Thermal Radiation

Thermal radiation

A hot body emits energy. The energy emitted by a hot body in the form of radiation, by virtue of its temperature, is called thermal radiation.

Radiation —a mode of heat transmission

There are three modes of transmission of heat energy. They are : conduction, convection and radiation.
The radiation is the mode of transmission of heat from a hot body to a cold body or surroundings without needing an intervening medium. The speed of radiation is the speed of light in medium.

Black body

A body which completely absorbs thermal radiations of all wavelengths falling upon it, is called a black body.
When such a body is heated, it emits radiations of all possible wavelengths. The radiations emitted by a black body, are called black body radiations or full radiations.
There is no ideal black body but Ferry cavity can be considered a perfectly black body.

Some elementary definitions

1. Total Emissive Power (e). The total emissive power of a body at a particular temperature is defined as the total amount of radiant energy emitted per second per unit area of the surface of the body. It is represented by the symbol e.
Its SI unit is J m^{-2} s^{-1}. Total emissive power of a black body is represented by the symbol E.
2. Emissivity ε. Emissivity of a body is the ratio of the total emissive power of the body to the total emissive power of a black body. It is represented by the symbol ε. It means that $\varepsilon = e/E$ or $e = \varepsilon E$. For a block body , $\varepsilon=1$.
3. Total Absorptive Power (a). The total absorptive power of a body is defined as the ratio of the total radiant energy absorbed by the body in a certain interval of time, to the total energy falling upon it in the same interval of time. It is represented by the symbol a. Total absorptive power of a black body is represented by the symbol A. By definition A = 1.

Kirchhoff's law

Statement. The law states that for a given temperature, the ratio of the emissive power to the absorptive power of a body, at a particular wavelength is a constant for all bodies and is equal to the emissive power of a perfectly black body.
Explanation. If e_λ and a_λ be the emissive and absorptive powers of a body for wave-length λ, and E_λ be the emissive power of a black body for wavelength λ, then
$e_\lambda / a_\lambda = \text{Constant} = E_\lambda$

According to this law, good emitters are good absorbers and poor emitters are poor absorbers.

Stefan's law

Statement. The law states that the total amount of radiant energy emitted by unit area of a perfectly black body in one second is directly proportional to the fourth power of its absolute temperature.

Explanation. If E be the amount of radiant energy emitted by unit area in one second and T be the absolute temperature of the body, then

$$E \propto T^4$$

or

$$E = \sigma T^4$$

where σ is a constant known as Stefan's constant. Its value is 5.672×10^{-8} J m^{-2} s^{-1} K^{-4}.

Newton's law of cooling

Statement. The rate of cooling (i.e., heat lost per second) of a body is directly proportional to the difference of temperature of the body (T) and the surrounding (T_0), provided difference in temperature should not exceed by 30°C.

$$E \propto (T - T_0)$$