CHAPTER

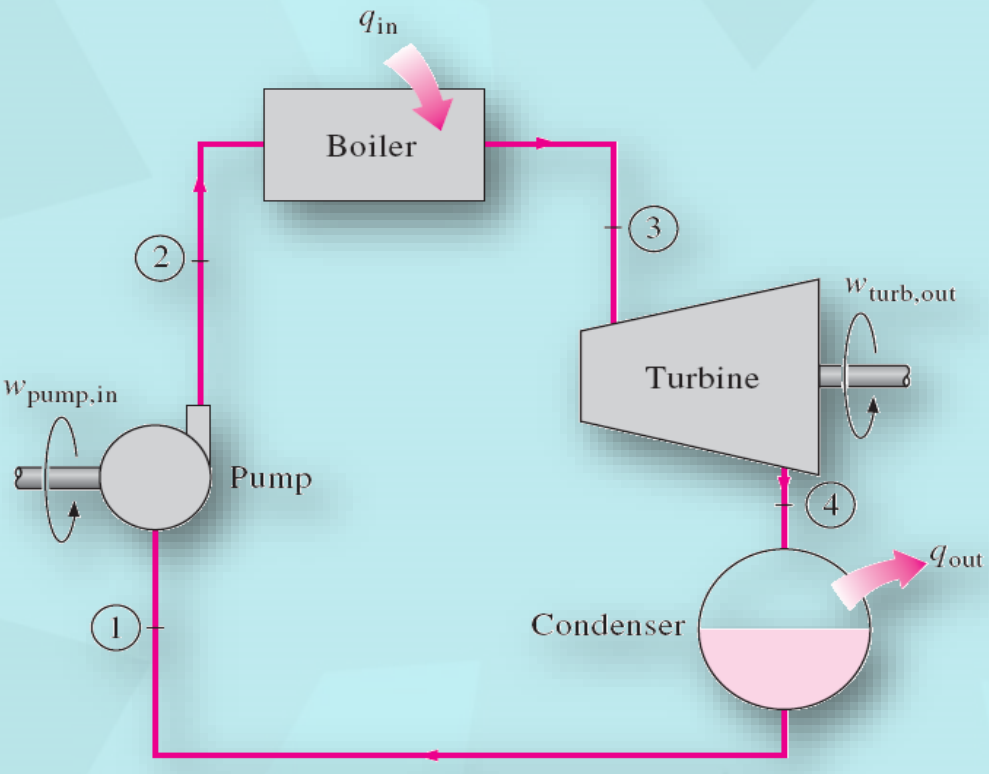
1

MRAC 311 Thermodynamics

Fundamental Concepts

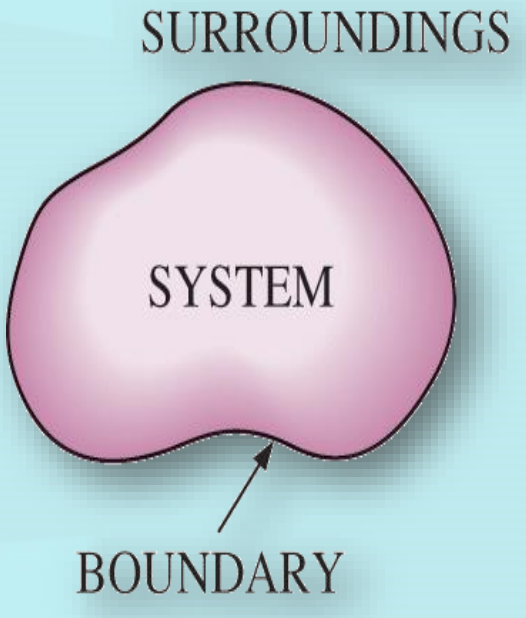
What is Thermodynamics?

- The science of energy, that concerned with the ways in which energy is stored within a body.
- Energy transformations – mostly involve heat and work movements.
- The Fundamental law is the *conservation of energy* principle: energy cannot be created or destroyed, but can only be transformed from one form to another.

