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Kinetic Model of Heat and Temperature

Abstract

Heat and Temperature are biological concepts for living creatures. Heat is a measurable quantity of kinetic energy of elementary particles. Temperature is the kinetic energy density of elementary particles.

Disclaimer: Heat, Temperature, and Thermodynamics in general are complex subjects, worthy of several extensive papers. The reader is encouraged to visit the pages in Wikipedia for full treatment. Our purpose here is to show that in the Kinetic Model of the Universe, Heat and Temperatures are name variants for Kinetic Energy of Elementary Particles.

Heat and Temperature are Biological Concepts

Heat and Temperature are biological concepts for living creatures. Our senses tell us if an object is hot or cold. Our senses warn us of the dangers of getting burned by hot objects or freezing in the cold of the night. A cold drink on a hot summer day is appreciated. The sensation of heat on a cold day makes us feel warm and fuzzy. In reality, Heat and Temperature are kinetic issues, and in this paper we shall examine them.

Heat is a measurable quantity of kinetic energy of elementary particles that can be transferred from one object to another. Temperature is the kinetic energy density of elementary particles in an object. Heat is transferred by radiation or conduction from hotter objects to colder objects until their temperatures become equal. This heat energy transfer is not reversible. You may replace the word *heat* with *kinetic energy of elementary particles*.

The living skin has millions of sensors that are sensitive to energy emission from objects. Objects with higher energy density radiate energy at higher rate than objects with smaller energy density. The brain translates energy levels received from objects into temperatures of these objects.

Humans set up reference points for temperature. The most widely used reference points are the phase change points of water. The melting point of ice is assigned 0 degree Celsius, and the boiling point of water is assigned 100-degree Celsius. The scale between 0 and 100 is linear as indicated by the differential expansion of mercury in a glass container.

At higher temperatures, radiation intensity of objects are measured and compared to known values.

The idea that heat is matter in motion dates back hundreds of years. Tyndall, Thompson, Maxwell, and others were pioneers in this field. This idea is strange to us because we sense heat, and we sense cold. We are thinking of kilograms of matter and volumes of air, and we do not see Atoms and Molecules and Aethons in motion in them, but they are in motion.

In gases the kinetic energy of atoms and molecules results in pressure. Molecules and atoms collide with each other and container walls and bounce off after elastic collisions. Higher temperature at constant volume means higher molecular speed that result in higher pressure. The relationship between pressure, density and kinetic energy of gases was discussed in detail in another paper.

Ideal gas law includes the temperature of the gas: $$P = \frac{n \times R \times T}{V}$$

P is the absolute pressure of the gas
n is the amount of gas
R is the ideal gas constant.
T is the absolute temperature
V is the volume of gas

The pressure in the kinetic model of gas: $$P = \frac{density \times v^2}{4}$$

v is the average velocity of gas molecules or atoms
v^2 is proportional to the absolute temperature *T*

The collision between gas molecules or atoms and container walls is complex. If the container wall is *cooler* than the gas, part of the kinetic energy of the gas atoms will be transferred to atoms in the container wall. As the kinetic energy of gas atoms decreases, atoms in the container wall will vibrate more vigorously. This process continues until the net rate of energy transfer between the container walls and the gas becomes zero. This energy transfer is a statistical process, and it is similar between solids, liquids, and gases.

In liquids the intensity of motion is not enough to free the atoms and molecules from the effects of gravity, though it is sufficient to free them from the constraints of being solid.

In solids the situation is more complicated. Atoms and molecules are locked in place except for small vibrations. Energy input increases the amplitude and the frequency of vibrations of atoms and molecules. In solids and liquids this increased activity results in size expansion. Humans have used this expansion to indicate temperature. In a thermometer we are observing the expansion of mercury in a glass container to determine temperature. In bimetal sensors and actuators we utilize the differential thermal expansion of two metals to determine temperature. At very low temperatures the vibrations of atoms are reduced. Electrons of an electric current do not have to run the gauntlet of intensely vibrating atoms and molecules, resulting in superconductivity in some materials.

Measuring Temperature

Measuring temperature of an object is measuring kinetic energy density of the object and it can only be measured indirectly. Kinetic energy density of an object is the average kinetic energy density of elementary particles in the object.

For objects on hand at moderate temperature we can use thermometers. The object passes part of the kinetic energy of its elementary particles to the thermometer where the particles of mercury or some other substance will use this energy to vibrate more vigorously and expand to indicate the temperature of the mercury and indirectly the temperature of the object.

For objects at a distance and for objects with elevated temperatures we measure the rate of energy radiation and compare it to known or calculated values to estimate the temperature of these objects.

