

# The Laws of Thermodynamics

**ZEROTH LAW:** If two systems are in thermal equilibrium with a third system, they must be in thermal equilibrium with each other.

**FIRST LAW:**

An equilibrium macrostate of a system can be characterized by a quantity  $U$  called internal energy.

If isolated  $\longrightarrow U = \text{const}$

If allowed to interact  $\longrightarrow \Delta U = Q - W$   
HEAT WORK

**SECOND LAW:**

- Heat is transferred spontaneously from a hot object to a cold object.

$\Leftrightarrow$

- An equilibrium macrostate of a system can be characterized by a quantity  $S$  called entropy which has the property that:

If isolated  $\longrightarrow \Delta S \geq 0$

If not isolated and undergoes a slow infinitesimal process in which it absorbs heat  $dQ$

$$\longrightarrow \Delta S = \frac{dQ}{T}$$

### THIRD LAW:

The entropy of a system has the following property:

$$\text{As } T \rightarrow 0 \quad S \rightarrow S_0$$

(where  $S_0$  is