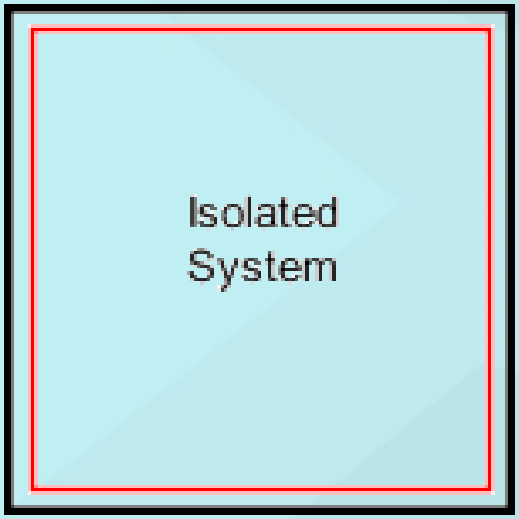


System, surroundings and boundary

- **System**: A quantity of matter or a region in space chosen for study.
- **Surroundings**: The mass or region outside the system
- **Boundary**: The real or imaginary surface that separates the system from its surroundings.

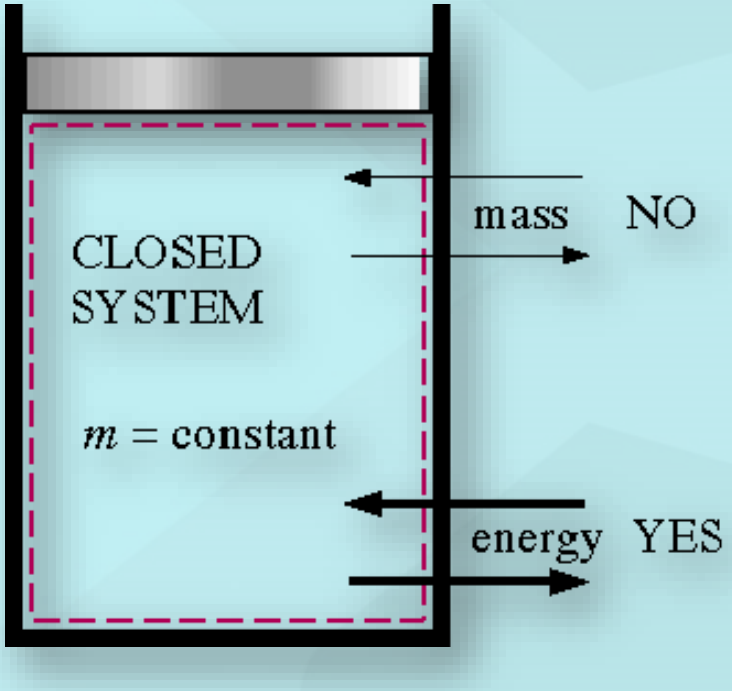


Type of system
(isolated system)



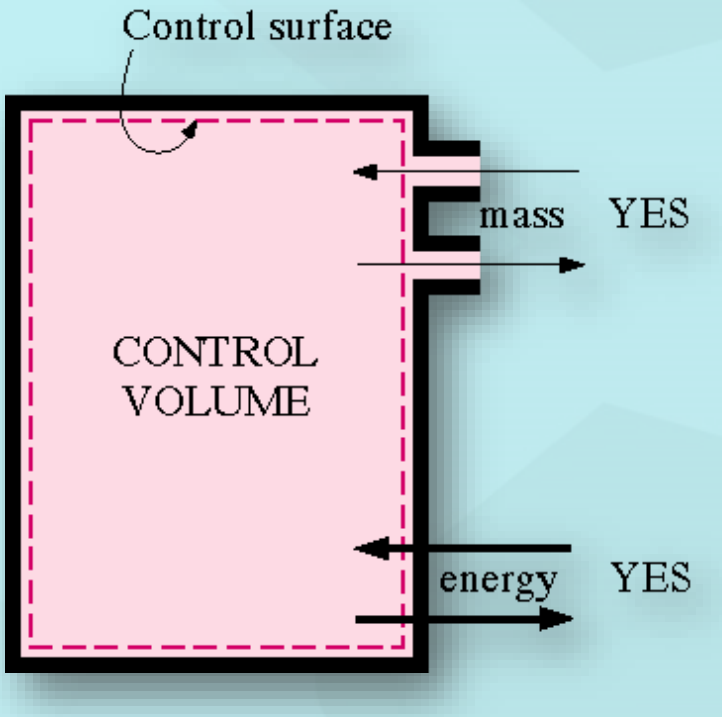
- Isolated system – neither mass nor energy can cross the selected boundary
- Example (approximate): coffee in a closed, well-insulated thermos bottle

Type of system
(Closed system)



- Closed system – only energy can cross the selected boundary
- Examples: a tightly capped cup of coffee

Type of system
(Open system)



- Open system – both mass and energy can cross the selected boundary
- Example: an open cup of coffee

Properties of a system

Properties of a system is a measurable characteristic of a system that is in equilibrium.

