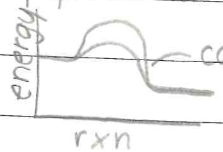
2. $S = k \ln W$ in which $k = 1.38 \cdot 10^{-23}$ J/K, W = # of microstates

Boltsmann's const.

3. Entropy is a state function

i. 

entropy is path independent

Third Law of Thermodynamics

The entropy of a pure crystalline substance at absolute 0 is zero

i. All motion stops at absolute zero

ii. Only 1 arrangement

Standard molar entropy (J/molK): all positive at 298 K

i. Gas molar entropy generally greater than liquids and solids

ii. Molar entropy increases with molecular complexity

Calculations

i. $\Delta S^\circ_{system} = \sum n \Delta S^\circ (prod) - \sum n \Delta S^\circ (react)$

a. $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

↳ $2(69.9) - [2(130.6) + 205.0]$ J/mK $= -327$ J/K

b. $2NO_2(g) \rightarrow 2NO(g) + O_2(g)$

↳ (2 mol NO (g) · 211 J/molK) + (1 mol O_2 · 205 J/molK) − (2 mol NO_2(g) · 240 J/molK

= +147 J/K

redicting Entropy

Entropy increases with freedom of motion

$S^\circ(g) > S^\circ(l) > S^\circ(s)$

ncreasing volume, increase S°

more microstates

ncreasing temperature, increase S°

Average kinetic energy increases, more microstates

4 Entropy increases with size and complexity
5 Entropy increases if
i # of moles increases
ii gas formation from liquids / solids
iii liquid formation from solids
Temperature and Spontaneity
1 Some endothermic processes are spontaneity
2 Entropy can be calculated as the heat transferred reversibly to the system at temperature T
i $\Delta S = \frac{q_{rev}}{T}$ if heat gained, $\Delta S = \frac{-q_{rev}}{T}$ if heat lost

Zeroth Law of Thermodynamics
1 Two bodies in contact reach thermal equilibrium, with heat flowing from the warmer to cooler object
2 If the system and surroundings have a very small temperature difference, then heat will flow from the warmer to cooler reversibly
i At constant pressure, $\Delta S_{surr} = \frac{-\Delta H_{rxn}}{T}$

ii What is ΔS for an ice cube melting at 0°C?
↳ $\Delta H_{fus} = 6.01\ kJ/mol$, 1.56 mol ice
$$\Delta S_{sy} = \frac{6.01 \frac{kJ}{mol} \cdot 1.56\ mol}{273K} = 34.3\ kJ/K$$

iii What is ΔS of the universe?
$\Delta S_{surr} = -34.3\ kJ/mol$, $\Delta S_{univ} = 0 \rightarrow$ reversible
iv. What is ΔS for ice cube melting at 25°C?
$\Delta S_{sy} = 34.3\ kJ/mol$ still!
$$\Delta S_{surr} = \frac{-6.01 \frac{kJ}{mol} \cdot 1.56\ mol}{298K} = -31.5\ kJ/K$$

$\Delta S_{univ} = 34.3 + (-31.5) = 2.8\ kJ/K$