THERMODYNAMICS

Thermodynamics deals with energy interactions between two bodies & its effect on the properties of matter.

SCOPE OF THERMODYNAMIC

- Feasibility of a process
- Extent of a process
- Efficiency of a process

SYSTEM

The part of the universe under thermodynamical observation is called system.

SURROUNDINGS

All the part of the universe except system is called surroundings.

BOUNDARY

The part which separates system and surroundings is called boundary. It may be rigid or flexible.

TYPES OF THERMODYNAMIC PROCESSES

- **QUASI-STATIC PROCESS**

  Arbitrarily slow process such that the system always stays arbitrarily close to thermodynamic equillibrium.

- **REVERSIBLE PROCESS**

  Any changes induced by the process in the universe (system + environment) can be removed by retracing its path.

  Reversible processes must be quasi-static.

- **IRREVERSIBLE PROCESS**

  Any process in which a part or whole of process is not reversible.

  E.g. : any process involving friction, free expansion of gas etc.

BASIC THERMODYNAMIC PROCESS

- **ISOBARIC:** Constant **P**

  $W = p\Delta V$

- **ISOTHERMAL:** Constant **T**

  $\Delta U = 0$ (for ideal gases)

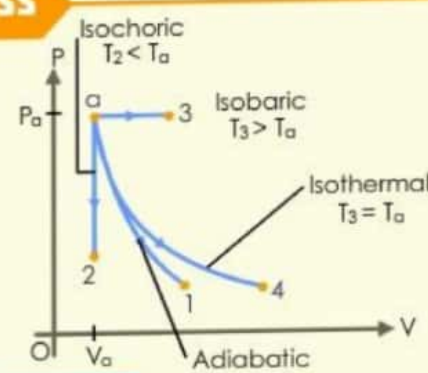
- **ISOCHORIC:** Constant **V**

  $W = 0$

- **ADIABATIC:** No heat exchange

  $Q = 0$

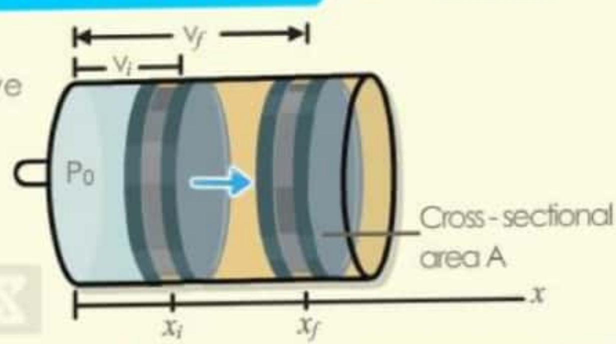
- There are an infinite number of **other processes** without any special name!



WORK DONE IN THERMODYNAMIC PROCESS

Work done compressing a system is defined to be positive

$$W_{Vi-Vf} = \int_{Vi}^{Vf} PdV = P_0 \int_{Vi}^{Vf} PdV = P_0.W_{Vi-Vf}$$

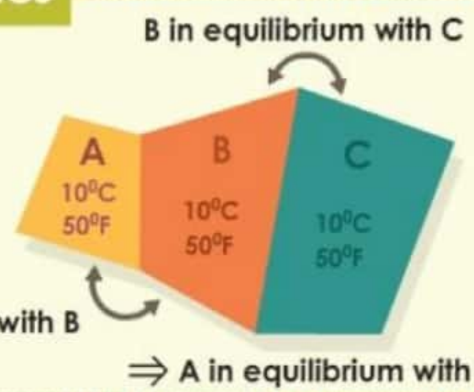


THERMODYNAMICS LAWS

The branch of physical science that deals with the relations between heat and other forms of energy (such as mechanical, electrical or chemical energy) and by extension of relationship between them.

ZEROTH LAW OF THERMODYNAMICS

If two systems are in thermal equilibrium with a third system, then they all are in thermal equilibrium with each other. This law helps define the notion of temperature.

