

## 11.6: Adiabatic Flame Temperature

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With a few simple approximations, we can estimate the temperature of a flame formed in a flowing gas mixture of oxygen or air and a fuel. We treat a moving segment of the gas mixture as a closed system in which the temperature increases as combustion takes place. We assume that the reaction occurs at a constant pressure equal to the standard pressure, and that the process is adiabatic and the gas is an ideal-gas mixture.

The principle of the calculation is similar to that used for a constant-pressure calorimeter as explained by the paths shown in Fig. 11.11. When the combustion reaction in the segment of gas reaches reaction equilibrium, the advancement has changed by  $\Delta\xi$  and the temperature has increased from  $T_1$  to  $T_2$ . Because the reaction is assumed to be adiabatic at constant pressure,  $\Delta H(\text{expt})$  is zero. Therefore, the sum of  $\Delta H(\text{rxn}, T_1)$  and  $\Delta H(\text{P})$  is zero, and we can write

$$\Delta\xi\Delta_c H^\circ(T_1) + \int_{T_1}^{T_2} C_p(\text{P}) dT = 0 \quad (11.6.1)$$

where  $\Delta_c H^\circ(T_1)$  is the standard molar enthalpy of combustion at the initial temperature, and  $C_p(\text{P})$  is the heat capacity at constant pressure of the product mixture.

The value of  $T_2$  that satisfies Eq. 11.6.1 is the *estimated* flame temperature. Problem 11.9 presents an application of this calculation. Several factors cause the actual temperature in a flame to be lower: the process is never completely adiabatic, and in the high temperature of the flame there may be product dissociation and other reactions in addition to the main combustion reaction.

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