following sections we reinforce this general technique by applying it to other modes. Before we continue, however, we will use the present results to establish *the conditions for which the indistinguishable limit is satisfied.*

Our procedure in this unit is to apply the Boltzmann distribution to indistinguishable Bosons and Fermions. Thus the results are limited by the indistinguishable limit, $n_j^{il} = n_j^{MB}$. The limit was introduced in Sect. I as corresponding to those conditions for which no state is densely populated, $n_j << g_j$. Our development of Z_{tr} and its consequent equation of state, $p\bar{v} = \bar{R}T$ (or $p = n_v kT$ where $n_v = N/V = N_A/\bar{v}$), allows this vague criterion to be written explicitly in terms of the physical state of the gas. This result is developed in Appendix IIIC-A, Exmp. A1. The resulting condition is

$$\left.\frac{n_j}{g_j}\right|_{max} = n_v\left(\frac{h^2}{2\pi m^* kT}\right)^{3/2} = \frac{p}{(kT)^{5/2}}\left(\frac{h^2}{2\pi m^*}\right)^{3/2} \overset{?}{<<} 1 \qquad \text{(IIIC-15)}$$

This relationship is the test of the indistinguishable limit. To develop a feel for the limits it imposes, consider the following illustrations.

Example 6. Nitrogen is the principal constituent in air. Does N_2 satisfy the indistinguishable limit at STP? At its normal boiling point, 77 K?

The answer to both of these queries is provided by substituting into eqn. IIIC-15. At STP

$$\left.\frac{n_j}{g_j}\right|_{max} \simeq \frac{1.013 \cdot 10^5 N/m^2}{[1.38 \cdot 10^{-23} J/(part\ K) \cdot 300\ K]^{5/2}}$$

$$\cdot \left[\frac{(6.625 \cdot 10^{-34} Js/part)^2}{2\pi \cdot 28.01\ kg/(kg\ mol)\ /6.023 \cdot 10^{26} part/(kg\ mol)}\right]^{3/2} = 1.69 \cdot 10^{-7} part/state << 1$$

And at $T_{NBP} = 77$ K, $p = 1$ atm, $n_j/g_j|_{max} \leq 5.06 \cdot 10^{-6}$ part/state << 1. Clearly N_2 is within the indistinguishable limit under both of these conditions.

Exmp. 6 shows that N_2 gas will not be encountered under conditions that do not satisfy the indistinguishable limit. Examining the criteria, we see that high pressure, low molecular weight, and especially low temperatures (5/2 exponent) tend to invalidate approximation IIIC-15.[8] Thus, the molecular gases that are most likely to violate the criteria are those of lowest boiling temperature.

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[8]The indistinguishable limit is separate from the independent particle, perfect gas limit. But their parametric relationship to pressure and temperature is of the same form. Thus one frequently finds that when one limit is satisfied the other is satisfied also.

Ans. 2. $V = (h^2/8m^*\theta_{tr}k)^{3/2}$. Using $\theta_{tr} = 10^{-6}$K and $m^*_{H_2} = M_{H_2}/N_A = 3.32 \cdot 10^{-27}$kg/part, we find $V = 1.31 \cdot 10^{-18} m^3$. This corresponds to a cube whose sides are about 1 μm. To achieve higher values of θ_{tr} a smaller box would be required.