**Heat of Dilution**

[CdSO₄ solution] → add water H₂O, more heat absorbed

\[ \text{very rare} \quad \text{T} \text{H}_2\text{O} \downarrow \]

[CdSO₄ solution] → add water H₂O, more heat released

\( \Delta H \text{rxn} \) conc. acid \( \rho \) H₂SO₄

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**Bond Energy** (Chapter 9)

- Bond breaking is **endothermic**
- Bond formation is **exothermic**

\[ \Delta H_{\text{rxn}} = \Sigma \text{BE}_{\text{reactants}} - \Sigma \text{BE}_{\text{products}} \]

\[ = \Sigma \text{BE}_{\text{broken}} + \Sigma \text{BE}_{\text{formed}} \]

**AP 2001**

\[ 2 \text{NO} + \text{O}_2 \rightarrow 2 \text{NO}_2 \quad \Delta H_{\text{rxn}} = -114.1 \text{ kJ/mol} \]

given

\[ \begin{array}{c}
N=0 \\
N=0 \\
O=0 \\
O=0 \\
\end{array} \]

\[ \begin{array}{c}
\Delta H_{\text{NO}} \\
\Delta H_{\text{NO}} \\
\Delta H_{\text{O}_2} \\
\Delta H_{\text{O}_2} \\
\end{array} \]

\[ \Delta H_{\text{rxn}} = \left[ 2(N=0) + O=0 \right] - [4N=0] \]
**Heat of Dilution**

(+) \( \Delta H_{\text{soln}} \) \( \rightarrow \) add more \( H_2O \), more heat absorbed

\( \rightarrow \) may see \( +H_2O \)

(-) \( \Delta H_{\text{soln}} \) \( \rightarrow \) add more \( H_2O \), more heat released

* conc. acids, e.g. \( H_2SO_4 \)

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**Bond Energy** (chapter 9)

- Bond Breaking is **Endothermic**
- Bond Formation is **Exothermic**

\[
\Delta H_{\text{rxn}} = \sum \text{BE}_{\text{Reactants}} - \sum \text{BE}_{\text{Products}}
\]

\[
= \sum \text{BE}_{\text{broken}} + \sum \text{BE}_{\text{formed}}
\]

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**AP 2001**

\[ 2 \text{NO} + O_2 \rightarrow 2 \text{NO}_2 \]

\( \Delta H_{\text{rxn}} = -114.1 \text{ kJ/mol} \)

Given:

- \( N=0 \)
- \( N=0 \)
- \( O=0 \)
- \( O=0 \)
- \( O=0 \)

\( \Delta \text{H}_{\text{rxn}} = [2(N=0) + O=0] - [4N=O] \)
Thermodynamics \( \rightarrow \) the interconversion of heat with other types of energy

"State" of the system \( \rightarrow T, P, V, E, \) internal composition

State function \( \rightarrow \) change in 1 or more of path independent

\[ q + w \Rightarrow \text{are NOT state functions} \]

1st Law of Thermodynamics
"Conservation of Energy"

\[ \boxed{\Delta E_{\text{system}} + \Delta E_{\text{surroundings}} = 0} \]

\( \Delta E = q + w \rightarrow \) work

\( \text{heat} \)

**Sign convention**

Endothermic \( q^+ \) \( q > 0 \) \( E \) is added to the system

Exothermic \( q^- \) \( q < 0 \)

System does work on the surroundings \( W^- \)
Surroundings do work on the system \( W^+ \)

Work = Force \( \times \) Distance

for a gas changing volume \( W = \Theta P \Delta V \)

Surroundings push \( W^+ \) on the system (compression) \( \Delta V = (-) \)
System pushes out against the surroundings \( \Delta V = (+) \) (expander)
Work = -PΔV ⇒ \[ \text{work} = \text{mass} \times \frac{L}{101.3} \Rightarrow J \]

\[ P = \frac{\text{force}}{\text{area}} = \frac{N}{m^2} = 1 \text{ N/m}^2 = 1 \text{ J} \]

**Example**

Reactant produces a gas

reactant volume = \( \Delta V \) ⇒ \( \Delta V \) ⇒ V of gas produced

\[ P_{\text{air}} = 0.95 \text{ atm} \; \; \; V = 3.00 \text{ L} \; \; \; W = ? \]

\[ W = 0\left(0.95 \text{ atm}\right)\left(3.00 \text{ L}\right) \times 101.3 = 0 \text{ J} \]

**Whenever a reaction results in a net increase in volume of gas, the system does work on the surroundings (Expansion)**

If \( P_{\text{external}} \) is constant (open air)

\[ \Delta H = \Delta E + P\Delta V \]

\[ \Delta E = \Delta H - P\Delta V \quad (\Delta E = q+w) \]

\[ \Delta E = \Delta H - \Delta U_{\text{ext}} \]

\[ \Delta E = \Delta H - RT \Delta U \]

**Constant volume (Bomb calorimeter)**

\[ W = -P\Delta V \; \; \Delta V = 0 \]

\[ W = 0 \]

\[ \Delta E = q + w = q \]