text{g}) + 7\text{O}_2(\text{g}) \longrightarrow 4\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{g})$.
Give your answer per mole of ethane too.

C. Working backwards

7. For $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \longrightarrow 2\text{HI}(\text{g})$, $\Delta H = -9\text{ kJ/mol}$. Use the data to calculate the H-I bond enthalpy.

D. Challenge

8. The measured enthalpy of combustion of methane forming liquid water is -890 kJ/mol , but the bond-enthalpy estimate (forming gaseous water) is -802 kJ/mol . Give two reasons for the difference.