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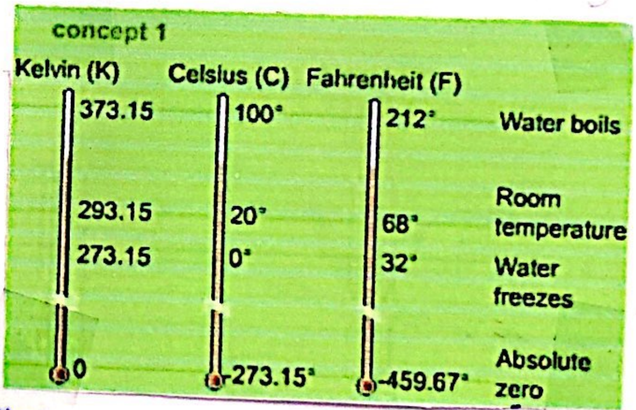
Temperature and Heat

Temperature is a measure of how hot or cold something is; specifically, a measure of the average kinetic energy of the particles in an object, which is a type of energy associated with motion.

- Therometers: measure temperature based on physical properties.
- In the "old" days, body temperature was measured with a glass thermometer filled with mercury, a material that expands significantly with temperature and whose expansion is proportional to the change in temperature.
- Today, a wide variety of physical properties are used to determine temperature. Some medical clinics use thermometers that measure temperature with plastic sheets containing a chemical that changes color with temperature. Battery-powered digtial thermometers rely on the fact that resistor's resistance chang with temperature.

Temperature scales



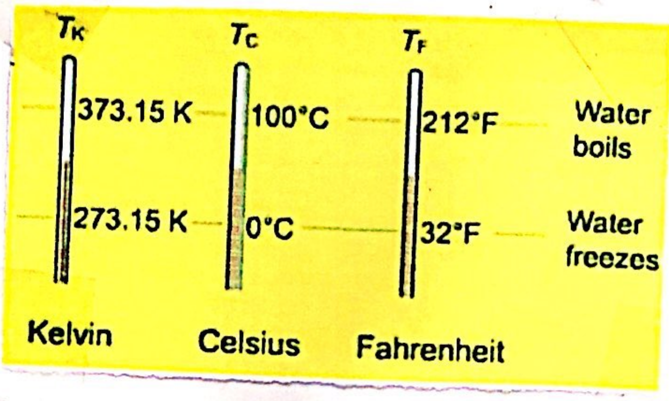
In the United States, the Fahrenheit system is the most common measurement system for temperature. The units in this system are called degrees. In most of the rest of the world, however, temperatures are measured in degrees Celsius. Physicistes use the Celsius scale or, quite often, another scale called the Kelvin scale. All three scales are shown on right.

- Temperature scales

Kelvin, Celsius, and Fahrenheit

water freezes at 0 °C

Absolute zero is 0 K



Temperature Scale conversions.

$$T_K = T_C + 273.15$$

$$T_C = (5/9)(T_F - 32)$$

where

T_K = Kelvin temperature

T_C = Celsius temperature

T_F = Fahrenheit temperature

Example: convert 98.6 °F to celsius and kelvin

Solution

$$T_C = (5/9)(T_F - 32)$$

$$T_C = (5/9)(98.6 - 32) \Rightarrow T_C = 37.0\ ^{\circ}C$$

$$T_K = T_C + 273.15$$

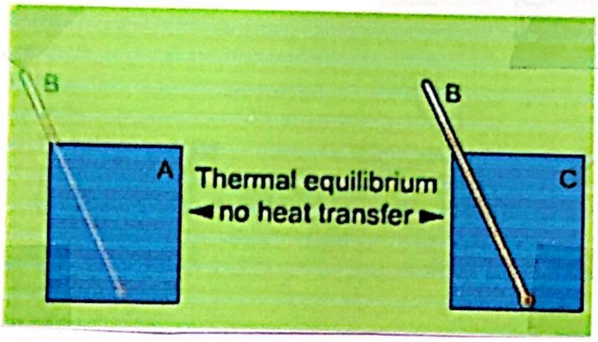
$$T_K = 37.0 + 273.15 \Rightarrow T_K = 310.15\ K$$

Heat: Thermal energy transferred between objects because of a difference in their temperatures.

- Energy flow due to temperature difference
- q: represents heat
- units: watt (W)

Zeroth law of thermodynamics.

