


# Standard Enthalpies of Formation and Calculating Enthalpy of Reaction ( $\Delta H_{\text{rxn}}^0$ )

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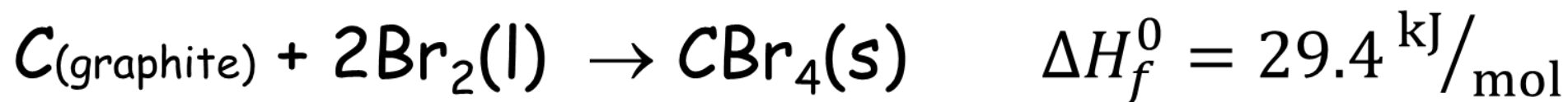
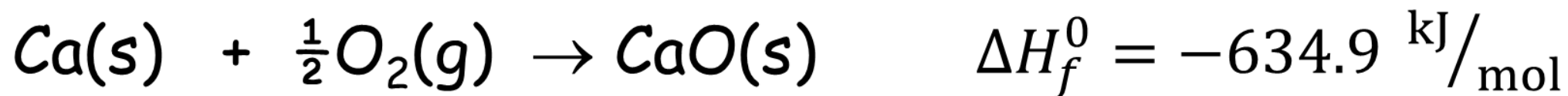
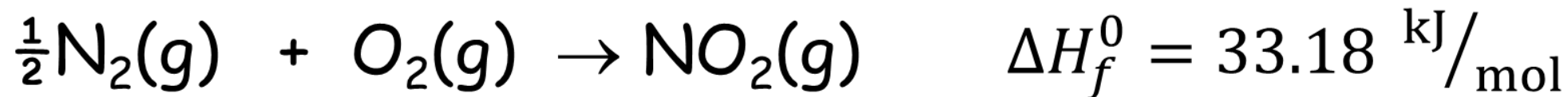



# Standard Enthalpy of Formation ( $\Delta H_f^0$ )

□ Standard Enthalpies of formation ( $\Delta H_f^0$ ) are defined as the enthalpy change for the formation of one mole of a given compound from its constituent elements in their standard states.

# Standard Enthalpy of Formation ( $\Delta H_f^0$ )

## Examples:





# Standard Enthalpy of Formation ( $\Delta H_f^0$ )

□ Standard Enthalpies of formation ( $\Delta H_f^0$ ) are tabulated at 298 K (usually) and 1 atm.

They are compiled in huge tables of thermodynamic quantities.

# Examples of Standard Enthalpies of Formation ( $\Delta H_f^0$ ) in a Table

□ An example is given below.

Substance	$\Delta H_f^0$ (kJ/mol)	$\Delta G_f^0$ (kJ/mol)	$S^0$ (J/mol K)
Aluminum:			
Al(s)	0.0	0.0	28.3
Al(g)	330.0	289.4	164.6
AlCl <sub>3</sub> (s)	-704.2	-628.8	109.3
Al <sub>2</sub> O <sub>3</sub> (s)	-1675.7	-1582.3	50.9

Here is the column that provides  $\Delta H_f^0$  values (in kJ/mol).

## Standard Enthalpies of Formation ( $\Delta H_f^0$ ) for Elements in their Standard States

□ Standard Enthalpies of formation ( $\Delta H_f^0$ ) for pure elements in their standard states are **assigned zero**. ( $\Delta H_f^0 = 0$ )

Examples:

$$\Delta H_f^0(\text{O}_2(\text{g})) = 0$$

$$\Delta H_f^0(\text{Al}(\text{s})) = 0$$

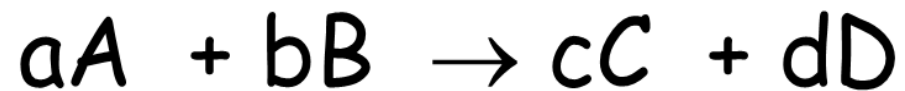
$$\Delta H_f^0(\text{Fe}(\text{s})) = 0$$

$$\Delta H_f^0(\text{C}(\text{s, graphite})) = 0$$

# Calculating $\Delta H_{\text{rxn}}^0$ ( $\Delta H_{\text{rxn}}$ ) Using Std Enthalpies of Formation ( $\Delta H_f^0$ )

□ We can calculate  $\Delta H_{\text{rxn}}^0$  (i.e.,  $\Delta H_{\text{rxn}}$ ) from these tabulated enthalpies of formation ( $\Delta H_f^0$ )

