

# Enthalpy

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**Enthalpy** (heat content) is a quantity expressing the thermal energy stored in a given substance. It is a thermodynamic function of the state of a thermodynamic system, which is determined by the relationship for a system with a constant number of particles, internal energy  $U$ , pressure  $p$  and volume  $V$  of the system. It is introduced in connection with the first thermodynamic theorem.

## Formulas

It is based on the 1st law of thermodynamics: the system can do work only if its internal energy  $U$  decreases or if heat  $Q$  is supplied to it:

$$\Delta U = Q - W$$

(The internal energy  $U$  is increased by supplying heat  $Q$  or work  $-W$ .)

If the system increases its volume  $\Delta V$  against the external pressure  $p$ , it does mechanical work:

$$\Delta W = p \cdot \Delta V$$

Given the previous equation, we can write that

$$Q = \Delta U + p \cdot \Delta V.$$

Therefore, the function  $H$  (enthalpy, heat content) was defined:

$$H = U + p \cdot V$$

The unit of enthalpy in the SI system is the joule (J).

So the equation says that enthalpy is equal to the internal energy of the system multiplied by the product of the pressure of the system and its volume.

$\Delta H$  is the amount of heat that the system receives during a chemical reaction ( $\Delta H > 0$ ) - this is an endothermic reaction, or gives up ( $\Delta H < 0$ ) - this is an exothermic reaction.

It is also possible to introduce the specific enthalpy  $h$  by the relation

$$h = H/m,$$

where  $m$  is mass. In the SI system, the unit of specific enthalpy is joule per kilogram of substance ( $\text{J} \cdot \text{kg}^{-1}$ )

## Relation to internal energy

Internal energy  $U$  is suitable for expressing energy changes of events taking place at constant volume, enthalpy is preferably used to calculate energy changes at constant pressure. Since most chemical processes take place at constant pressure, enthalpy is a more commonly used quantity in chemical thermodynamics than internal energy.

If we knew the enthalpy values of the reacting components in a chemical reaction, the calculation would be simple. However, the problem arises in the fact that we cannot determine the absolute values of enthalpies. Only the change of this function is always detected, which occurs when the substance passes from one state to another (from initial to final). Therefore, a scale of relative enthalpy values is introduced in chemical thermodynamics. The zero enthalpy value is the enthalpy of the elements in their ground state, in their stable form - at a pressure of 101.325 kPa and a temperature of 298.15 K (25 °C). Only in this state can their enthalpies be measured.

## Meaning of enthalpy

By introducing enthalpy, the thermodynamic relations for isobaric processes are greatly simplified. If the system receives heat and does volumetric work, the equation for calculating the change in internal energy will be:

$$U_2 - U_1 = Q - W$$

in differential form:

$$dU = dQ - p dV$$

If the work is reversible, then  $p$  denotes the pressure of the system. If this pressure is constant (in an isobaric event), we can write the equation ( $H = U + p V$ ) in the form:

$$dQ = dU + d(p V) = d(U + p V) = dH$$

Therefore, for an isobaric process, the heat received by the system is equal to the increase in the enthalpy of the system.

Its importance is also in the assessment of processes in heat engines in which the substance is supplied and removed at a constant pressure. If the substance does work in the machine during expansion without heat supply and removal, this work is proportional to the difference in enthalpy of the substance (initial and final state) during one cycle.

$$\Delta H = Q$$

## Heat of reaction

Heat of reaction [ $\Delta H$ ] is the amount of heat that the system exchanges with the environment during a reaction. The reaction takes place under constant pressure in the range of 1 mole of basic reaction transformations. As we already know, in isobaric processes, the heat exchange between the system and the surroundings is expressed by the enthalpy.

In exothermic events, the heat of reaction is negative - the system supplied heat to the surroundings. In endothermic events, it is positive - the system has received heat, so it is richer in energy.

Graphic representation:

520px

## Distribution

We can divide the heat of reaction according to whether a compound is formed from the elements during the reaction, or whether the compound burns in an excess of oxygen. The calculation of reaction heats is made possible thanks to the 2nd law of thermodynamics.

### Standard heat of fusion

$\Delta H_{298}^0$  [kJ.mol<sup>-1</sup>]. It is the reaction heat of the reaction at which 1 mole of the compound is formed from the elements. The condition for creation is the standard state of elements and products, i.e. temperature 298.15 K, pressure 101.325 kPa. The standard heats of fusion of the elements are always zero.

### Standard heat of combustion

$\Delta H_{298}^0$  [kJ.mol<sup>-1</sup>]. It is the reaction heat of the reaction at which 1 mole of the substance is burned. Again, items and products must be in standard condition. The combustion heats of the elements are non-zero.

## Links

### Related articles

- Gibbs function

### Extern links

- Entalpie (czech wikipedia)
- Enthalpy (english wikipedia)

### Source

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