May 25th, 2016

Pillip Lee

**CP317 – Physics Content Research: Statistical Mechanics**

* **Laws of Thermodynamics**
* **Zeroth Law of Thermodynamics**
* The Zeroth law of Thermodynamics has been described as a logical afterthought, as it was created after the other laws. Due to the fact it is fundamental to the remaining laws, it was rightly named as the zeroth law, so that it will precede the others. The Zeroth law states that two bodies are each in thermal equilibrium with each other, if they are each separately in thermal equilibrium with the same third body. This gives us a way to define temperature. If two bodies are in thermal equilibrium with each other, then they are at the same temperature.
* **First Law of Thermodynamics**
* The first law of thermodynamics is applying the conservation of energy to heat and thermodynamics. The law says that the internal energy of a system is equal to the amount of heat added to the system, minus the work done by the system. The Joule is the SI unit for each term. Make special note of whether WW is defined as work done by the system, or work done on the system, as it will affect the sign for the formula. In physics it is generally accepted that WW is work done by the system - resulting in the minus sign – while in chemistry WW represents work done on the system – resulting in a plus sign.

HD:Users:PillipLee:Desktop:Screen Shot 2016-05-31 at 9.20.43 PM.png

* **Second Law of Thermodynamics**
* If a process occurs in a closed system, the entropy of the system increases. Another way of looking at the second law of thermodynamics is with a heat engine example. It is impossible to construct a heat engine that when operating in a cycle, produces no other effect than the absorption of heat from a reservoir and the performance of an equal amount of work. This is basically saying that the process is never “perfect”, in the way that the absorption of heat is exactly equal to the amount of work, thus increasing entropy.
* **Temperature**
* **Definition**
  + Temperature is a measure of the average kinetic energy of all the particles in an object. If this energy is distributed evenly throughout an object, it is in thermal equilibrium, and the temperature will be the same everywhere.
* **Thermometers**
  + Thermometers are devices to measure temperatures of objects. A volume of gas changes by 1/273.15 of its volume for every Celsius degree change. While the temperature becomes lower, the volume gets smaller. When this result is extrapolated to a volume of zero, it is defined as absolute zero. This is 0K on the Kelvin scale, an alternative to Celsius and Fahrenheit, and is equal to -273.15 degrees C.
  + HD:Users:PillipLee:Desktop:Screen Shot 2016-05-31 at 9.33.51 PM.pngTo convert between the Kelvin temperature scale and the Celsius temperature scale: HD:Users:PillipLee:Desktop:Screen Shot 2016-05-31 at 9.33.48 PM.png
  + To convert between Fahrenheit and Celsius:
  + The letters C, F and K are used to distinguish measurements and degrees on the three scales.
* **Thermal Expansion of Solids and Liquids**
  + Thermal expansion occurs when a material experiences an increase in temperature, causing the volume of the material to expand. An example of this is seen when trying to unscrew the lid on a jar. Because metal expands more than glass, it is common practice to run stubborn jar lids under the hot tap so they are easier to remove. This thermal expansion occurs in liquids as well, which is how a liquid-in-glass thermometer works. When the temperature of a metal rod is raised, its length is found to increase.
* **Anomalous Behaviour of Water**
  + The most common liquid, water, does not behave as other liquids do. When above about 4 Celsius water expands as the temperature rises, as to be expected. However, water contracts with increasing temperature when between 0 and 4 Celsius. The density of water passes through a maximum at about 4 Celsius, and at all other temperatures the density is less than that maximum.
* **Kinetic Theory of Gases**
* **Definition**
  + To better understand what is happening to gases, they must be looked at on the atomic or molecular level. An ideal gas has the following properties: The number of molecules is large and the inter-molecular distance is large relative to the size of the molecule. As a whole the molecules move randomly in any direction. The molecules go through elastic collisions. The particles are non-interacting, except during collisions. All of the molecules are the same.
* **Translational Kinetic Energy**
  + Consider a single molecule moving around in a box. As it collides with other molecules, its speed will change.
  + Kinetic energy may be found using the equation:
  + After some derivation, we can then find that:
  + Using EQUATION INSERT, we find that:
  + This relates macroscopic properties (P,V,T) to microscopic properties.
  + An important concept to take from this is that at a given temperature of T, all ideal gas molecules of any mass have the same average translational kinetic energy. Therefore in measuring the temperature of a gas, the average translational energy of its molecules is also being measured.
* **Mean Free Path**
  + Mean Free Path is used as a parameter to describe the motion of molecules. It is helpful to picture a glass box with molecules inside. Every molecule is moving at a constant speed in a straight line, until it collides elastically with another molecule and changes both its speed and direction. Mean Free Path is the term for the average distance traversed by a molecule between collisions. This is easily remembered, as a “mean” indicates an average, and “free path” indicates the path before a molecule collides with something. λ=12√πd2N/Vλ=12πd2N/V Also, the larger the molecules, the smaller the mean free path, as there would be a bigger “target area” or contact area between molecules. Remember, because a molecule is 3D, it is not the diameter that determines the effective target area, but the cross section, or diameter squared.
  + Variables
    - λ:mean free path
    - dd:diameter
    - N:number of molecules
    - V:unit volume
* **Distribution of Molecular Speeds**
  + Root-mean-square speed is often used in molecular speed calculations. It is symbolized by νrmsνrms.
  + When in combination with the ideal gas law, it leads to this helpful equation:
  + Maxwell’s speed distribution law is a function such that P(V)dvP(V)dv gives the fraction of molecules with speeds in the interval dvdv at speed vv. This is helpful in knowing what fraction of molecules have speeds greater than the νrmsνrms value. INSERT EQUATION
* **[Heat](http://hopper.wlu.ca/upod/page.php?id=479)**
* **Temperature and Heat**
* **Units of Heat**
* **Specific Heat**
* **Latent Heat and Phase Changes**
* **Work and Heat**
* **Heat Engines**
* **Carnot Engine**
* **Entropy**
* **Definition**
* **Change in Entropy**
* **Reversible and Irreversible Processes**
* **Entropy Changes in Reversible and Irreversible Processes**
* **A Statistical View of Entropy**
* **Boltzmann’s Entropy Equation**
* **The Macroscopic Behaviour of Ideal Gases**
* **Pressure**
* **Avagadro's Number**
* **Ideal Gases**