Heat

Matter consists of small particles. In a solid body theses particles have fixed places, but wiggle a bit around their place. In a liquid, these particles stay close together, but don't have a fixed place and move around in the liquid. In a gas these particles can freely fly around and hit each other often. When these particles hit each other in a random way, there is an irregular movement of many particles. This movement cannot be seen from the outside. All these moving particles have kinetic energy. The Heat Q is the sum of the kinetic energies of the irregular movement of all these particles. It is measured in J [Joule].

Temperature

The temperature T indicates the average kinetic energy of the irregular movement of all particles.

That means, that the Celsius scale (0 °C for freezing water and 100 °C for boiling water at sea level) is not the best way to give a temperature. The Kelvin scale starts at 0 K, when all the irregular movements have ceased. 0 °C = 273,15 K and 100 °C = 373,15 K. The symbol for temperature given in the Kelvin scale is T.

The average kinetic energy of a particle in the irregular movement is $\overline{E}_{kin} = 3/2 \cdot k \cdot T$ with $k = 1{,}3805 \cdot 10^{-23}$ J/K.

Heat in Matter

To increase the temperature of 1 kg water by 1 K or 1 °C, we have to put 4128 J into the water. Melting ice, that means to set the water particles (molecules) free to move freely around in the liquid needs 334,000 J per kg ice.

If we want to set the water molecules free to leave the liquid, we need 2,500,000 J per kg water. These freely flying water molecules are the water vapor. The human body uses that for cooling: It puts sweat on the skin, and this sweat is mostly water. If that water becomes water vapor, it takes the energy needed for it out of the body and cools thus the body.

If water molecules in the water vapor come together and form liquid droplets, the energy we had put in to set them free is released again as heat. That means, that water vapor has stored a lot of energy as "latent heat". Hot water vapor, therefore, is very dangerous.

Atoms come together to form molecules, for example 2 Hydrogen atoms (H) and an Oxygen atom (O) build together a water molecule H_2O. When 1 kg liquid water is built by burning Hydrogen gas in air, 15,9 Million J are set free. Chemical reactions between molecules or atoms receive and give lots of energy.

Gas and Temperature

Gas molecules hit a surface with the size A. Many hits from many molecules give a force F on this surface. This force F divided through the area A is the pressure $p = F/A$. If we have a gas in a closed volume V, the number of molecules hitting the surface per second doubles, if we compress the gas to half of its volume, and becomes half, if we let the volume become double its size. If we increase the temperature, the molecules have more kinetic energy and their collisions with the walls of the volume become stronger and the pressure of the gas increases. If we have a constant pressure and decrease the temperature T, the volume V becomes smaller. At T = 0 K = -273.15 °C, the volume of the gas = 0 l. If we have a volume of 1 l at 273.15 K = 0 °C, then we have a volume of 2 l at 2 · 273.15 K = 546,30 K = 273.15 °C and 3 l at 3 · 273.15 K = 819.45 K = 546,30 °C.

Vapor Pressure

Let us start with a water surface and no water vapor above it. The thermal movement of the molecules in the water hits some water molecules so strongly, that they leave the water surface and become molecules of the water vapor. The higher the temperature T of the water surface is, the more water molecules can leave the liquid. The number of water molecules in the water vapor increases. The molecules in the water vapor fly around, and some of them hit the water surface and become part of the liquid again. The number of these hits increases with the number of the water molecules in the water vapor. Finally the same number of water molecules per second leaves the liquid and enters the liquid. Then the number of water molecules per cm^3 in the water vapor doesn't change anymore. this number, however, changes strongly with the temperature of the liquid.
The following table gives the maximum amount of water vapor in 1 m^3, that can be carried by air with a given temperature.

T in ºC	18	20	22	24	26	28	30	32	34
max. water in g/m^3	15.3	17.3	19.4	21.7	24.3	27.2	30.3	33.7	37.5

The relative humidity says, how much of the possible water is now in the air. 50 % humidity at 26 ºC means 50% of 24.3 g/m^3 = 12.2 g/m^3. If the relative humidity is over 95%, the air cannot receive much more water vapor. We can't cool our body any longer by evaporation of our transpiration, and we can't do much.

Warm air can carry much more water than cold air. When air cools down, the water vapor remains in the air, until the relative humidity becomes 100%. Then water vapor becomes water, either as dew or as fine droplet in clouds and fog or as raindrops. Lots of energy become free and heat the surrounding air. This air expands and becomes lighter than the surrounding air and goes upward. This upward movement can become very strong, if new air from below is sucked in, climbs and gives away more energy. That process leads to thunderstorms, and if a lot of air is involved, even to hurricanes.

If water vapor and some water is in a closed vessel, the water molecules produce a pressure by hitting the walls of the vessel. If the temperature increases, the pressure can increase very quickly. Bottles with Propane and Butane contain liquid and gas. If you heat these vessels too strongly, the pressure can quickly become so big, that the vessel explodes.

Friction

A mass is hit and slides upon a table. It becomes slower and slower and finally stops. A part of the kinetic energy of the mass becomes irregular kinetic energy of the particles of the table and of the mass, that means it has become heat and the temperature of the mass and the table increase. This transfer of kinetic energy into heat is called <u>friction</u>. It is used in the brakes of cars and bicycles. Because of friction the sum of kinetic energy and potential energy often decreases.

Book used here: Houghton, J.T..The Physics of Atmospheres. Cambridge, Londn, New York,Melbourne 1979