PE Diagrams

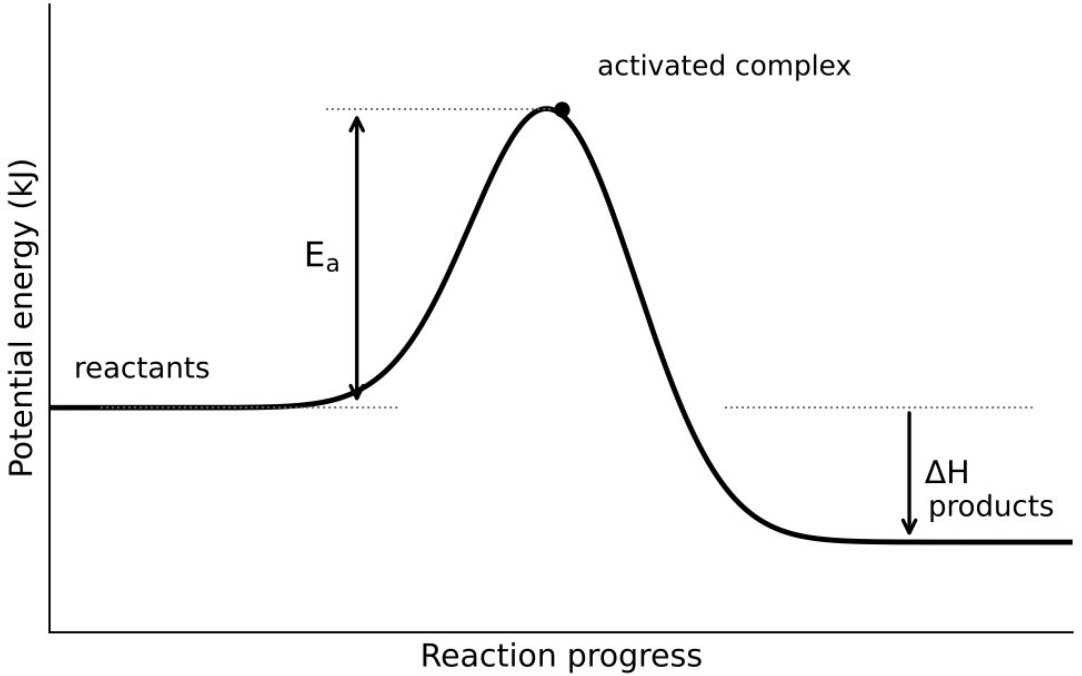
Essential Question

How does energy change during a reaction?

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What a PE Diagram Shows

- Y axis: potential energy (kJ), stored in bonds
- X axis: reaction progress
- Left line: reactants. Right line: products.
- Reaction pathway: the route over the hill



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Exothermic Reactions

- Products end lower
- ΔH is negative (−)
- Heat is released: hand warmers, campfires

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Endothermic Reactions

- Products end higher
- ΔH is positive (+)
- Heat is absorbed: instant cold packs

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Activation Energy

- E_a: the energy needed to start
- E_a = peak − reactants
- Tall hill: slow. Short hill: faster.

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Activated Complex

- The arrangement at the top of the hill
- Also called the transition state
- Old bonds partly broken, new bonds partly formed

