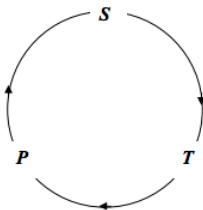


15.2: Adiabatic Decompression

We are going to calculate an expression for $(\partial T / \partial P)_S$. The expression will be positive, since T and P increase together. We shall consider the entropy as a function of temperature and pressure, and, with the variables



we shall start with the cyclic relation

$$\left(\frac{\partial S}{\partial T}\right)_P \left(\frac{\partial T}{\partial P}\right)_S \left(\frac{\partial P}{\partial S}\right)_T = -1. \quad (15.2.1)$$

The middle term is the one we want. Let's find expressions for the first and third partial derivatives in terms of things that we can measure.

In a reversible process $dS = dQ/T$, and, in an isobaric process, $dQ = C_P dT$. Therefore

$$\left(\frac{\partial S}{\partial T}\right)_P = \frac{C_P}{T}. \quad (15.2.2)$$

Also, we have a Maxwell relation (Equation 12.6.16). $\left(\frac{\partial S}{\partial P}\right)_T = -\left(\frac{\partial V}{\partial T}\right)_P$. Thus Equation 15.2.1 becomes

$$\left(\frac{\partial T}{\partial P}\right)_S = \frac{T}{C_P} \left(\frac{\partial V}{\partial T}\right)_P. \quad (15.2.3)$$

Check the dimensions of this. Note also that C_P can be total, specific or molar, provided that V is correspondingly total, specific or molar. $(\partial T / \partial P)_S$ is, of course, intensive.

If the gas is an ideal gas, the equation of state is $PV = RT$, so that

$$\left(\frac{\partial V}{\partial T}\right)_P = \frac{R}{P} = \frac{V}{T}. \quad (15.2.4)$$

Equation 15.2.3 therefore becomes

$$\left(\frac{\partial T}{\partial P}\right)_S = \frac{V}{C_P}. \quad (15.2.5)$$

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