

4.3.3 Bond Enthalpy



Premium Formula-Led Deck

Defining Bond Enthalpy



The amount of energy required to break **one mole** of bonds of a particular type between two atoms in a **gaseous state**.

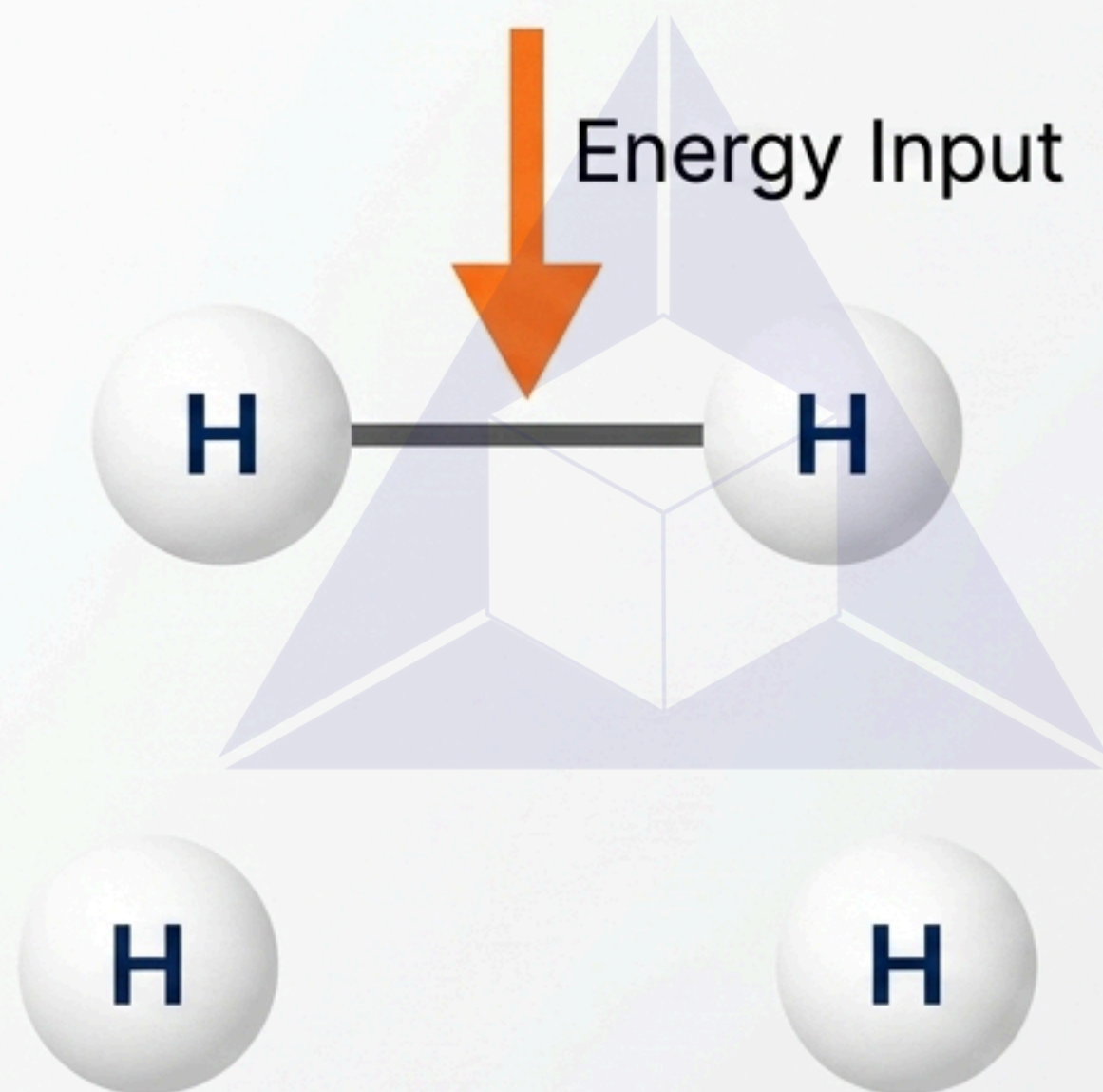
Unit: kJ mol^{-1}



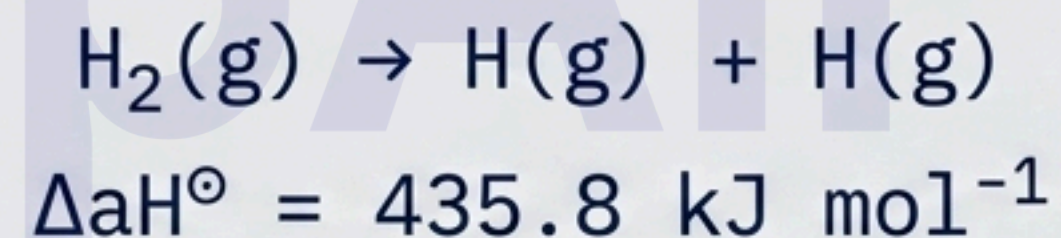
For heteronuclear diatomic molecules like Hydrogen Chloride, the concept applies **identically** to breaking the bond between two different atoms:



The Hydrogen Baseline



The simplest application of bond enthalpy is homonuclear diatomic molecules. The required energy perfectly dissociates the molecule into two neutral, gaseous atoms.



Bond Order: 1 (Single Bond)



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$$E=mc^2$$



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Key Highlights

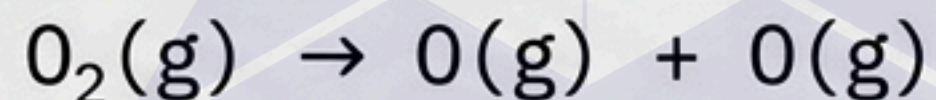
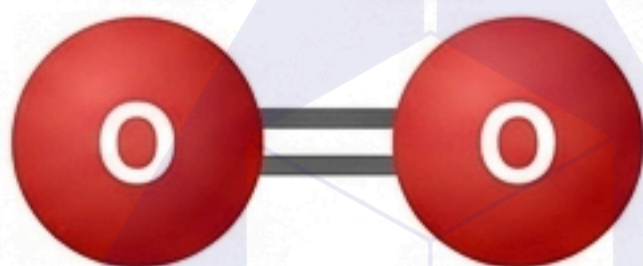
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Oxygen Vs. Nitrogen

How do multiple bonds affect the energy required for molecular dissociation?

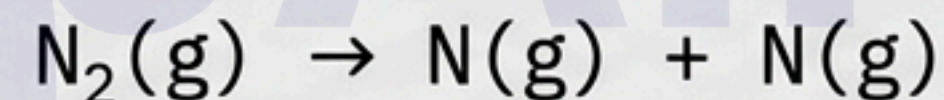
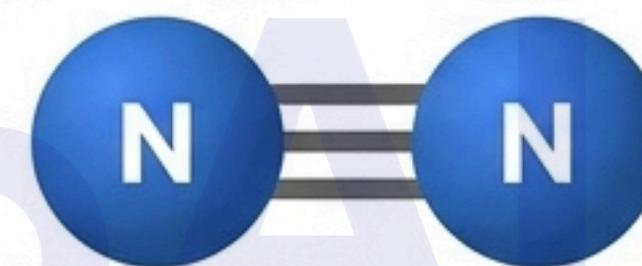
Oxygen (O₂)



$$\Delta_{\text{a}}H^\ominus = 498.0 \text{ kJ mol}^{-1}$$

Bond Order: 2

Nitrogen (N₂)