For the reaction



$$\Delta H_{\text{rxn}}^0 = c \left( \Delta H_f^0(\text{C}) \right) + d \left( \Delta H_f^0(\text{D}) \right) - \left[ a \left( \Delta H_f^0(\text{A}) \right) + b \left( \Delta H_f^0(\text{B}) \right) \right]$$



## Calculating $\Delta H_{\text{rxn}}^0$ ( $\Delta H_{\text{rxn}}$ ) Using Std Enthalpies of Formation ( $\Delta H_f^0$ )

Another way to write the equation:

For the reaction  $aA + bB \rightarrow cC + dD$

$$\Delta H_{\text{rxn}}^0 = \sum n_p \Delta H_f^0(\text{products}) - \sum n_r \Delta H_f^0(\text{reactants})$$

$$\Delta H_{\text{rxn}}^0 = c \left( \Delta H_f^0(\text{C}) \right) + d \left( \Delta H_f^0(\text{D}) \right) - \left[ a \left( \Delta H_f^0(\text{A}) \right) + b \left( \Delta H_f^0(\text{B}) \right) \right]$$



## Example: Calculate $\Delta H_{\text{rxn}}^0$ ( $\Delta H_{\text{rxn}}$ ) Using Std Enthalpies of Formation ( $\Delta H_f^0$ )

□ For the reaction  $\text{N}_2\text{O}_4(\text{g}) \rightarrow 2\text{NO}_2(\text{g})$

The following data was found in the table:

$$\Delta H_f^0(\text{N}_2\text{O}_4(\text{g})) = 9.16 \text{ kJ/mol}$$

$$\Delta H_f^0(\text{NO}_2(\text{g})) = 33.18 \text{ kJ/mol}$$

**Calculate  $\Delta H_{\text{rxn}}^0$  using these values for the given reaction.**

## Example: Calculate $\Delta H_{\text{rxn}}^0$ ( $\Delta H_{\text{rxn}}$ ) Using Std Enthalpies of Formation ( $\Delta H_f^0$ )

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**Use the equation:**

$$\Delta H_{\text{rxn}}^0 = \sum n_p \Delta H_f^0(\text{products}) - \sum n_r \Delta H_f^0(\text{reactants})$$

## Example: Calculate $\Delta H_{\text{rxn}}^0$ ( $\Delta H_{\text{rxn}}$ ) Using Std Enthalpies of Formation ( $\Delta H_f^0$ )

□ For the reaction  $\text{N}_2\text{O}_4(\text{g}) \rightarrow 2\text{NO}_2(\text{g})$

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**Fill in the appropriate quantities:**

$$\Delta H_{\text{rxn}}^0 = 2 \left( \Delta H_f^0(\text{NO}_2(\text{g})) \right) - \left[ 1 \left( \Delta H_f^0(\text{N}_2\text{O}_4(\text{g})) \right) \right]$$

$$\Delta H_{\text{rxn}}^0 = 2(33.18) - [1(9.16)] = 57.2 \text{ kJ/mol}$$

**Endo or exothermic?**

More examples coming soon...

# What You Should Be Able to Do (so far)

□ Describe what standard enthalpies of formation ( $\Delta H_f^0$ ) are and how they are acquired.

Describe how standard enthalpies of formation ( $\Delta H_f^0$ ) can be used to calculate the standard enthalpy of reaction ( $\Delta H_{\text{rxn}}^0$ ).

Be able to use standard enthalpies of formation ( $\Delta H_f^0$ ) to calculate the std enthalpy of reaction ( $\Delta H_{\text{rxn}}^0$ ), often called ( $\Delta H_{\text{rxn}}$ ).

Determine whether enthalpy of reaction ( $\Delta H_{\text{rxn}}^0$ ) is exo- or endothermic from the sign of  $\Delta H$ .