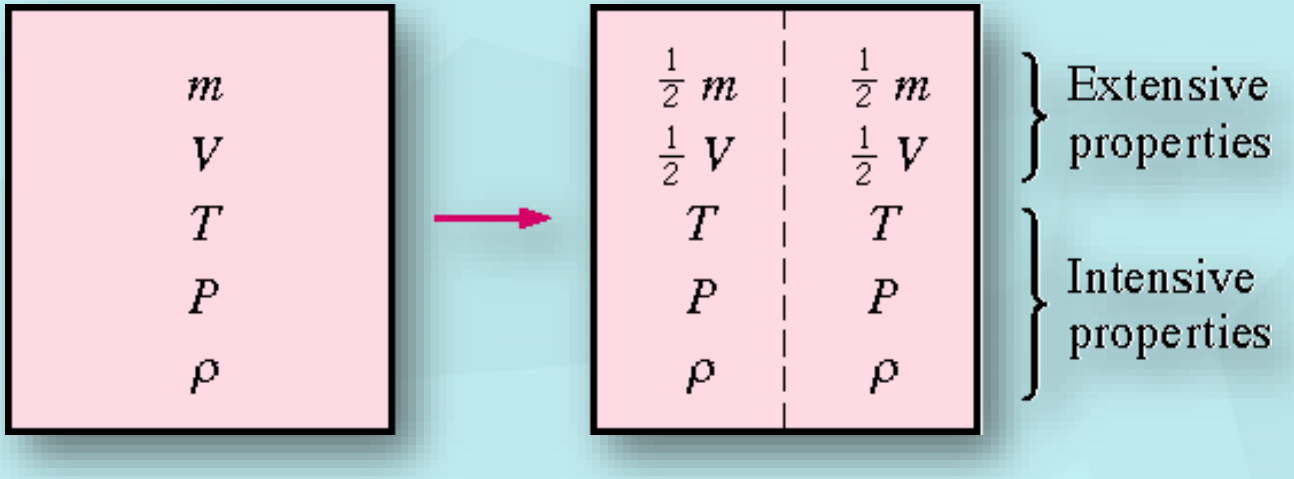
Properties may be intensive or extensive.

- **Intensive – Are independent of the amount of mass:**

e.g: Temperature, Pressure, and Density,

- **Extensive – varies directly with the mass**

e.g: mass, volume, energy, enthalpy



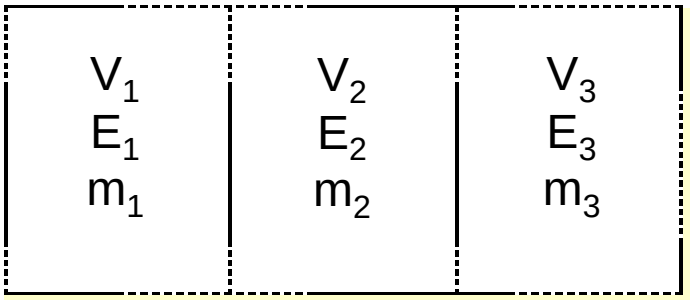
Properties of a system

Specific properties – The ratio of any extensive property of a system to that of the mass of the system is called an average specific value of that property (also known as intensives property)

• Specific Volume	$v=V/m$	m^3/kg
• Density	$\rho=m/V=1/v$	kg/m^3
• Specific Energy	$q=Q/m$	J/kg
• Specific Internal Energy	$u=U/m$	J/kg
• Specific Enthalpy	$h=H/m$	J/kg
• Specific Entropy	$s=S/m$	J/kg.K
• Specifc Heat	C_p, C_v	J/kg.K
• Ideal Gas Constant	C_p-C_v	J/kg.K

