Newton’s law of cooling

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Introduction to Newton’s law of cooling

Newton’s law of cooling states that a body’s rate of loss of heat is directly proportional to the temperature difference between the body and its surroundings. When a hot body is placed at a lower temperature, the hot body slowly cools down by losing heat energy to its surroundings.

Isaac Newton found that the temperature of a hot object decreases at a rate proportional to the difference between it and the surrounding temperature. Obversely, an object colder than its surroundings warms at a rate proportional to the same difference.

Equation of Newton’s law of Cooling

The formula governing the law is $dQ/dt = c\,(T - S)$ (1)

where T is the object's temperature, S is the surrounding temperature, dQ is the quantity of heat lost in time dt, and c is a constant of proportionality.

Derivation of Equation

For a small temperature difference between a body and its surroundings, the body’s rate of cooling is directly proportional to the temperature difference. If a body of temperature T and surface area A is kept in a surrounding temperature $T_0 (T_0 < T)$, then net loss of thermal energy per unit time amounts to:

$dQ/dt = ?? A(T^0 - T_0^0)$

If the temperature difference is small, then:

$T = T_0 + ?T$

$=>?? A[(T_0 +? T)^4] =?? A[T_0^4 (1 + ?T/T_0)^4 - T_0^4]$

$=>?? AT_0^4[1 + 4\ ?T/T_0 + \text{higher powers of } ?T/T - 1]$

$= 4?? AT_0^3\ ?T$

Now, the rate of loss of heat at temperature T is:

$dQ/dt = -mcdT/dt$

$mc\ dT/dt = -\ 4??\ AT_0^3[T - T_0]$

$dT/dt = -\ K[T - T_0]$

$K = 4??AT_0^3\ /mc$

$dT/dt\ \ ?(T - T0)$

We know that the heat that a body loses depends on its heat capacity. If m is the mass of the body and s is the specific heat, then

$$dQ/dt = m\ s\ dT/dt$$

With Newton's law (eq. 1), this equation can be used to find the specific heat capacity of the liquid.

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Reference links:

- http://www.hyperphysics.phy-str.gsu.edu/hbase/thermo/spht.html
- http://www.physics.about.com/od/energyworkpower/f/KineticEnergy.htm
- http://www.en.wikipedia.org/wiki/heat

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