Chapter V :

Third Law Of Thermodynamics

1. Introduction :

You might ask, what is the Third Law of Thermodynamics? In a simple and straight-forward explanation, it states that the entropy of a perfect crystal of a pure substance approaches zero as the temperature approaches absolute zero.

2. The Basic Concept of Third Law of Thermodynamics

The third law of thermodynamics states that the entropy of a pure substance in a perfect crystalline state at zero temperature is zero. The third law of thermodynamics defines that the temperature of a system proceeds towards absolute zero, but its entropy becomes constant, or the change in entropy is zero. The third law of thermodynamics forecasts the behavior of entropy and the properties of a system in a unique environment, known as absolute temperature. This law assists in computing the absolute entropy of a substance at any given temperature. This resoluteness is traditionally based on heat capacity measurements.

3. Explanation of Third Law of Thermodynamics:

As the temperature of any system decreases, the atom and molecules in the system lose their energy and approach their lowest energy points, by doing so atom & molecule's kinetic energy decreases and hence their random motion.

Since Entropy is the measurement of the randomness of any closed system. So, when absolute zero temperature is achieved, the atom and molecules of the crystal have the lowest energy and hence no randomness in the particles. So, zero entropy of the system was observed.

4. Mathematical Application:

Let for any solid S^0_0 is entropy at zero kelvin and S is entropy at T kelvin.

So, $\Delta S = S - S_0$

$$\Delta S = \int_0^T \frac{C_p}{T} dt$$

Also, we know

Since $S_0 = 0$ at by third law.

$$\Delta S = \int_0^T \frac{C_p}{T} dt$$

So,

By this we can calculate the absolute entropy of any solid at temperature T.

5. Application of the Third Law of Thermodynamics :

Applying the third law of thermodynamics helps calculate the absolute entropy at any temperature 'T' These calculations are based on the heat capacity measurements of the substance.

There are two major applications of the third law of thermodynamics, which are given below.

1. The third law of thermodynamics is used. It helps to find if substances are pure crystalline or not?
2. It helps find the absolute entropy related to substances at a specific temperature.

The third law of thermodynamics refers to perfectly crystalline substances to find whether the substance is pure crystalline or not. It defines the entropy of a perfectly Crystalline substance that might be zero at Kelvin temperature. If the substance is not perfectly crystalline, its entropy will not be zero at 0 Kelvin temperature.

Such substances will not be purely crystalline substances. The substances will be imperfect within their crystal structure and show some disorders. Thus, whether the substances are purely crystalline or not could be found.

To find the absolute entropies of substances at a given temperature, utilizing the third law of thermodynamics. The comparison over entropies of a given substance at T temperature with the entropy of that substance at zero Kelvin temperature. We should estimate the changes within entropies between the temperatures.

6. Contradiction with the other laws of Thermodynamics :

The third law of thermodynamics defines absolute zero as a state, whereas the second Law of Thermodynamics denotes that the temperature can never become zero. Based on the second law, the heat cannot spontaneously be moved from a colder body to a hotter body. If a system tries to reach absolute zero, its actual tendency is to draw heat from an external environment, and if it happens. As a result, it will never reach absolute zero.

On the other hand, the first law defines that energy can neither be created nor be destroyed. In that case, the heat energy has to be drawn from outside the system, which ends the chances of the system reaching absolute zero.

7. Conclusion :

In the above content, we have discussed the importance of absolute zero and entropy and how these two aspects make up the third law of thermodynamics. This law states that absolute zero temperature is not possible in physics. This is often overlooked whenever anybody tries to attain zero temperature and regains temperature from the external environment and other sources. Hence, this law is highly intuitive to real-life applications.