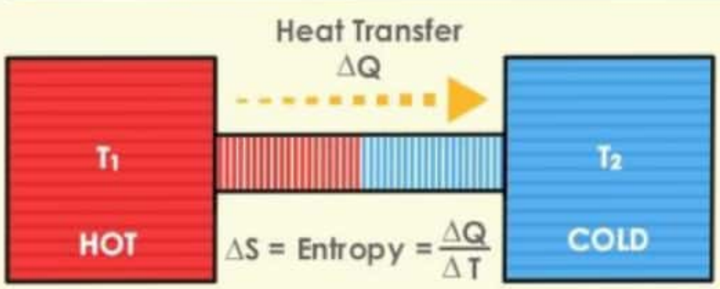


THE FIRST LAW OF THERMODYNAMICS

The first Law of thermodynamics states that overall amount of energy is Conserved. Therefore, energy cannot be created or destroyed, only lost to an outside system.

$$\Delta U = Q - W$$

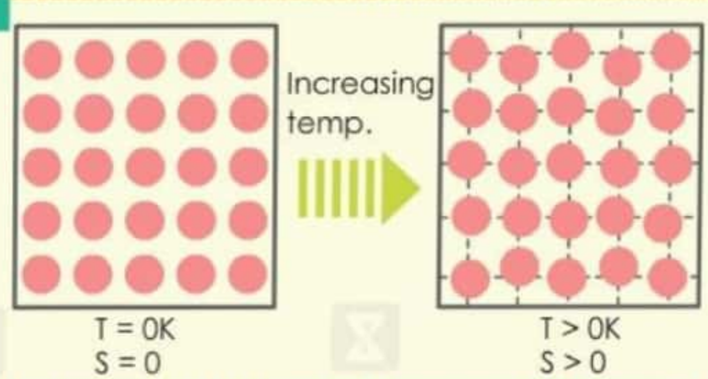
THE SECOND LAW OF THERMODYNAMICS



This law states that energy naturally flows from hotter objects to cooler objects. In order for energy to flow from a cooler object to a hotter object, work must be done. When heat is converted into work, the efficiency or output of usable work will always be less than 100%.

THE THIRD LAW OF THERMODYNAMICS

The entropy of a system approaches a constant value as the temperature approaches absolute zero. With the exception of non-crystalline solids (glasses), the entropy of a system at absolute zero is typically close to zero and is equal to the logarithm of the product of the quantum ground states.



EXOTHERMIC Vs ENDOTHERMIC

An exothermic reaction occurs when the temperature of a system increases due to the evolution of heat.

An endothermic reaction occurs when the temperature of an isolated system decreases while the surroundings of a non-isolated system gains heat.

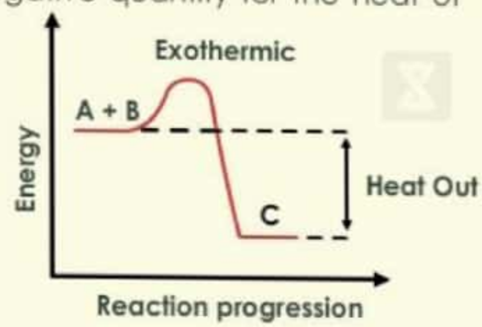
EXOTHERMIC

Heat is released into the surroundings, resulting in an overall negative quantity for the heat of reaction.

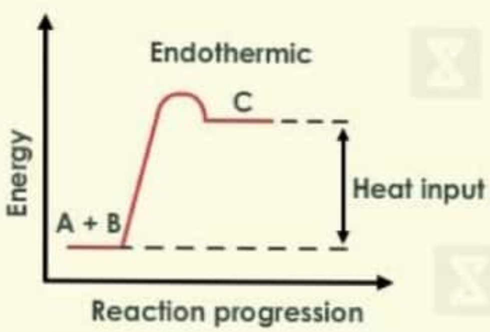
An exothermic reaction has a negative **ΔH** by convention, because the enthalpy of the products is lower than the enthalpy of the reactants of the system.