$$\Delta_{\text{a}}H^\ominus = 946.0 \text{ kJ mol}^{-1}$$

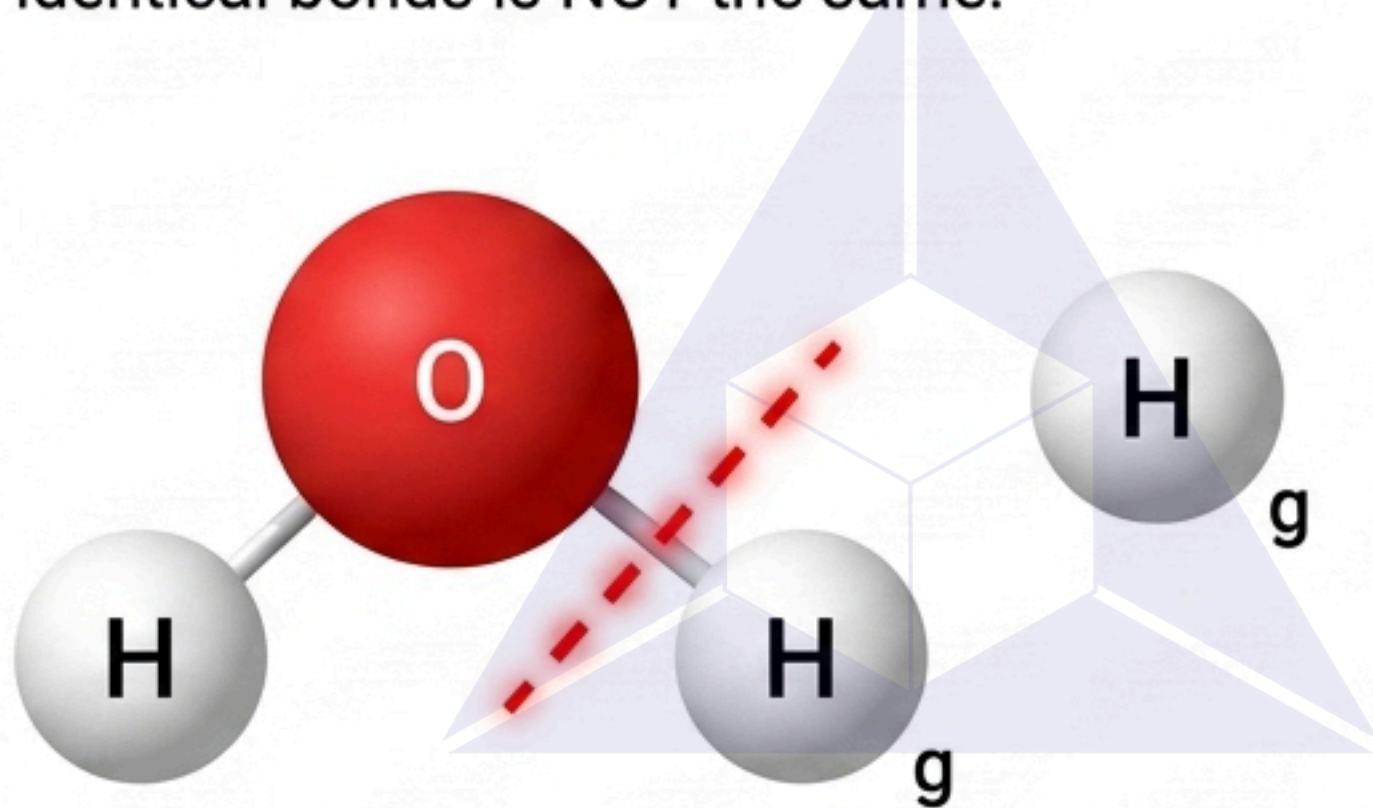
Bond Order: 3

One of the highest for a diatomic molecule

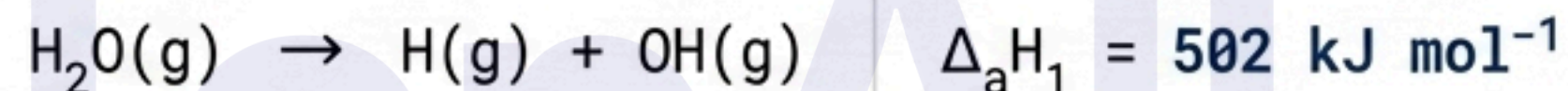
As bond order increases from 1 (H₂) to 2 (O₂) to 3 (N₂), the required bond enthalpy significantly increases.

The Water (H₂O) Dilemma

In polyatomic molecules, measuring bond strength is complicated. The energy required to break visually identical bonds is NOT the same.



Step 1 (Breaking the first O-H bond):



Step 2 (Breaking the second O-H bond):



Why the difference?

The second O-H bond undergoes a change because of a **changed chemical environment**. An **OH radical behaves thermodynamically differently** than an H₂O molecule.

Average Bond Enthalpy

Because the energy of the same bond type (e.g., O-H) varies in different molecules (water vs. ethanol) or even within the same molecule, we rely on a calculated average.

$$\text{Average Enthalpy} = \text{Total Bond Dissociation Enthalpy} / \text{Number of Bonds Broken}$$

Applying to the H₂O data:

$$\begin{aligned}\text{Average O-H Bond Enthalpy} &= (502 + 427) / 2 \\ &= 929 / 2 \\ &= 464.5 \text{ kJ mol}^{-1}\end{aligned}$$

Exam Note: When textbook tables list the 'O-H' bond enthalpy, they are providing this exact averaged value.

H1: The Golden Rule Of Bond Strength

Bond Order
(UP)



Bond Enthalpy
(UP)



Bond Length
(DOWN)

**Larger bond dissociation enthalpy =
Stronger bond in the molecule.**

1. Definition: Energy to break 1 mole of bonds (strictly gaseous state).

2. Diatomic: Values are specific to the exact molecule (e.g., H_2 , O_2 , N_2 , HCl).

3. Polyatomic: Uses Average Bond Enthalpy due to shifting chemical environments.

4. Correlation: Stronger bond = higher bond enthalpy.



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