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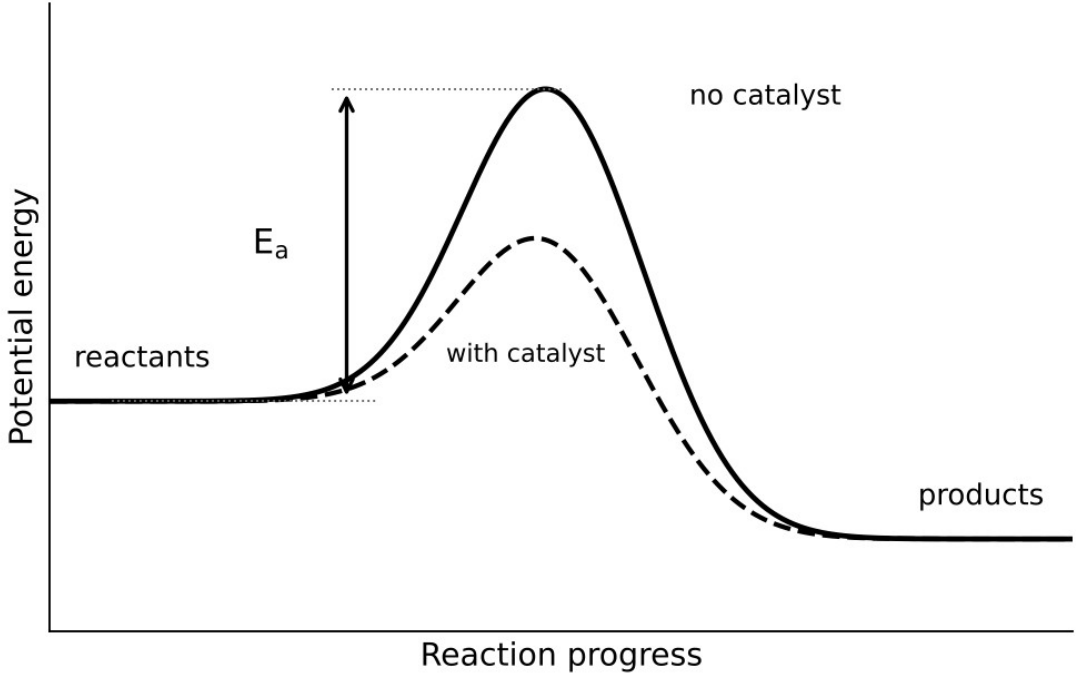
Finding ΔH on a Diagram

- $\Delta H = PE_{products} - PE_{reactants}$
- The peak does not matter for ΔH
- Reverse reaction: same size, opposite sign
- $E_{a,\ reverse}$ = peak − products

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Effect of a Catalyst

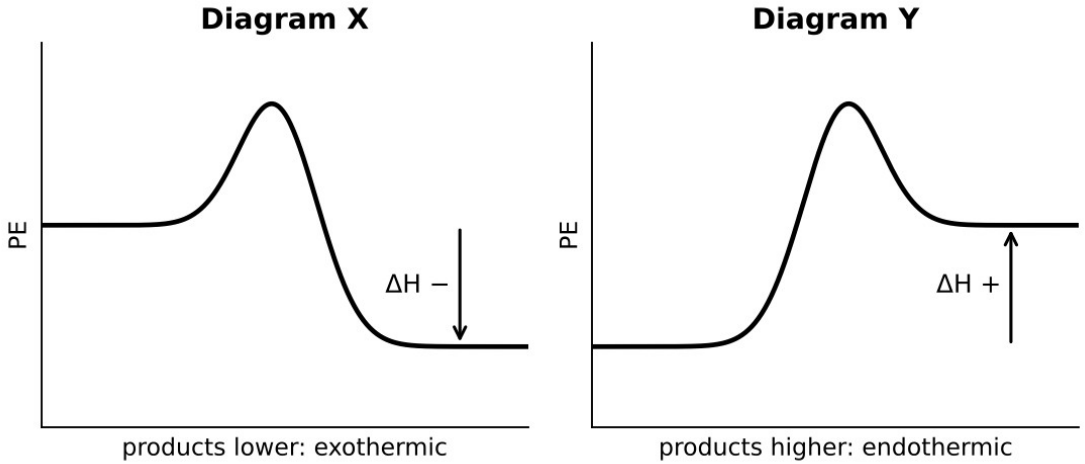
- Lowers E_a: a new, easier path
- Reaction goes faster
- Same flat lines, same ΔH



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Matching an Equation to a Diagram

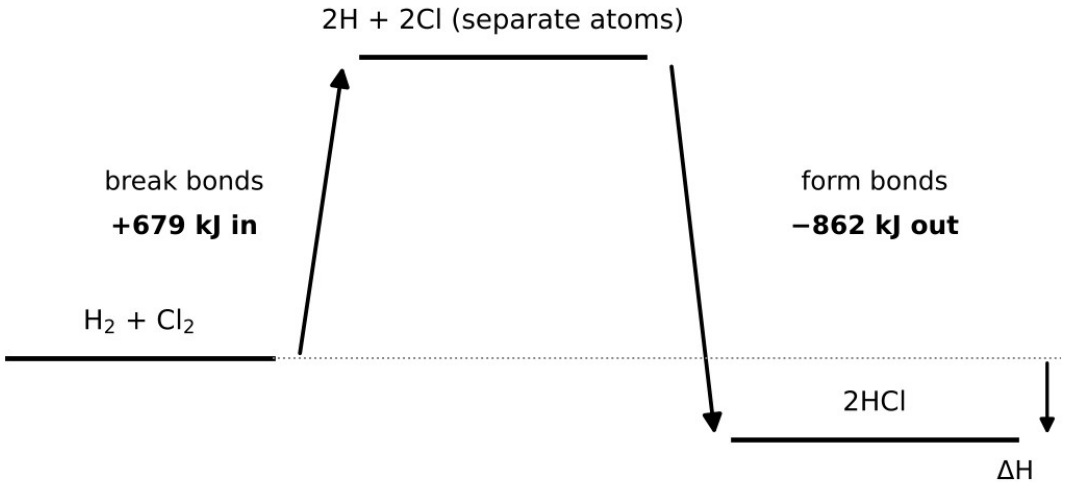
- Heat on the right: exothermic, products lower
- Heat on the left: endothermic, products higher
- The number is the gap between the flat lines



