High temperature gases can be produced in different ways, for example, by an isentropic compression, by an adiabatic compression in shocks, by combustion, by electrical means or by thermo-nuclear reaction, etc. For calculating the temperature generated by combustion, in general, one has to proceed in two steps. First, one has to calculate, at given pressure for combustion, the specific enthalpy per unit mass of the reacting components before combustion, and also of the equilibrium composition after combustion as a function of temperature. In an adiabatic combustion, the specific enthalpy of the product must be the same (provided the specific enthalpy is absolute, that is it includes the heat of reaction as its part) as that of the initial reacting components, and this allows determination of the temperature after reaction. As an example, the stoichiometric reaction of carbon monoxide with oxygen is taken, for which, in Fig. 9.1, the equilibrium composition (mole fraction) and in Fig. 9.2 the enthalpy are plotted against the temperature for different pressures. Before combustion, the ideal gas mixture is not dependent on pressure, and it gives in the latter figure a single line. After the combustion, however, the equilibrium composition is dependent on pressure. To find the adiabatic flame temperature, first the enthalpy of the gas mixture before combustion is found, and then only one has to move to the right at constant enthalpy. Thus for the reaction of the stoichiometric mixture of the carbon monoxide and oxygen, initially at room temperature of 300 K, the adiabatic flame temperature after reaction at pressures of $10^{-2}$, 1 and $10^2$ bar are 2,780 K, 3,210 K and 3,240 K, respectively. Thus the effect of higher dissociation is to reduce the adiabatic flame temperature. At the same time it is noted that at high pressures, an increase in the pressure does not lower the adiabatic flame temperature proportionately.

We shall now examine the range of temperatures that can be reached by an isentropic compression. As an example, nitrogen is taken whose specific heat ratio at around the room temperature is $\gamma = 1.4$. In the range of temperatures, in which the value of $\gamma$ remains essentially constant and equal to 1.4, the temperature ratio $(T_2/T_1)$ is dependent only on the pressure ratio $(p_2/p_1)$, both of which are linked by the relation

$$\frac{T_2}{T_1} = \left(\frac{p_2}{p_1}\right)^{(\gamma-1)/\gamma}. \quad (9.1)$$
Since, however, at higher temperatures the gases dissociate, it is necessary to consider the initial state \( (p_1, T_1) \). Keeping \( p_1 = 10^{-2} \) bar and for two different initial temperatures of \( 10^3 \) and \( 10^4 \) K, the compression ratio for nitrogen is plotted against the temperature ratio, and are shown in Fig. 9.3. It may be noted from the figure that for a compression ratio of 100, if \( T_1 = 300, 1000 \) and 10000 K, the respective temperature after compression of nitrogen with real gas properties (\( \gamma \) is not constant) are 1122, 2800 and 13600 K. Calculation of this and other processes can be studied best with the help of thermodynamic charts, as has been described for air plasma in the next section.