Enthalpy of Formation (ΔH_f°)

Calculating Enthalpy Changes of Reactions from Heat of Formation

Standard enthalpy (heat) of formation (___ΔH_f°___): change in enthalpy that accompanies the formation of ___1___ mole of the compound in its standard state from its component ___elements___ their standard states.

Note: The naught, ___°___, simply indicates standard conditions (**1 atm** and **25°C**).

Examples

$C_{(s)} + 2\,H_{2(g)} \rightarrow CH_4(g)$ $\quad \Delta H_f^\circ$ = -74.9 kJ/mol$_{rxn}$

$S_{(s)} + \frac{3}{2}\,O_{2(g)} \rightarrow SO_3(g)$ $\quad \Delta H_f^\circ$ = -396 kJ/mol$_{rxn}$

Note: you will see ___fractional___ coefficients to ensure only ___1___ mole of compound is formed.

The ΔH_f° for ___elements___ (in their standard state) is always ___∅___ kJ/mol$_{rxn}$!

Now you try! Write the formation reaction of NH_3: (liquid) $\frac{1}{2}N_{2(g)} + \frac{3}{2}H_{2(g)} \rightarrow NH_{3(\ell)}$

The ___enthalpy___ change for a chemical reaction, or amount of heat released or absorbed, can be determined by the following formula, which is known as Big Momma's Equation:

$$\Delta H_{rxn}^\circ = \Sigma\left[n\Delta H_f^\circ(products)\right] - \Sigma\left[n\Delta H_f^\circ(reactants)\right]$$] on F.C!

Example:

$CH_4(g) + 2\,O_2(g) \rightarrow CO_2(g) + 2\,H_2O(g)$

$\Delta H^\circ_{rxn} = \Delta H^\circ_{comb} = \left[\Delta H_f^\circ(CO_2) + 2\cdot\Delta H_f^\circ(H_2O)\right] - \left[\Delta H_f^\circ(CH_4) + 2(\emptyset)\right]$

Enthalpy Changes of Different Types of Reactions

You will encounter a variety of ___Subscripts___ following the ΔH, however, they are simply indicating a ___reaction___ type of reaction or change of state.

Examples

ΔH_{comb}°	= Enthalpy of Combustion	(Heat Energy Released during Combustion Reactions)
ΔH_{neut}°	= Enthalpy of Neutralization	(Heat Energy Released during Acid-Base Neutralization Reactions)
ΔH_{soln}°	= Enthalpy of Solution	(Heat Energy Released/Absorbed Dissolving a Solute in Water)
ΔH_{vap}°	= Enthalpy of Vaporization	(Heat Energy Absorbed to Convert from Liquid to Gas Phase)
ΔH_{fus}°	= Enthalpy of Fusion	(Heat Energy Absorbed to Convert from Solid to Liquid Phase)

Let's Practice!

1. For each reaction below, fill in the box with a subscript that specifies the type of reaction:

   a. $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$ $\Delta H_{\boxed{neut}}$ = −55.8 kJ/mol

   b. $H_2O(s) \rightarrow H_2O(l)$ $\Delta H_{\boxed{fus}}$ = +6.02 kJ/mol

   c. $CH_4(g) + 2\,O_2(g) \rightarrow CO_2(g) + 2\,H_2O(g)$ $\Delta H_{\boxed{comb}}$ = −80.52 kJ/mol

2. Circle each of the following which will have a standard heat of formation equal to zero.

   (H₂(g)), Hg(s), CO₂(g), H₂O(l), (Br₂(l)), N₂(l)

   Hg(s): not s @ room temp! N₂(l): not ℓ @ room temp!

3. Write a balanced molecular equation representing the enthalpy for standard heat of formation reaction of ethanol, $C_2H_5OH(l)$.

$$C_{(s)} + 3H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow C_2H_5OH_{(\ell)}$$

4. Use the information provided and the balanced equation to determine ΔH_f° of carbon tetrachloride.

$CH_4(g) + 4\,Cl_2(g) \rightarrow CCl_4(g) + 4\,HCl(g)$ $\quad \Delta H°_{rxn} = -389\ kJ/mol_{rxn}$

Substance	$\Delta H°_f$
$CH_4(g)$	−75 kJ/mol$_{rxn}$
$HCl(g)$	−92 kJ/mol$_{rxn}$

$$\Delta H°_{rxn} = -389\ \frac{kJ}{mol_{rxn}} = \sum n\Delta H_f^\circ(pr) - \sum n\Delta H_f^\circ(re)$$

$$= [CCl_4 + 4HCl] - [CH_4 + 4Cl_2]$$

$$= [CCl_4 - 4(-92)] - [-75 + 4(\emptyset)]$$

$$-389 = CCl_4 - 293 \Rightarrow \Delta H_f^\circ(CCl_4) = \boxed{-96\ kJ/mol_{rxn}}$$