Heat Capacity

The specific heat c is defined as the amount of heat transferred to raise unit mass through increasing of one degree temperature:

$$c=\frac{\Delta q}{\Delta T}$$

The specific heat is usually considered as constant for solid and liquid, therefore we can calculate the heat transferred with the help of the corresponding heat capacity:

$$dQ=m\cdot c\cdot dT$$

Pay attention here, as a matter of fact, the heat capacity of solid and liquid also vary with change of temperature for example. But in our most engineering analysis, changes are so little that they can be neglected.

Example 1:

A boiler is filled with 1 liter water. At the beginning the water has the temperature of 20°C. We heat up the water and the temperature of water rises to 100°C. Calculate the heat transferred into water. The density of water is $\rho=1000\ kg/m^3$ and the heat capacity c=4.184 kJ/(kg·K). Assume that density and heat capacity remain unchanged.

Answer:

First we calculate the mass of contained water:

$$m=\rho\cdot V=1000\ kg/m^3\cdot(1\cdot10^{-3}\ m^3)=1\ kg$$

$$Q=m\cdot c\cdot\Delta T=1\ kg\cdot 4.184\ kJ/(kg\cdot K)\cdot(100°C-20°C)=334.72\ kJ$$

Here Q>0, that means water absorbs heat of 334.72 kJ.

Example 2:

We place an iron bar with the temperature of 200°C in the environment of 25°C. The temperature of environment does not change. After a period of time, this iron bar reaches its equilibrium state. Determine the heat transferred in this case. The mass of the iron bar is 5 kg. The heat capacity of iron is c=0.449 kJ/(kg·K) and remains constant.

Answer:

In this example, we should take thermal equilibrium into consideration. And at the final state, the iron bar also reaches the temperature of 25°C.

$$Q=m\cdot c\cdot\Delta T=5\ kg\cdot 0.449\ kJ/(kg\cdot K)\cdot(25°C-200°C)=-392.875\ kJ$$

$Q<0$ means that the heat is transferred from iron bar to environment. In other words, the iron bar releases heat of 392.875 kJ