Thermodynamics

States, Systems, Processes
Consider states and state processes in terms of the Ideal Gas Law:

\[ PV = nRT \]

- This would include considering pressure vs volume graphs
- Work would be calculated as area under the curve
- Adiabatic: \( P = C/V \)
- Isovolumetric: NA
- Isothermal: \( P = nRT/V \)

\[ \text{Adiabatic: } U = -W \]
\[ \text{Isothermal: } U = Q \]
\[ \text{Isovolumetric: } Q = -W \]

States are described by State Functions
Equilibrium usually measured at Standard conditions or Standard Temperature and Pressure (STP)

**Standard Conditions**: 298 K, 1 atm, 1 M concentrations
**STP**: 273 K, 1 atm
Conversion: \( K = ^\circ C + 273 \)
Equilibrium conditions will be tested on the MCAT

Phase Diagrams
Most relevant reactions will take place in standard conditions, so Standard enthalpy, entropy, and free energy values will be used

Terms to remember:
- Melting vs. Freezing (solid ↔ liquid)
- Sublimation vs Deposition (solid ↔ gas)
- Vaporization vs Condensation (liquid ↔ gas)

Heat, Enthalpy, Entropy, and Gibbs Free Energy

Heat (Q) - Think of it less as ‘temperature’ and more as the kinetic energy of molecules. Q>0, Q<0 means energy added or removed from system, respectively.

Temperature and heat are both related to the kinetic energy of a substance: heat is the exchange in energy between two substances at different temperatures.

- Heat measured using calorimetry

Convection: Movement in a fluid due to heat transfer, rising of high T fluid and sinking of low T fluid (gas too)

Conduction: Transfer of heat through direct contact

Radiation: Transfer of heat through electromagnetic waves; infrared radiation

Heating Curves—measuring the heat absorbed by a compound as its T rises (may include fusion, vaporization).

Enthalpy (ΔH) – Total heat of a compound

Usually considered with regards to the formation of chemical compounds or processes with a reaction mechanism. Standard enthalpies will be provided.

Entropy (ΔS) – Measure of disorder, but a more accurate definition is the measure of the dispersion of energy

- 2nd Law of Thermodynamics: Tot energy in a system never decreases, entropy is spontaneously maximized
- Reactions usually have positive entropy
- ΔS gases > ΔS liquids > ΔS solids

Gibbs Free Energy (ΔG) – For the MCAT, this is generally considered a measure of the ‘total energy’ in a system or product

Very important to determine the spontaneity of a reaction:

(+ ΔG means reaction is nonspontaneous
(−) ΔG means reaction is spontaneous

<table>
<thead>
<tr>
<th>ΔG</th>
<th>ΔH</th>
<th>ΔS</th>
<th>Spontaneous?</th>
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<tbody>
<tr>
<td>(+) at low T, (-) at high T</td>
<td>+</td>
<td>+</td>
<td>Yes, at high T</td>
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<tr>
<td>Always (-)</td>
<td>+</td>
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<td>Never</td>
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<tr>
<td>Always (+)</td>
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Key Takeaways: The MCAT tests understanding more than it tests the ability to plug and chug equations

Knowing units and strong dimensional analysis skills will make answering thermo questions a breeze! Many times, the questions and answers will have hints in the form of units or state functions used that will partially answer the question for you.