Predicting ΔH_r Using Formation Reactions

The Standard Enthalpy Change (ΔH^o_r) for a reaction can be found by writing the formation equation and corresponding standard enthalpy change for each compound in the given equation and then applying Hess' Law.

Ex. $CaO_{(s)} + H_2O_{(l)} \longrightarrow Ca(OH)_{2(s)}$ $\Delta H_r = ?$

Step 1: Write formation equations (with standard enthalpy change) each compound in the given equation.

① $Ca_{(s)} + \frac{1}{2}O_{2(g)} \rightarrow CaO_{(s)}$ $\Delta H_f =$

② $H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(\ell)}$ $\Delta H_f =$

③ $Ca_{(s)} + O_{2(g)} + H_{2(g)} \rightarrow Ca(OH)_{2(s)}$ $\Delta H_f =$

Step 2: Apply Hess's Law

Rev ①

④ $CaO_{(s)} \rightarrow Ca_{(s)} + \frac{1}{2}O_{2(g)}$

Rev ②

⑤ $H_2O_{(\ell)} \rightarrow H_{2(g)} + \frac{1}{2}O_{2(g)}$

Enthalpies of Formation to Predict ΔH_r

$$\Delta H_r = \Delta H_f + (-\Delta H_f) + (-\Delta H_f)$$

$Ca(OH)_2$ product; CaO reactant; H_2O reactant

$$\Delta H_r = \Delta H_f - (\Delta H_f + \Delta H_f)$$

$Ca(OH)_2$ CaO H_2O

$$\Delta H_r = \Delta H_{fp} - \Delta H_{fr}$$

products reactants

$$\Delta H_r = \Sigma n H_{fp} - \Sigma n H_{fr}$$

knowing that $\Delta H = nH$

Ex. What is the standard molar enthalpy of combustion of methane fuel?

$$CH_{4(g)} + 2O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(g)}$$

$\Delta H_r = ?$

$\Delta H_r = \Sigma n H_{fP} - \Sigma n H_{fr}$

$\Delta H_r = \left[(1\,mol)\left(-393.5\frac{kJ}{mol}\right)_{CO_{2(g)}} + (2\,mol)\left(-241.8\frac{kJ}{mol}\right)_{H_2O_{(g)}}\right] - \left[(1\,mol)\left(-74.4\frac{kJ}{mol}\right)_{CH_4} + (2\,mol)\left(0\frac{kJ}{mol}\right)_{O_2}\right]$

$\Delta H_r = (-877.1\,kJ) - (-74.4\,kJ)$

$\Delta H_r = -802.7\,kJ$

$\Delta H_r = n H_r$

$H_r = \frac{\Delta H_r}{n} = \frac{-802.7\,kJ}{1\,mol} = \boxed{-802.7\frac{kJ}{mol}}$

Homework

Worksheet

Thermal Stability

Thermal Stability - the tendency of a compound to resist decomposition when heated.

- the more endothermic the simple decomposition (sd), the more stable the compound.

Ex. $H^o_{(sd)}$ = + 280.7 kJ/mol
SnO

$H^o_{(sd)}$ = + 577.6 kJ/mol
SnO_2

Therefore ' is more stable.

*Normally not given the H_{sd}, but given the H_f

Which is more stable, ammonia or butane?