Bond Energies and Reaction-Energy Estimates

Student Worksheet | g10_u02_w07

I can: estimate a reaction enthalpy by adding energy required to break reactant bonds and subtracting energy released when product bonds form.
Classroom model: all values below are supplied *mean gas-phase bond enthalpies* in kJ/mol: C–H 413; C–C 348; C=C 614; O=O 498; C=O in CO_2 799; O–H 463; H–H 436; Cl–Cl 243; H–Cl 431; N≡N 945; N=O 607. Use

$$\Delta H_{\text{rxn}} \approx \sum E_{\text{broken}} - \sum E_{\text{formed}}.$$

Breaking a bond requires energy; forming a bond releases energy. Because these are averaged values, every result is an estimate, not an exact measured enthalpy. All prompts are paper/data-card analyses; no chemical handling is requested.

1. In your own words, define a bond enthalpy. Why is the word *mean* important in this worksheet?

2. Complete both statements: Breaking a bond _____ energy; forming a bond _____ energy. Give the energy-flow reason for each.

3. For $H_2 + Cl_2 \rightarrow 2HCl$, list the bonds broken and the bonds formed. Do not calculate yet.

4. For item 3, calculate $\sum E_{\text{broken}}$ and $\sum E_{\text{formed}}$. Keep units.

5. Use item 4 to estimate ΔH_{rxn} for $H_2 + Cl_2 \rightarrow 2HCl$. Is the estimate exothermic or endothermic?

6. Sketch a relative-energy diagram for item 5. Label reactants, products, and the sign of ΔH. Why is a reaction with negative ΔH not proof that it is fast?

7. Estimate ΔH_{rxn} for $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O(g)$. Show the number of each bond counted on both sides.

8. Item 7 specifies $H_2O(g)$. Explain why changing the water state or using a different tabulated data set can change a comparison with a measured enthalpy.

9. Estimate ΔH_{rxn} for $C_2H_4 + H_2 \rightarrow C_2H_6$. Count only bonds whose totals differ between reactants and products.

10. Estimate ΔH_{rxn} for $N_2 + O_2 \rightarrow 2NO$ using the supplied N≡N, O=O, and N=O values.

11. A learner says, "The bonds in the products are stronger, so breaking them released the energy." Correct the statement using item 5 or 7 as evidence.

12. If the item 7 estimate applies to 0.250 mol of reaction as written, calculate the estimated heat change in kJ. State the sign.

13. Estimate ΔH_{rxn} for $C_2H_6 + \frac{7}{2}O_2 \rightarrow 2CO_2 + 3H_2O(g)$. Show a bond-count table or organized calculation.

14. A reference value for item 13 is -1428 kJ/mol, while your mean-bond estimate differs. Calculate the signed difference, estimate minus reference.

15. Give two scientifically reasonable reasons that a mean-bond estimate can differ from a reference reaction enthalpy. Do not call either value "wrong" based on one comparison.

16. Hess's law gives a path-independent enthalpy when appropriate measured equations are added. How is that result different from a bond-energy estimate?

17. Distinguish a *bond dissociation enthalpy for one specified bond* from a *mean bond enthalpy.* Which one does this packet use?

18. A headline says, “Bonds store energy that is released when they break.” Rewrite it accurately in one or two sentences.

19. List three model limits or context labels a careful report should include when presenting a bond-energy estimate.

20. A proposed reaction has $\sum E_{\text{broken}} = 910$ kJ/mol and $\sum E_{\text{formed}} = 760$ kJ/mol. Estimate ΔH, state the energy direction, and write one next step before making a high-confidence prediction.