Molar Heat Capacity

A convenient way to look at specific heat of elements is the Molar Heat Capacity that is favored by chemists and physicists. It is expressed in Joules per Mole per degree Kelvin. This is the amount of energy needed to elevate the temperature of one Mole substance by one degree Kelvin. Three groups of elements are listed in Table 1: Atomic gases, Molecular gases, and Solids / Mercury.

I thank the many scientists for their efforts to measure and compile the data used here. This data was obtained from Wikipedia and other sources. Plato, Aristotle, Newton, and others did not have access to this valuable source of knowledge we are fortunate to have.

It is interesting to note that the Molar Heat Capacity is similar for most elements in the same group despite the big differences in their masses. One notable exception is Carbon. Carbon structures are unique, very tight, especially Diamond. Beryllium and Boron are other exceptions to lesser degree. Molar Heat Capacity does not vary much between the groups either.

Please note that according to the data, more energy is needed to heat one gram of Hydrogen than 196 grams of Gold or 200 grams of Mercury. Hydrogen is used to transport heat in some high-performance industrial cooling systems for good reason.

From the numbers in Table 1 it is reasonable to conclude that Nucleons do not absorb *heat*. Nucleons do not heat up. There is no such thing as heat. Heat is a substitute concept for kinetic energy of Atoms and Molecules. Temperature is the Intensity of the Kinetic Energy of Atoms, and Molecules.

Type of Element Element	1 Mole Grams	Molar Heat Capacity Joule/K	Number of Nucleons×10^{23} per Mole
Noble Gases			
Helium	4.003	20.800	24.106634
Neon	20.179	20.786	121.520790
Argon	39.948	20.786	240.572520
Krypton	83.798	20.786	504.643430
Xenon	131.293	20.786	790.665080
Molecular Gases			
$Hydrogen_2$	2.016	28.836	12.140638
$Nitrogen_2$	28.014	29.124	168.704280
$Oxygen_2$	31.998	29.378	192.696492
Solids & Mercury			
Lithium	6.940	24.860	41.793664
Beryllium	9.012	16.400	54.271541
Boron	10.810	11.087	65.099352
Carbon12	12.000		72.265704
Diamond	12.011	6.155	72.331947
Graphite	12.011	8.517	72.331947
Sodium	22.989	28.230	138.443010
Magnesium	24.305	24.869	146.368190
Aluminium	26.981	24.200	162.479582
Calcium	40.078	25.929	241.349716
Iron	55.845	25.100	336.298590
Copper	63.546	24.400	382.674012
Silver	107.868	25.350	649.581096
Gold	196.166	25.418	1181.311652
Mercury	200.590	27.983	1207.981400
Lead	207.200	26.650	1247.758400

Table 1. Molar Heat Capacity of Elements

Avogadro's Number: 1 Mole contains $6.0221417930 \times 10^{23}$ atoms
Data in Table 1 obtained from Wikipedia.

Electrical Current and Heat

Electrical current generating heat in a wire is a kinetic event. As Electrons move through the wire they bump into atoms and molecules and change their direction of movement. The collisions transfer Momentum from Electrons to molecules or atoms they bump into. The offending Electrons will bump into other molecules or atoms of the wire to change direction again like the action in a pinball machine. Overall forward motion of electrons is powered by the electrical potential applied to the wire. That is another complex Kinetic event transferring Momentum from outside sources to Electrons in the wire. Molecules and atoms of the wire gain kinetic energy from the colliding Electrons. We already know that kinetic energy of atoms and molecules is heat. There is no friction at the molecular level, only collisions and momentum transfers.

Friction

Friction between objects generates Heat in comparable manner: Atoms and molecules collide and convert kinetic energy of objects into kinetic energy of atoms and molecules of these objects. This is a Kinetic Universe.

Chemical Events

Chemical reactions are kinetic events. This subject deserves its own publication. For now, let me make a short illustration. Suppose we mix small amounts of oxygen and methane gas in a container at low temperature in a safe environment. Nothing happens. The molecules have low velocities and reaction does not occur.

By adding kinetic energy – compression – to the mixture, the molecular velocities of the gases increase and eventually some molecules or atoms will reach the critical velocity where recombination of molecules is triggered. The event of joining of two oxygen atoms and a carbon atom is violent, driven by the pressure of Aether and the result is more kinetic energy.

Oxygen atoms have higher affinity for carbon atoms and for hydrogen atoms than hydrogen atoms have for carbon atoms. It has to do with shapes and hardness of Atoms. We will touch on this subject in another paper.