Classes of properties

Box with 3 sections after equilibrium



Extensive: Total :

$$V = V_1 + V_2 + V_3$$

$$E = E_1 + E_2 + E_3$$

$$m = m_1 + m_2 + m_3$$

Intensive: not size independent

$$v = v_1 = v_2 = v_3 = V/m$$

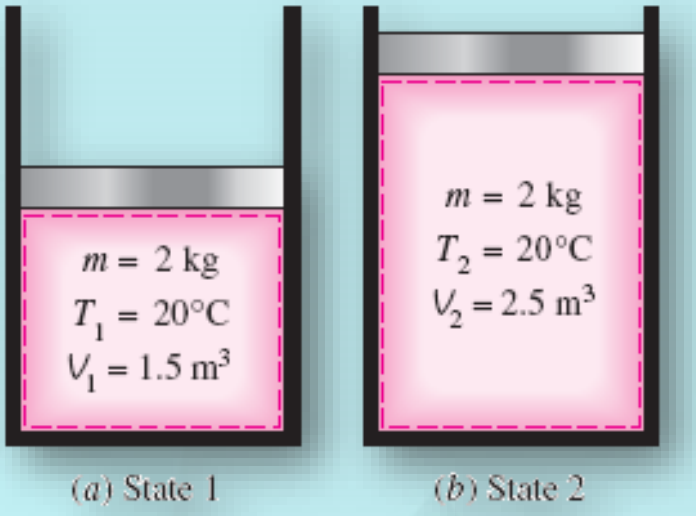
$$e = e_1 = e_2 = e_3 = E/m$$

$$T, P$$

State, Equilibrium and Process

- State – a set of properties that describes the conditions of a system. E.g. Mass m, Temperature T, volume V

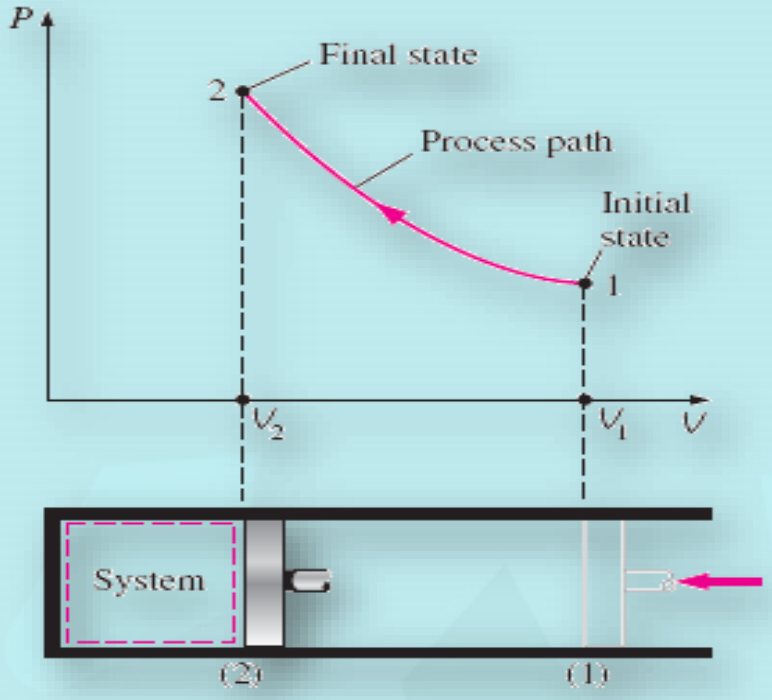
- Thermodynamic equilibrium - system that maintains thermal, mechanical, phase and chemical equilibriums.



State, Equilibrium and Process

- Process – change from one equilibrium state to another.

Process	Property held constant
isobaric	pressure
isothermal	temperature
isochoric	volume
isentropic	entropy

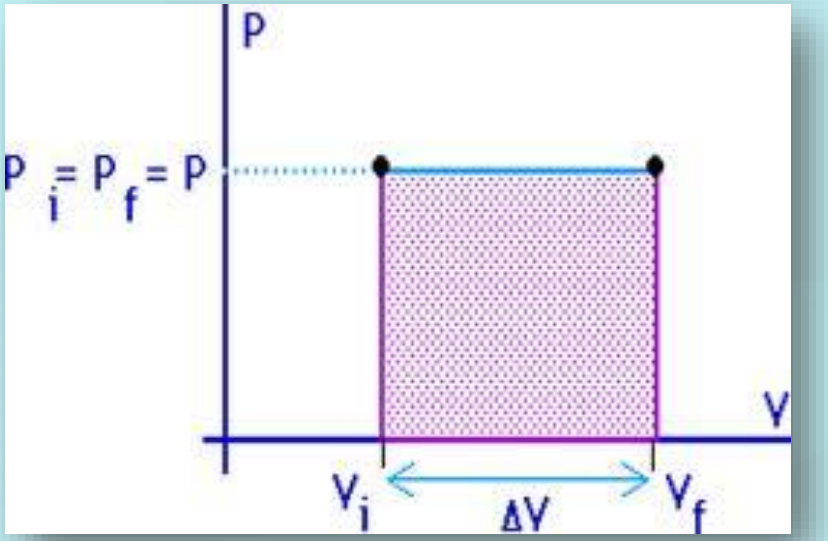


State, Equilibrium and Process

The prefix *iso-* is often used to designate a process for which a particular property remains constant.

