

ChatGPT-4 & Questions from a Materials Thermodynamics Course

Question 3: Consider implications of the first law of thermodynamics when written as: $dU = \delta Q - \delta W$. What's the meaning of the various differential & difference terms?

TLL Question 3:

The differential form of the first law of thermodynamics is given by: $dU = \delta Q - \delta W$; where U the internal energy is an exact differential, and W and Q are process variables. Explain how the change in a state function can be equivalent to a change in the sum of 2 process variables.

ChatGPT4 answer:

In the differential form of the first law of thermodynamics, which is given by $dU = \delta Q - \delta W$, the symbol “d” represents an exact differential, implying that the change in internal energy (dU) is a state function. On the other hand, δQ and δW represent infinitesimal amounts of heat transfer and work done, respectively, and they are process variables.

To understand how the change in a state function (dU) can be equivalent to a change in the sum of two process variables (δQ and δW), let's break down the equation:

$$dU = \delta Q - \delta W$$

The term “ dU ” represents the change in internal energy, which is a state function. It only depends on the initial and final states of the system and is independent of the path taken to reach those states. In other words, dU represents the net energy change of the system due to heat transfer and work done during a process.

The terms δQ and δW represent the infinitesimal amounts of heat transfer and work done during the process, respectively. They are process variables because their values depend on the path or mechanism through which the system undergoes a change. δQ represents the heat added to or removed from the system, and δW represents the work done on or by the system.

Now, the equation $dU = \delta Q - \delta W$ states that the change in internal energy (dU) is equal to the difference between the infinitesimal amounts of heat transfer (δQ) and work done (δW). This equation implies that the net energy change of the system, which is captured by dU , can be achieved through a combination of heat transfer and work done.

In other words, the internal energy of a system can change through either heat transfer or work done or a combination of both. The equation acknowledges that the change in a state function (dU) can be expressed as the sum of the infinitesimal heat transfer (δQ) and infinitesimal work done (δW). The specific values of δQ and δW depend on the specific path taken during the process, but their sum accounts for the overall change in the system's internal energy.

Therefore, by considering the differential form of the first law of thermodynamics, we can understand how the change in a state function (dU) can be equivalent to a change in the sum of two process variables (δQ and δW).