Enthalpy of Reaction (Examples)

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Example 1

Calculate the standard heat of reaction at 25°C and l atm pressure of

$$3FeO\ (s) + 2Al\ (s) \rightarrow Al_2O_3\ (s) + 3Fe\ (s)$$

in terms of per mole of Al2O3 formed, per mole of Fe formed, per mole of FeO reacted, per mole of Al reacted and per gram of Fe formed.

Given that:

$\Delta H^\circ_{298,\ \mathrm{FeO\ (s)}}$ = - 6 3.3 kcal/mole

$\Delta H^\circ_{298,\ \mathrm{Al2O3\ (s)}}$ = - 400 kcal/mole

Atomic mass of Fe = 56 g/mole

Example 2

Calculate the standard heat of formation of solid WO_3 from solid W and O_2 gas at 25°C *(298 K)* and 1 atm pressure from the following data at 25°C and 1 atm pressure:

$W(s) + O_2(g) \rightarrow WO_2(s)$, $\Delta H^\circ_{298} = -134$ kcal

$3WO_2(s) + O_2(g) \rightarrow W_3O_8(s)$, $\Delta H^\circ_{298} = -131.5$ kcal

$W_3O_8(s) + \frac{1}{2}O_2(g) \rightarrow 3WO_3(s)$, $\Delta H^\circ_{298} = -66.5$ kcal

Example 3

Calculate the standard heat of formation of PbO from Pb and O_2 at 227°C from the following data:

$\boldsymbol{\Delta H^\circ}_{298,\ \mathrm{PbO\ (s)}} = -219.24$ kJ/mole

$\boldsymbol{C}_{p,PbO\ \mathrm{(s)}} = 44.35 + 16.74 \times 10^{-3}\ T$ J/K.mole

$\boldsymbol{C}_{p,Pb\ \mathrm{(s)}} = 23.56 + 9.75 \times 10^{-3}\ T$ J/K.mole

$\boldsymbol{C}_{p,O2\ \mathrm{(g)}} = 29.96 + 4.184 \times 10^{-3}\ T - 1.67 \times 10^{5}\ T^{-2}$ J/K.mole

Example 4

Calculate the standard heat of formation of solid PbO from liquid Pb and 0_2 gas at 527°C. The melting point of lead is 327°C and its latent heat of fusion is 4.81 kJ/mole.

$C_{p,Pb\ (l)} = 32.43 - 3.1 \times 10^{-3}\ T$ J/K. mole

Use other data as given in the previous example.

Maximum Reaction Temperature : Flame Temperature

- It is possible to consider a reaction taking place under adiabatic conditions so that no heat enters or leaves the system.
- For a constant pressure, this means that the enthalpy change will be zero.
- In such a reaction, the temperature of the system will change, so that the products will be at a different temperature from that of the reactants.

- If the enthalpy change is positive, i.e. heat is absorbed, the temperature of the adiabatic system will fall.
- Incase the enthalpy change is negative, the temperature will rise during the course of the reaction.
- From a knowledge of heat of reaction and the variation of the heat capacities of the reactants and products with temperature, it is possible to calculate the final temperature of the system.
- Such a type of treatment is useful in calculating the maximum flame temperature in connection with the combustion of fuels.
- Assuming that the process is adiabatic, the combustion of a fuel can be represented as

Fuel + Oxidant (at 298 K) → Combustion products (at a *very* high temperature, say T_m)

However, the above reaction may be performed in two imaginary steps, i.e.

(1) Fuel + Oxidant (at 298 K) → Combustion products (at 298 K).

(2) Combustion products (at 298 K) → Combustion products (at T_m)

The reaction represented in step (1) will be always exothermic. The available thermal energy is then used to heat up the combustion products from 298 K to their final temperature T_m . Using Kirchhoff's equation

$$q = \int_{298}^{T_m} \Sigma C_{P,\mathrm{product}} \, dT,$$

where q is the heat evolved in step (1) which can be found out from the standard enthalpy change value

Example 5

The combustion of acetylene fuel with nitrous oxide as oxidant at 25°C *(298 K)* is widely performed in flame emission spectrophotometry. Calculate the maximum temperature attained if the best mixture corresponds to the reaction

$$C_2H_2\ (g) + 3N_2O\ (g) \rightarrow 2CO\ (g) + H_2O\ (g) + 3N_2\ (g)$$

$\Delta H^\circ_{298,\ \mathrm{C2H2\ (g)}} = 54.23$ kcal/mole

$\Delta H^\circ_{298,\ \mathrm{N2O\ (g)}} = 19.7$ kcal/mole

$\Delta H^\circ_{298,\ \mathrm{CO\ (g)}} = -\ 26.42$ kcal/mole

$\Delta H^\circ_{298,\ \mathrm{H2O\ (g)}} = -\ 57.8$ kcal/mole

$C_{p,CO\,\mathrm{(g)}} = 6.8 + 1 \times 10^{-3}\ T - 0.11 \times 10^{5}\ T^{-2}$ cal/deg.mole

$C_{p,H2O\,\mathrm{(g)}} = 7.17 + 2.56 \times 10^{-3}\ T + 0.08 \times 10^{5}\ T^{-2}$ cal/deg.mole

$C_{p,N2\,\mathrm{(g)}} = 6.5 + 1 \times 10^{-3}\ T$ cal/deg.mole