Zeroth law of thermodynamics: If objects A and B are in thermal equilibrium, and objects B and C are in thermal equilibrium, then A and C will be in equilibrium as well.

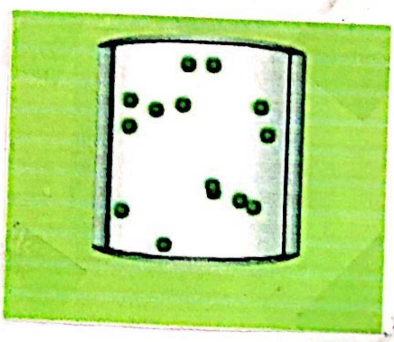


When you place two objects with different temperatures next to each other, the warmer object will cool off and the cooler object will warm up. Heat will flow until the objects reach thermal equilibrium, meaning they have the same temperature.

For example, thermometers rely on heat flowing until they reach thermal equilibrium with substance whose temperature they are measuring. Their practical use also relies on another principle, called the zeroth law of thermodynamics.

Internal energy: The energy associated with the molecules and atoms that make up a system.

- Internal energy: energy of system's atoms, molecules
- In thermodynamics, the properties of the molecules and/or atoms that make up the object or system are now the focus. They also have energy, a form of energy called internal energy. The internal energy includes the rotational, translational and vibrational energy of individual molecules and atoms.

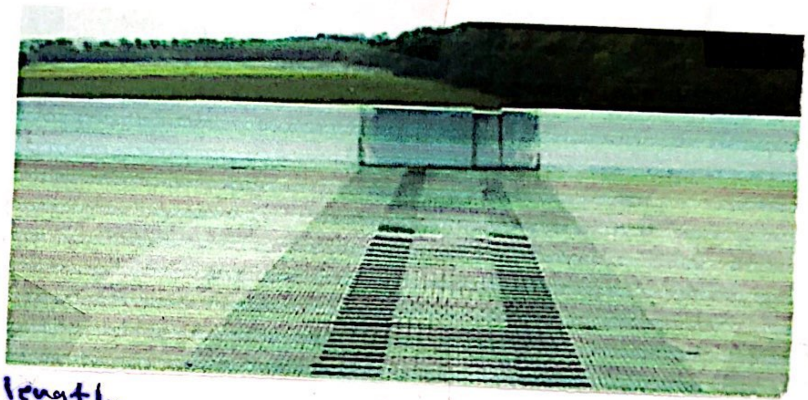


Thermal expansion:

The increase in the length or volume of a material due to a change in its temperature.

- Thermal expansion: Most materials expand with increased temperature.
- Different materials exeand at different rates-
- Good engineering takes expansion into account. For instance, bridges are built with expansion joints like the one shown in this figure

Thermal expansion: linear



Thermal linear expansion: change in the length of a material due to a change in temperature.

- Measured along one dimension
- Expansion proportional to initial length

linear expansion

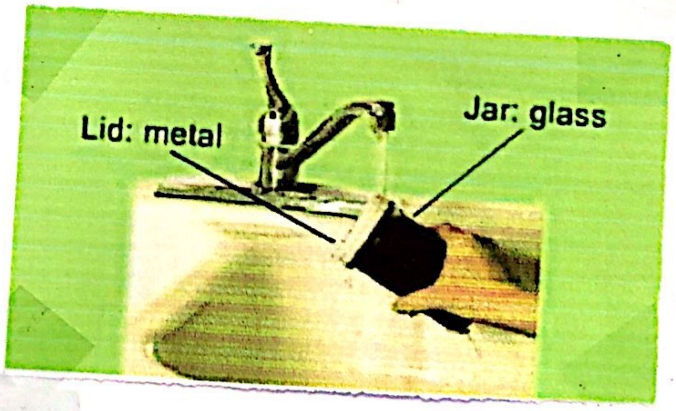
$$\Delta L = L_i \alpha \Delta T$$

where

α: coefficient of linear exeansion

L_i: initial length

ΔT: change in temperature



Coefficient of linear expansion (1/C°)	
Carbon steel	1.17 x 10-5
Iron	1.18 x 10-5
Copper	1.65 x 10-5
Silver	1.89 x 10-5
Aluminum	2.31 x 10-5
Magnesium	2.48 x 10-5
Lead	2.89 x 10-5