**Physics Content Research - Statistical Mechanics**

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| **Topic** | **Statistical Mechanics** |
| **Subtopic** | **Laws of Thermodynamics** |
| **Concept Name** | **Zeroth Law of Thermodynamics** |
| **Description** | 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. |
| **Formula** | N/A |
| **Drawing/Animation** | Thermodynamics equilibrium Diagram – refer to the Github |
| **Relevant Tags** | #ZerothLaw #Thermal #Equilibrium |

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| **Topic** | **Statistical Mechanics** |
| **Subtopic** | **Laws of Thermodynamics** |
| **Concept Name** | **First Law of Thermodynamics** |
| **Description** | 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. |
| **Formula** | HD:Users:PillipLee:Desktop:Screen Shot 2016-05-31 at 9.20.43 PM.png |
| **Drawing/Animation** | <http://philschatz.com/physics-book/contents/m42232.html> <- Very useful diagram regarding this concept |
| **Relevant Tags** | #FirstLaw #Energy #conservation #internal #Joule |

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| **Topic** | **Statistical Mechanics** |
| **Subtopic** | **Laws of Thermodynamics** |
| **Concept Name** | **Second Law of Thermodynamics** |
| **Description** | 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. |
| **Formula** | N/A |
| **Drawing/Animation** | <http://hockeyschtick.blogspot.ca/2010/07/why-greenhouse-theory-violates-2nd-law.html> <- Second Law of Thermodynamics |
| **Relevant Tags** | #SecondLaw #Entropy #ClosedSystem |

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| **Topic** | **Statistical Mechanics** |
| **Subtopic** | **Temperature** |
| **Concept Name** | **Thermometers** |
| **Description** | Definition of Temperature: 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 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. |
| **Formula** | The letters C, F and K are used to distinguish measurements and degrees on the three scales.  HD:Users:PillipLee:Desktop:Screen Shot 2016-05-31 at 9.33.51 PM.pngHD:Users:PillipLee:Desktop:Screen Shot 2016-05-31 at 9.33.48 PM.png |
| **Drawing/Animation** | A thermometer that can be used as a slider that changes the value of the T. |
| **Relevant Tags** | #Temperature #thermometers #absolutezero #celsius #farhrenheit |

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| **Topic** | **Statistical Mechanics** |
| **Subtopic** | **Temperature** |
| **Concept Name** | **Thermal Expansion of Solids and Liquids** |
| **Description** | 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. |
| **Formula** | N/A |
| **Drawing/Animation** | N/A |
| **Relevant Tags** | #thermal #expansion # solids #liquids |

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| **Topic** | **Statistical Mechanics** |
| **Subtopic** | **Temperature** |
| **Concept Name** | **Anomalous Behaviour of Water** |
| **Description** | 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. |
| **Formula** | N/A |
| **Drawing/Animation** | N/A |
| **Relevant Tags** | #thermal #water #expands #density #maximum |

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| **Topic** | **Statistical Mechanics** |
| **Subtopic** | **Kinetic Theory of Gases** |
| **Concept Name** | **Translational Kinetic Energy** |
| **Description** | 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.  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. |
| **Formula** | HD:Users:PillipLee:Desktop:Screen Shot 2016-06-28 at 8.23.58 PM.png |
| **Drawing/Animation** |  |
| **Relevant Tags** | #Kinetic #energy #transitional #gas #molecule #temperature |

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| **Topic** | **Statistical Mechanics** |
| **Subtopic** | **Kinetic Theory of Gases** |
| **Concept Name** | **Mean Free Path** |
| **Description** | 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. |
| **Formula** | λ=12√πd2N/Vλ=12πd2N/V |
| **Drawing/Animation** | TBD. |
| **Relevant Tags** | #meanfreepath #diameter #molecules #motion #constantspeed |

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| **Topic** | **Statistical Mechanics** |
| **Subtopic** | **Kinetic Theory of Gases** |
| **Concept Name** | **Distribution of Molecular Speeds** |
| **Description** | 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. |
| **Formula** | TBD. |
| **Drawing/Animation** | TBD. |
| **Relevant Tags** | #Kinetic #energy #gasLaw #molecule #speed |

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| **Topic** | **Statistical Mechanics** |
| **Subtopic** | **The Macroscopic Behaviour of Ideal Gases** |
| **Concept Name** | **Avogadro’s Number** |
| **Description** | Avogadro’s Number is the number of units in one mole of any substance. It is equal to 6.022140857 x 1023. Depending on the nature of the substance, the units may be electrons, atoms, ions, or molecules. |
| **Formula** | NA = 6.022140857 x 1023 mol-1 |
| **Drawing/Animation** | TBD. |
| **Relevant Tags** | #gases #Avogadro #mole |

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| **Topic** | **Statistical Mechanics** |
| **Subtopic** | **Heat** |
| **Concept Name** | **Specific Heat** |
| **Description** | Specific heat is the amount of heat per unit mass required to raise the temperature of a substance by one degree Celsius. The relationship between temperature change and heat is expressed in the form of the formula below.  This relationship does not apply if a phase change occurs, as heat added or removed during a phase change does not change the temperature. |
| **Formula** | Q = cm∆T where  Q = heat added  c = specific heat  m = mass  ∆T = change in Temperature |
| **Drawing/Animation** | TBD. |
| **Relevant Tags** | #heat #temperature #change |

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| **Topic** | **Statistical Mechanics** |
| **Subtopic** | **Heat** |
| **Concept Name** | **Units of Heat** |
| **Description** | The following outlines the most common units of heat that you may encounter.  Joule (J) - a unit of energy equal to the work done when a force of one newton acts through a distance of one meter. 4.184 joules of heat energy is required to raise the temperature of 1g of water from 0oC to 1oC.  Calorie (cal) – The amount of heat required to raise the temperature of 1g of water 1oC. 1 calorie = 4.184 J  British Thermal Unit (BTU) – the amount of heat required to raise the temperature of one pound of water 1oF at sea level. 1 BTU = 1055.06 J = 252 cal |
| **Formula** | TBD. |
| **Drawing/Animation** | TBD. |
| **Relevant Tags** | #heat #temperature #units #measure |