Thermodynamics

Zeroth Law of Thermodynamics

- If temp of A=temp of B & Temp of B= Temp of C then temp of A=temp of C
- **Temperature** is proportional to average kinetic energy.
- **Heat** refers to the transfer of thermal energy from something hot to something cold
- Kelvin Scales: absolute zero is the theoretical temperature where there is no thermal energy.
    - Third Law states that the entropy of a perfectly-organized crystal at absolute zero is zero.

$$F = \frac{9}{5}C + 32 \qquad K = C + 273$$

Thermal Expansion

- This equation is used for solids: $\Delta L = \propto L \Delta T$
- For liquids only meaningful parameter is the volume expansion: $\Delta V = \beta V \Delta T$
- The value of β is three times the coefficient of linear expansion ($\beta = 3 \propto$)

Systems

A system is the portion of the universe that we are interested in observing or manipulating. The rest is called **surroundings**.

- Isolated Systems: Not capable of exchanging energy or matter with their surroundings. Total change in internal energy must be zero.
- Closed Systems: Capable of exchanging energy, but not matter with the surroundings. E.g – gas in vessels with moveable pistons
- Open Systems: Can exchange both matter and energy with the environment.
- State Functions: thermodynamic properties are a function of only the current equilibrium state. These are defined by the fact that they are path independent.
    - E.g – Pressure, density, temperature, volume, enthalpy, internal energy, Gibbs free energy, and entropy
- Process Function: describe the path taken to get from one state to another
    - E.g. – Work and Heat

First law of Thermodynamics

Just another iteration of the energy conservation law (energy cannot be created or destroyed).

$$\Delta U = Q - W$$

Heat

- Second Law of Thermodynamics: objects in thermal contact and not in thermal equilibrium will exchange heat energy.
- Heat: defined as the process by which a quantity of energy is transferred between two objects as a result of difference in temperature.
    - Unit is Joule, but can also be in calories (c), nutritional calories (C), and British thermal unit (BTU).

- One calorie is the amount og heat required to raise 1g of water by 1 degrees

$$1\ Cal = 10^3 cal = 4184\ J = 3.97\ BTU$$

Heat Transfer

- Conduction: direct transfer of energy from molecule to molecule through molecular collisions.
  - Metals are the best conductors while gases are the worst
- Convection: transfer of heat by the physical motion of a fluid over a material. Only for liquids and gases since it needs the movement of a fluid.
- Radiation: transfer of energy by electromagnetic waves. Can transfer energy through a vacuum.

Specific Heat

- Specific heat of a substance is defined as the amount of heat energy required to raise one gram of a substance by one degree Celsius or one-unit kelvin.
  - Specific heat of water is $1\ \frac{\text{cal}}{\text{g}*\text{K}}$ or $4.184\ \frac{\text{J}}{\text{g}*\text{K}}$

$$q = mc\Delta T$$

Heat of Transformation

- Phase change occurs at a constant temperature since these changes are related to changes in potential energy and not kinetic energy.
- Increasing the temperature of a substance undergoing a phase change will increase the potential energy which permits a greater number of **microstates** (ability to move).

$$q = mL\ where\ L\ is\ the\ heat\ of\ transformaiton\ or\ latent\ heat$$

- Liquid to solid is **freezing/solidification**; solid to liquid is **melting/fusion** and it occurs at the melting point and heat of transformation is called the **heat of fusion.**
- Liquid to gas is **boiling/evaporation/vaporization**; gas to liquid is **condensation** and this occurs at the boiling point and heat of transformation is called the **heat of vaporization.**

Thermodynamic Processes

- Have three particular processes that are focused on **isothermal, adiabatic and isovolumetric**.
- Thermodynamic processes can be showed on a P-v or T-V diagram.

Second Law of Thermodynamics and Entropy

- Energy Dispersion: Energy goes from being concentrated to being spread out.
- Entropy is a measure of how spontaneous a reaction will be.

$$\Delta S = \frac{Q_{rev}}{T}$$

$$\Delta S_{Universe} = \Delta S_{System} + \Delta S_{Surroundings} > 0$$

- Naturally Process: Something that intuitively occurs
- Reversible Reaction: processes that can spontaneously reverse course. This only occurs when the system is always in equilibrium, as such an infinite time period would be needed.