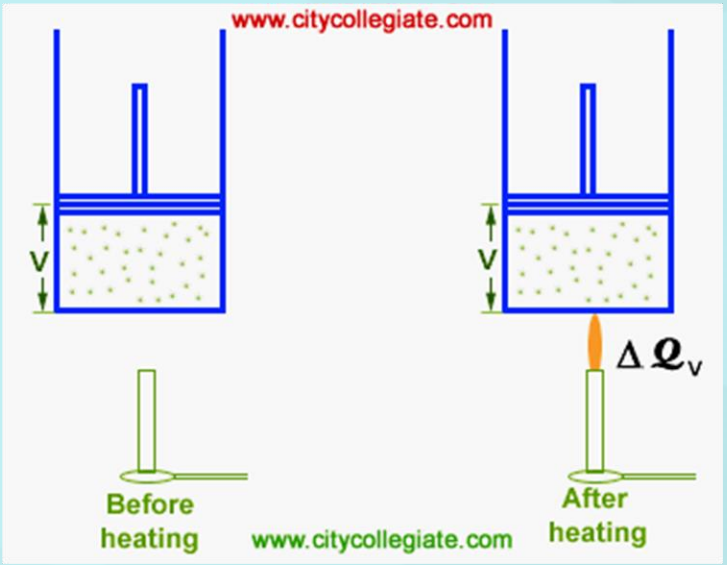
Isobaric process: A process during which the pressure *P* remains constant.

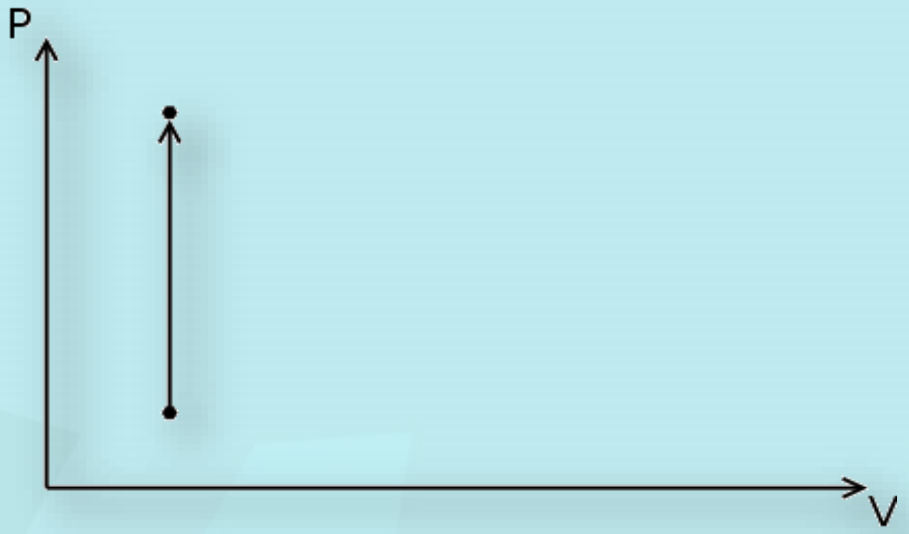
Pressure is Constant (**ΔP = 0**)