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Where ΔH Comes From: Bonds

- Breaking bonds absorbs energy
- Forming bonds releases energy
- Bond energy: kJ to break 1 mol of a bond
- Net energy change: ΔH = energy in − energy out



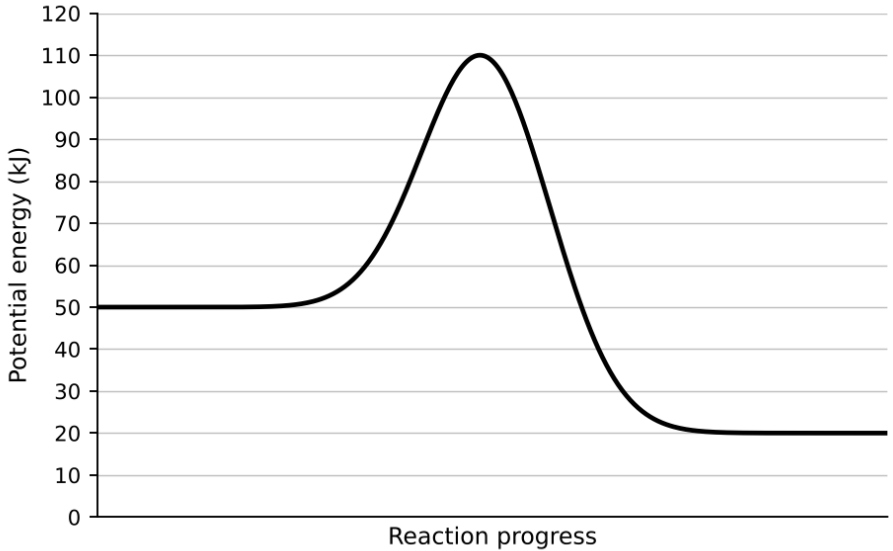
Net energy change: ΔH = 679 − 862 = −183 kJ

More energy out than in: exothermic

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Example: Reading a PE Diagram

Use the PE diagram. (a) Find ΔH. (b) Find E_a. (c) Exothermic or endothermic?



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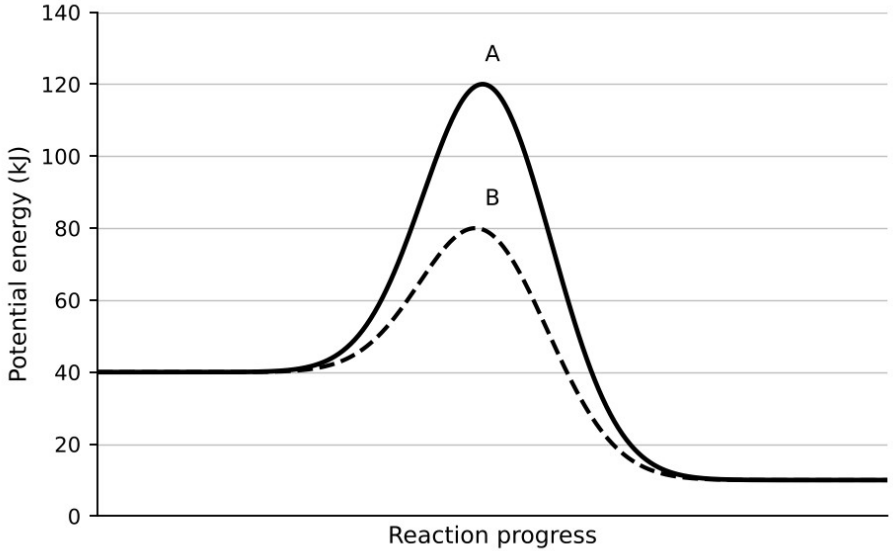
Example: Sketch a PE Diagram

Sketch a PE diagram for a reaction with reactants at 25 kJ, $\Delta H = +50$ kJ, and $E_a = 100$ kJ.

