

# **Enthalpy of Reaction (Examples)**

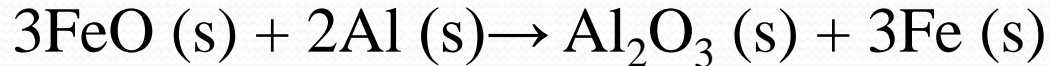
**By**

**Assist. Prof.**

**Dr. Kadhum Muttar**

# Example 1

Calculate the standard heat of reaction at 25°C and 1 atm pressure of



in terms of per mole of Al<sub>2</sub>O<sub>3</sub> formed, per mole of Fe formed, per mole of FeO reacted, per mole of Al reacted and per gram of Fe formed.

Given that:

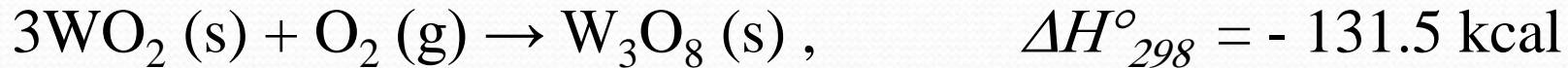
$$\Delta H^\circ_{298, \text{FeO (s)}} = - 63.3 \text{ kcal/mole}$$

$$\Delta H^\circ_{298, \text{Al}_2\text{O}_3 \text{ (s)}} = - 400 \text{ kcal/mole}$$

$$\text{Atomic mass of Fe} = 56 \text{ g/mole}$$

## Example 2

Calculate the standard heat of formation of solid  $\text{WO}_3$  from solid W and  $\text{O}_2$  gas at  $25^\circ\text{C}$  ( $298\text{ K}$ ) and 1 atm pressure from the following data at  $25^\circ\text{C}$  and 1 atm pressure:



## Example 3

Calculate the standard heat of formation of  $\text{PbO}$  from  $\text{Pb}$  and  $\text{O}_2$  at  $227^\circ\text{C}$  from the following data:

$$\Delta H^\circ_{298, \text{PbO (s)}} = - 219.24 \text{ kJ/mole}$$

$$C_{p, \text{PbO (s)}} = 44.35 + 16.74 \times 10^{-3} T \quad \text{J/K.mole}$$

$$C_{p, \text{Pb (s)}} = 23.56 + 9.75 \times 10^{-3} T \quad \text{J/K.mole}$$

$$C_{p, \text{O}_2 \text{ (g)}} = 29.96 + 4.184 \times 10^{-3} T - 1.67 \times 10^5 T^{-2} \quad \text{J/K.mole}$$

## Example 4

Calculate the standard heat of formation of solid PbO from liquid Pb and O<sub>2</sub> gas at 527°C. The melting point of lead is 327°C and its latent heat of fusion is 4.81 kJ/mole.

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

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.
- In case 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)  $\rightarrow$  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)  $\rightarrow$  Combustion products (at 298 K).

(2) Combustion products (at 298 K)  $\rightarrow$  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

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

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



$$\Delta H^\circ_{298, \text{C}_2\text{H}_2 (\text{g})} = 54.23 \text{ kcal/mole}$$

$$\Delta H^\circ_{298, \text{N}_2\text{O} (\text{g})} = 19.7 \text{ kcal/mole}$$

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

$$\Delta H^\circ_{298, \text{H}_2\text{O} (\text{g})} = - 57.8 \text{ kcal/mole}$$

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

$$C_{p, \text{H}_2\text{O} (\text{g})} = 7.17 + 2.56 \times 10^{-3} T + 0.08 \times 10^5 T^{-2} \quad \text{cal/deg.mole}$$

$$C_{p, \text{N}_2 (\text{g})} = 6.5 + 1 \times 10^{-3} T \quad \text{cal/deg.mole}$$