Heat, Temperature and Internal Energy

To know what internal energy is
To be able to explain the difference between heat, temperature and internal energy
To be able to explain what absolute zero is and how it was found

Internal Energy

The internal energy of a substance is due to the vibrations/movement energy of the particles (kinetic) and the energy due to the bonds holding them together (potential).

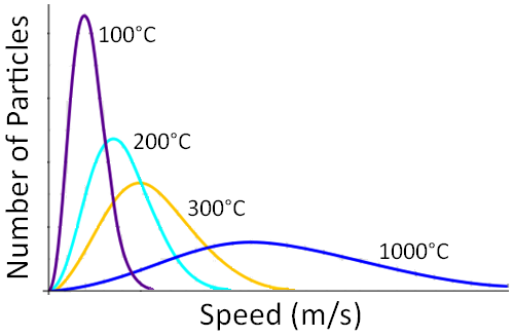
Solids: In a solid the particles are arranged in a regular fixed structure, they cannot move from their position in the structure but can vibrate. The internal energy of a solid is due to the kinetic energy of the vibrating particles and the potential energy from the bonds between them.

Liquids: In a liquid the particles vibrate and are free to move around but are still in contact with each other. The forces between them are less than when in solid form. The internal energy of a liquid is due to the kinetic and potential energies of the particles but since they are free to slide past each other the potential energy is less than that of it in solid form.

Gases: In a gas particles are free to move in all directions with high speeds. There are almost no forces of attraction between them. The internal energy of a gas is almost entirely due to the kinetic energy of the particles.

Temperature

Temperature is a measure of the kinetic energies of the particles in the substance. As we can see from the graph something with a high temperature means the particles are vibrating/moving with higher average speeds that a substance at a lower temperature. It is possible for two objects/substances to be at the same temperature but have different internal energies. We will go into this further in the next lesson: The Specifics.



Heat

Heat is the flow of thermal energy and it flows from a high temperature to a low temperature.

If two objects are at the same temperature we say that they are in thermal equilibrium and no heat flows.

If object A is in thermal equilibrium with object B and object B is in thermal equilibrium with object C then A and C must be in thermal equilibrium with each other.

Get into a hot or cold bath and energy is transferred:

In a cold bath thermal energy is transferred from your body to the water.

In a hot bath thermal energy is transferred from the water to your body.

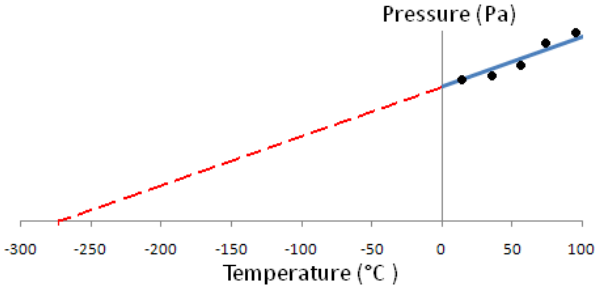
As the energy is transferred you and the water become the same temperature. When this happens there is no longer a flow of energy → so no more heat. You both still have a temperature due to the vibrations of your particles but there is no longer a temperature difference so there is no longer a flow of energy.

Temperature Scale

The Celsius scale was established by giving the temperature at which water becomes ice a value of 0 and the temperature at which it boils a value of 100. Using these fixed points a scale was created.

Absolute Zero and Kelvins

In 1848 William Thomson came up with the Kelvin scale for temperature. He measured the pressure caused by gases at known temperatures (in °C) and plotted the results. He found a graph like this one.



By extrapolating his results he found the temperature at which a gas would exert zero pressure. Since pressure is caused by the collisions of the gas particles with the container, zero pressure means the particles are not moving and have a minimum internal energy. At this point the particle stops moving completely and we call this temperature absolute zero, it is not possible to get any colder. This temperature is -273°C.

1 Kelvin is the same size as 1 degree Celsius but the Kelvin scale starts at absolute zero.

°C = K – 273 K = °C + 273