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Example: Catalyst or Not?

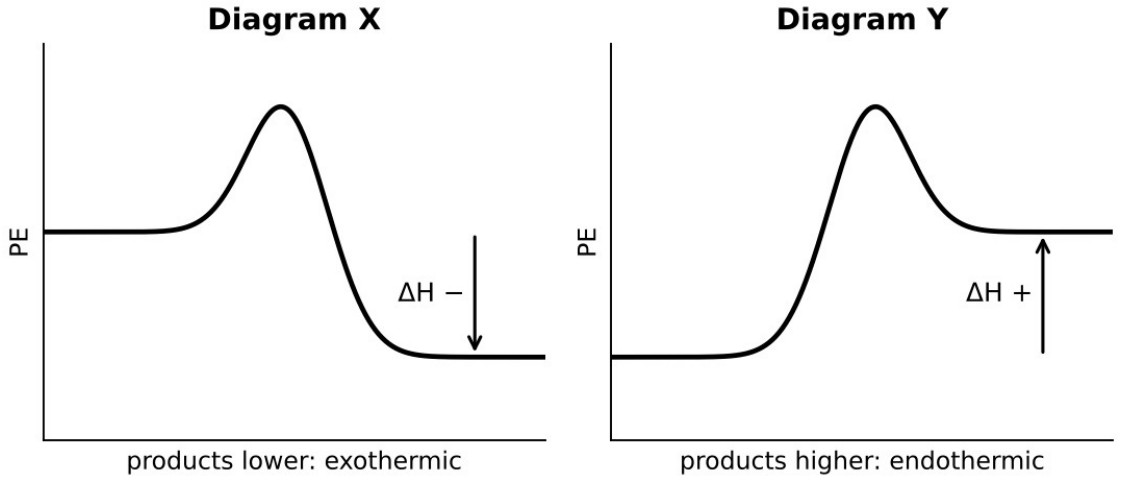
Curves A and B show the same reaction. (a) Which curve is catalyzed? (b) Find E_a for each curve. (c) Find ΔH for each curve.



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Example: Match the Equation

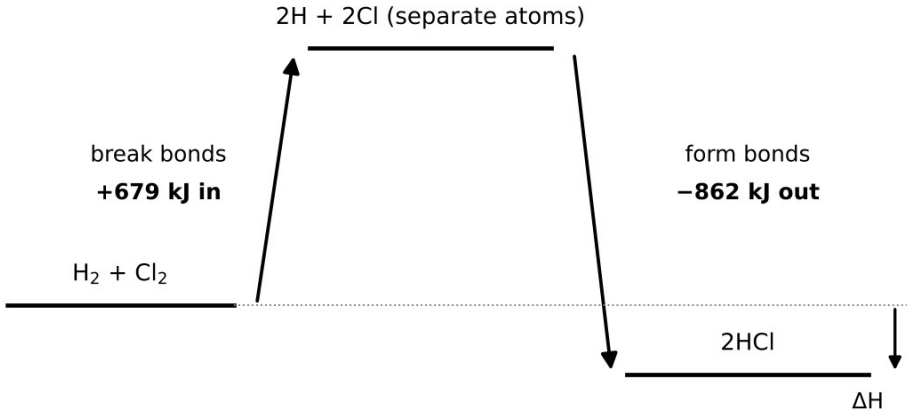
Which equation matches Diagram X, and which matches Diagram Y? Give ΔH for each. (1) $2H_2(g) + O_2(g) \rightarrow 2H_2O(g) + 484$ kJ. (2) $N_2(g) + O_2(g) + 181$ kJ $\rightarrow 2NO(g)$



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Example: Breaking and Forming Bonds

Use the average bond energies to find ΔH for $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$. Bond energies: H-H 436, Cl-Cl 243, H-Cl 431 kJ/mol



Net energy change: ΔH = 679 − 862 = −183 kJ

More energy out than in: exothermic

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PE Diagrams

Big Ideas

- PE diagrams track energy from reactants to products
- Exothermic: $\Delta H < 0$; endothermic: $\Delta H > 0$
- ΔH = products − reactants
- E_a = peak − reactants; a catalyst lowers E_a
- Heat on the right: exothermic; heat on the left: endothermic
- Breaking bonds absorbs energy; forming bonds releases it

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