$C(s) + O_2(g) \rightarrow CO_2(g) \quad (\Delta H = -393.5\ kJ)$

The enthalpies are **less than zero.**



ENDOTHERMIC



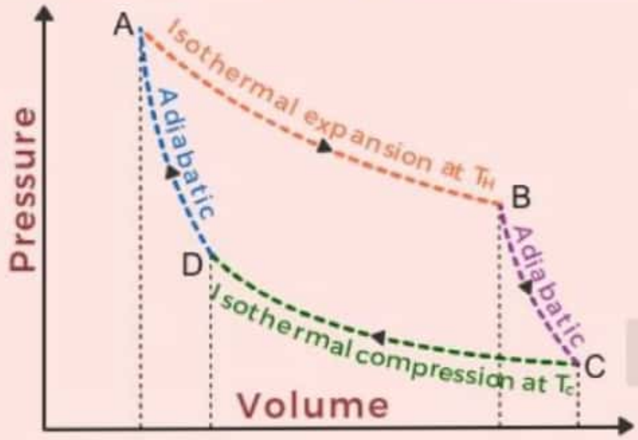
Endothermic reactions result in an overall positive heat of reaction.

An endothermic reaction has a positive **ΔH,** because the enthalpy of the products is higher than the enthalpy of the reactants of the system.

$N_{2(g)} + O_{2(g)} \rightarrow 2NO_{(g)} \quad (\Delta H = +180.5\ kJ)$

EXOTHERMIC	ENDOTHERMIC
Making ice cubes	Melting ice cubes
Formation of snow in clouds	Conversion of frost to water vapour
Condensation of rain from water vapour	Evaporation of water
A candle flame	Forming a cation from an atom in the gas phase
Mixing sodium sulphite and bleach	Baking bread
Rusting iron	Cooking an egg
Burning sugar	Producing sugar by photosynthesis
Forming ion pairs	Separating ion pairs
Combining atoms to make a molecule in the gas phase	Splitting a gas molecule apart
Mixing water and strong acids	Mixing water and ammonium nitrate
Mixing water with an anhydrous salt	Making an anhydrous salt from a hydrate
Crystallizing liquid salts (as in sodium acetate in chemical handwarmers)	Melting solid salts

CARNOT CYCLE

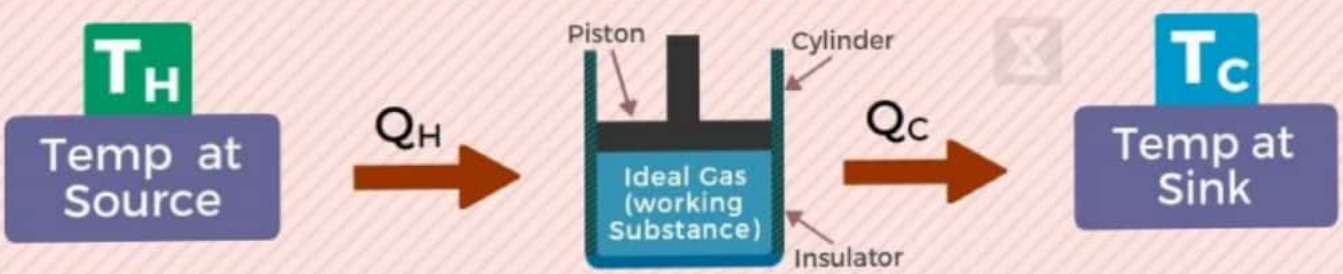


A Carnot heat engine is an engine that operates on the **reversible Carnot cycle**. The basic model for this engine was developed by **Nicolas Léonard Sadi Carnot** in 1824.

It is an ideal **heat engine** whose efficiency is less than 100%.

$$\text{Efficiency of Carnot Engine} = \frac{T_H - T_C}{T_H} \times 100\%$$

PARTS OF CARNOT ENGINE



Carnot engine diagram shows that an amount of heat 'Q_H' flows from a **high temperature** 'T_H' furnace through the fluid of the **"working body"** (ideal gas) and the remaining heat 'Q_C' flow into the cold sink 'T_C', thus forcing the working substance to do mechanical work 'W' on the surroundings, via cycles of contractions and expansions.

CYLINDER

It is a hollow cylinder whose walls are bad conductors of heat, and its base is a good conductor of heat.

PISTON

It is a movable piston which is fixed in a hollow cylinder. We neglect the friction force between the piston and walls of the cylinder.

SINK

It is a low-temperature reservoir; system rejects heat to the sink during iso-thermal compression. The thermal capacity of the sink is infinity.

SOURCE

It is a perfect insulator in which thermal conductivity is zero. System is placed on an insulator during adiabatic expansion and adiabatic compression.

INSULATOR

It is a high-temperature reservoir; system absorbs heat from the source during iso-thermal expansion. The thermal capacity of the source is infinity.