

First Law of Thermodynamics

$$\Delta U = Q + W$$

U – Internal (Thermal) Energy

Q – Heat adsorbed by the System

$W=Fd$ – Work done by external forces (Force * Displacement)

Conservation of Energy Revisited:

$$E_{kin} + E_{pot} + U = const$$

*“In thermally isolated system ($Q=0$),
Total Energy (Mechanical+Internal) is conserved”*

Calories and Joules

Traditionally, Heat was measured in calories (cal):

- **1 calorie** is an amount of heat needed to increase the temperature of 1g of water by 1°C.
- For nutritional/dietary purposes people use “big Calories” (Cal, with capital “C”).
1 Cal=1000cal (or simply kilocalorie). By definition, this is an amount of heat needed to increase the temperature of 1 kg (1 liter) of water by 1°C.
- Since Heat is a form of energy, calories can be converted to Joules:

$$1 \text{ cal} = 4.184 \text{ J}$$

$$1 \text{ Cal} = 1000\text{cal} = 4184 \text{ J (used for dietary purposes)}$$

Specific Heat

In order to know how much energy is needed to heat up an object by certain temperature, you need to know the specific heat capacity (aka specific heat) of the material, C:

$$Q = m C \Delta T$$

Here m is mass of the object, ΔT is change of its temperature, C is specific heat of its material. For instance, specific heat of liquid water is:

$$C_{\text{water}} = 1000 \frac{\text{cal}}{\text{kg} \cdot ^\circ\text{C}} = 4184 \frac{\text{J}}{\text{kg} \cdot ^\circ\text{C}}$$

Homework

Problem 1

A bullet made of lead has initial speed $v_0=350$ m/s. After it hits a wooden wall, its speed is reduced to $v=300$ m/s. Assuming that half of the mechanical energy lost was adsorbed by the bullet itself, find how much has its temperature changed. Specific heat of lead is $C=128$ J/kg/°C.

Problem 2

An electric motor consumes $P=150$ Watt of power, and lifts a payload of $M=50$ kg to a height of $h=2$ m in $t=20$ sec. Assume that all the heat generated in this process is adsorbed by the motor. By how much has its temperature changed? The motor is made of material with specific heat 400 J/kg/°C , and its mass is 0.5 kg.

Reminder: Power is energy consumed per second.