limit the net effect of spin on the combined partition function, $Z_{r,n}$, is division by a constant called the *symmetry number*, σ.[11] The symmetry number is equal to the number of indistinguishable molecular orientations that can be achieved through rotational transformations.

Thus, the combined rotation-nuclear spin partition function for all molecular types can be summarized in the very broad temperature range defined by $\theta_r << T << \theta_{ns}$.

Monatomic. The rare gases and most metallic vapors. In the absence of a molecular bond only nuclear spin moments are present.	$Z_{r,n} = 1$
Asymmetric Linear molecules include all *heteronuclear* diatomic molecules (e.g., CO, HCl, NaCl, etc.) and linear polyatomic molecules that are not symmetric about their centers of gravity. These particles have no indistinguishable molecular orientations. Their symmetry number is one, $\sigma = 1$.[12]	$Z_{r,n} = \frac{T}{\theta_r}$

[11]The results listed below are simplified by the omission of the nuclear degeneracy. In the temperature range of interest, $T << \theta_{ns}$, nuclear spin is unexcited and the partition function series is accurately represented by the first term. Further, the energy of the lowest nuclear (ground) level is zero. So the partition function of each nucleus is equal to its ground level degeneracy. The nuclear partition function for a molecule is $Z_{ns} = \prod_i g^\circ_{n,i}/\sigma$. This partition function is a constant at ordinary temperatures. It will not influence the value of any property determined by a derivative of Z. Only the magnitude of the entropy is dependent on constants in the partition function. Thus, both components of the nuclear partition function, g°_n and σ, can be omitted in the analysis of a given substance. But if the character of the molecule is altered, σ is necessary; and if the character of the nuclei are altered, g°_n is necessary. The results listed in the text are valid for chemical reactions but must be reformulated to include g°_n to be valid for nuclear reactions.

[12]Since there is no rotation-nuclear spin coupling in asymmetric linear molecules, the entire range of the rotational partition function series can be employed to determine properties. Application in the range $T/\theta_r > 1$ is simplified by an approximate representation of the exponential partition function series in polynomial form.

$$Z_{r,n} = \frac{T}{\theta_r}\left[1 + \frac{1}{3}\left(\frac{\theta_r}{T}\right) + \frac{1}{15}\left(\frac{\theta_r}{T}\right)^2 + \frac{4}{315}\left(\frac{\theta_r}{T}\right)^3 + \cdot + \cdot\right]$$

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Ans. 7. For oxygen at room temperature, $\theta_r/T = 2.09$ K/300 K $= 6.97 \cdot 10^{-3}$. This is certainly within the high-temperature limit. Thus, for the 1st level ($\ell = 0$)

$$\rho_r(0) = 6.97 \cdot 10^{-3} \cdot (1)e^{0 \cdot 6.97 \cdot 10^{-3}} = 0.697 \cdot 10^{-2}$$

2nd level ($\ell = 1$)

$$\rho_r(1) = 6.97 \cdot 10^{-3} \cdot (3)e^{-2 \cdot 6.97 \cdot 10^{-3}} = 2.06 \cdot 10^{-2}$$

Similarly, for the 10th level ($\ell = 9$) $\rho_r(9) = 7.07 \cdot 10^{-2}$ and the 100th level ($\ell = 99$), $\rho_r(99) = 1.49 \cdot 10^{-30}$.

Ans. 8. In oxygen at room temperature $T/\theta_r = 300$ K/2.09 K = 144. Thus, $\ell_{max} = (144/2)^{\frac{1}{2}} - 1/2 = 7.99$ or $\ell = 8$. This is the 9th level and its occupancy is $\rho(8) = \rho_{max} = 0.0717$.