THERMODYNAMICS

THERMAL EQUILIBRIUM

We've all felt the warmth of a fire, the sun's heat, or the hotness of a coffee cup. Similarly, we've experienced the coldness of a soda can or a dip in the bathtub. But have you ever wondered why this happens? What does it mean to be hot or cold, and how does it connect to temperature? How does our body react when we touch something hot or cold? Well, we're going to explore all of this in a section called "thermal equilibrium." In simple terms, thermal equilibrium helps us understand the relationship between heat and temperature. So, let's get started without any delay!

Thermal Equilibrium

When two things are in "thermal equilibrium," it means that heat doesn't move between them when they're connected in a way that allows heat to move. This idea follows something called the "Zeroth Law of Thermodynamics." When things are in thermal equilibrium, it means they have the same temperature.

For example, if you put a hot mug of water in the freezer, the hot water cools down over time until it's as cold as the freezer. This cooling process is an example of thermal equilibrium. It's like when both things agree on the same temperature, and heat doesn't flow between them anymore.

Thermal Equilibrium Definition

Thermal equilibrium is when two things, connected by something that lets heat move between them, don't exchange heat, and they both have the same temperature. Think of temperature as a way to measure how fast the tiny particles inside something are moving. When two things touch, the faster-moving particles from the hotter thing bump into the slower-moving particles of the cooler thing. This bumping around transfers heat, and the temperatures of both things slowly become equal.

Thermal Equilibrium and Thermodynamic Equilibrium

When we talk about a system being in "thermodynamic equilibrium," it means that there are no big changes happening, like changes in heat, energy, and other stuff we can measure. We figure out if a body is in thermodynamic equilibrium by looking at its temperature, pressure, volume, and mass, among other things.

Being in thermodynamic equilibrium is a bit like how a moving car stays moving unless something makes it stop. A body in thermodynamic equilibrium tends to stay the way it is without changing on its own. To be in this state, it has to meet three conditions:.

1. Mechanical equilibrium: It means there are no big forces making it move or stop.

2. Chemical equilibrium: This happens when there's no chemical activity or reactions happening.

3. **Thermal equilibrium:** To be in thermal equilibrium, it needs to have the same temperature all over, and there shouldn't be any heat moving in or out from the surroundings.

Keep in mind that for a body to be in thermal equilibrium, it must have the same temperature everywhere, and there shouldn't be any heat exchange happening with its surroundings. But just because a body is in thermal equilibrium doesn't mean it's in thermodynamic equilibrium; it needs to meet all those other conditions too.

Thermal Equilibrium Equation

To figure out when two things in contact have the same temperature, you can use this formula:

$$Q = m.c.\Delta T.$$

Here's what each part means:

Q: This is the total energy in joules.

m: It represents how much stuff you have, like the mass of the objects.

c: This is something called "specific heat," which tells you how much heat energy it takes to raise the temperature of a certain amount of stuff by one degree. It's measured in joules per kilogram per kelvin (J/kg·K).

Specific heat is a unique property of a substance. It doesn't depend on how the stuff looks, how much of it there is, or what shape it has. It's always the same for that substance.

Thermal Equilibrium of Earth (For competitive exam)

To keep Earth habitable for us and other living things, it needs to stay at a stable temperature. This means the heat from the sun that comes into the Earth's atmosphere should be balanced by the heat leaving it. But, in reality, this balance doesn't always happen.

Because of things like greenhouse gases and harm to the environment, the Earth's ability to let heat escape into space has slowed down. This makes the planet get hotter. Greenhouse gases are important because they help keep our planet at a temperature we can live on, not too hot or too cold. However, when we release too much carbon dioxide, methane, and nitrogen dioxide, it messes up the way heat moves in and out of the Earth's atmosphere.

This change in how heat flows has led to problems like global warming, environmental crises, melting icebergs, and rising sea levels.