21.7: Standard Entropies Depend Upon Molecular Mass and Structure

Entropy is related to the number of microstates a collection of particles can occupy. As both the molecular mass and molecular structure of the particles will affect the number of available microstates, they also affect the entropy of the collection of particles.

From quantum theory, we know that increasing the molecular mass of a particle decreases the energy spacing between states. For a given temperature, more states are available to be occupied, increasing the number of available microstates the system may occupy, and hence the entropy of the system. The table below shows the molar entropies for the noble gases. As the mass of increases, so does the molar entropy.

Noble Gas	He	Ne	Ar	Kr	Xe	Rn
Mass $\left(\frac{\text{g}}{\text{mol}}\right)$	4.0	20.2	39.9	84.8	131.3	222.0
$S^{\circ}_{g,1\text{ bar}}$ $\left(\frac{\text{J}}{\text{mol·K}}\right)$	126.15[1]	146.33[1]	154.84[1]	164.08[1]	169.68[1]	176.2[1]

The same is true for the number of atoms in a molecule. A molecule with more atoms will, in general, have a more degrees of freedom to take up energy, increasing its number of available microstates and entropy.

References

1. Chase, M.W., Jr., *NIST-JANAF Themochemical Tables, Fourth Edition*, **J. Phys. Chem. Ref. Data, Monograph 9**, 1998, 1-1951.