

## 15.4 HESS'S LAW AND ENTHALPY OF FORMATION [15.4]

A third method used to determine enthalpies of reaction is the standard enthalpy of formation.

Others are calorimetry and Hess's law.

For example, the formation equation and the standard enthalpy of formation of carbon dioxide are:  
 $C(s) + O_2(g) \rightarrow CO_2(g) \quad \Delta H_f^\circ = -393.5 \text{ kJ/mol}$

Steps for writing Formation Equations:

1. Write one mole of product in the state that has been specified
2. Write the reactant elements in their standard states
3. Choose reaction coefficients for the reactants to give a balanced equation yielding one mole of product.

Example 1:

Write the equation for formation of liquid ethanol

1. Start with one mole of product:



2. Write the reactant elements in their standard states:



3. Balance the equation to yield one mole of product.



Example 2:

What is the formation equation for liquid carbonic acid?



Solution:



Example 3:



$\Delta H_f^\circ$  is always for 1 mole of the product being formed

In general  $\Delta H_f^\circ = (\Delta H_f^\circ \text{ compounds formed}) - (\Delta H_f^\circ \text{ element}_1 + \Delta H_f^\circ \text{ element}_2 + \dots + \Delta H_f^\circ)$

ENTHALPY OF REACTION:  $\Delta H_r^\circ$

is equal to the difference between the sum of enthalpies of the formation of products and that of the reactants.

$\Delta H_r^\circ = \text{enthalpy of Product} - \text{enthalpy of Reactants}$

$$\Delta H_r^\circ = \sum \Delta H_f^\circ \text{ Products} - \sum \Delta H_f^\circ \text{ Reactants}$$



$$\Delta H_r^\circ = [c\Delta H_f^\circ(D) + d\Delta H_f^\circ(E)] - [a\Delta H_f^\circ(A) + b\Delta H_f^\circ(B)]$$

Try the examples.

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