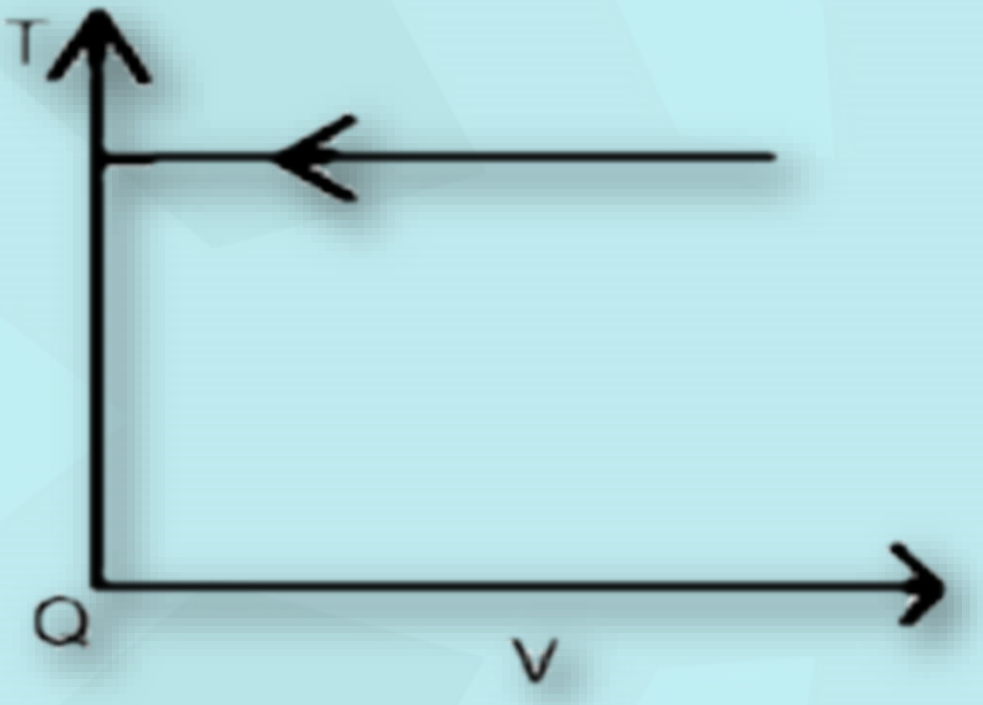
State, Equilibrium and Process

Isochoric (or isometric) process: A process during which the specific volume v remains constant



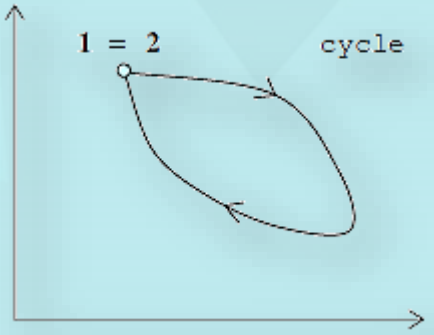


Isothermal process: A process during which the temperature *T* remains constant.



Types of Thermodynamics Processes

- **Cyclic process** - when a system in a given initial state goes through various processes and finally return to its initial state, the system has undergone a cyclic process or cycle.



- **Reversible process** - it is defined as a process that, once having take place it can be reversed. In doing so, it leaves no change in the system or boundary.

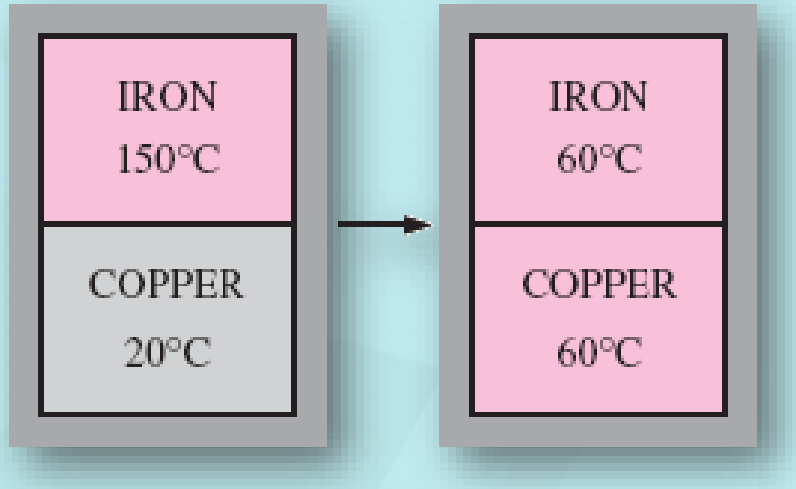
- **Irreversible process** - a process that cannot return both the system and surrounding to their original conditions

Types of Thermodynamics Processes

- **Adiabatic process** - a process that has no heat transfer into or out of the system. It can be considered to be perfectly insulated.
- **Isentropic process** - a process where the entropy of the fluid remains constant.
- **Polytropic process** - when a gas undergoes a reversible process in which there is heat transfer, it is represented with a straight line, PV^n = constant.
- **Throttling process** - a process in which there is no change in enthalpy, no work is done and the process is adiabatic.

Zeroth Law of Thermodynamics

" *If two bodies are in thermal equilibrium with a third body, there are also in thermal equilibrium with each other.*"



Two bodies reaching thermal equilibrium after being brought into contact in an isolated enclosure.

Application Areas of Thermodynamics