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Introduction to Basics of Thermodynamics

Introduction to Basics of Thermodynamics

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Learning outcome

After completing this slide show, one can explain

- What is thermodynamics?
- Scope of thermodynamics
- Limitations of thermodynamics
- Basic terms of thermodynamics
- Zeroth law, ideal gas temperature scale
- Joule's experiment
- First law of thermodynamics
- Internal energy
- State function and path function
- Reversible and irreversible processes

What is Thermodynamics?

- Thermodynamics is a branch of physics concerned with heat and temperature and their relation to energy and work.
- The word thermodynamics originates from Greek (*therme* : heat and *dynamics* : force)
- It is concerned with quantification of inter – relation between energy and change of state of any real world system.
- The extent of such change of state due to transfer of energy to or from the system is captured through the basic equation of thermodynamics which are derived starting from a set of fundamental observations known as ‘Laws of Thermodynamics’

Scope of thermodynamics

- The heat and work effects accompanying a physical or chemical process can be accurately predicted using thermodynamic calculations.
- Thermodynamic sets certain limits to the various processes occurring in nature.
- It also helps to determine that whether a proposed process is possible or not, it deals with direction of change and equilibrium.

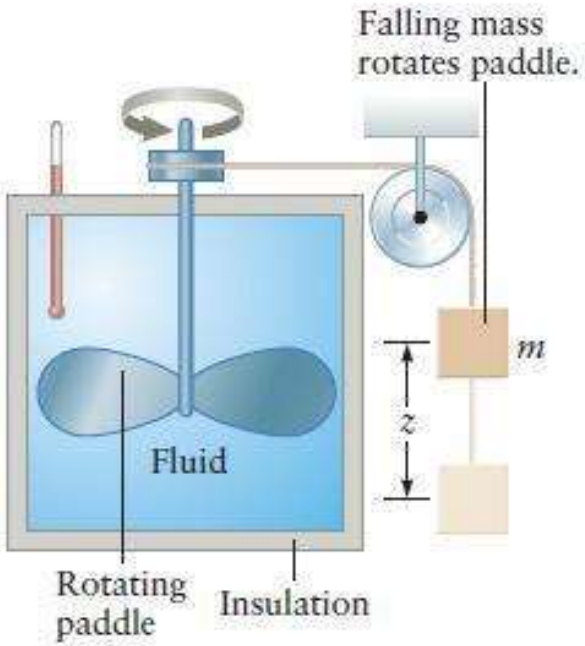
Limitations of thermodynamics

- Though thermodynamics can tell us whether a chemical reaction is possible or not, it cannot say whether a possible reaction will actually occur or not.
- Thermodynamic can predict the minimum work required in a process, but the actual work requirement can be determined only if we know the losses like friction that are unavoidable.

Temperature and zeroth law of themodynamics:

- Zeroth law
- Temperature

Joule's experiment



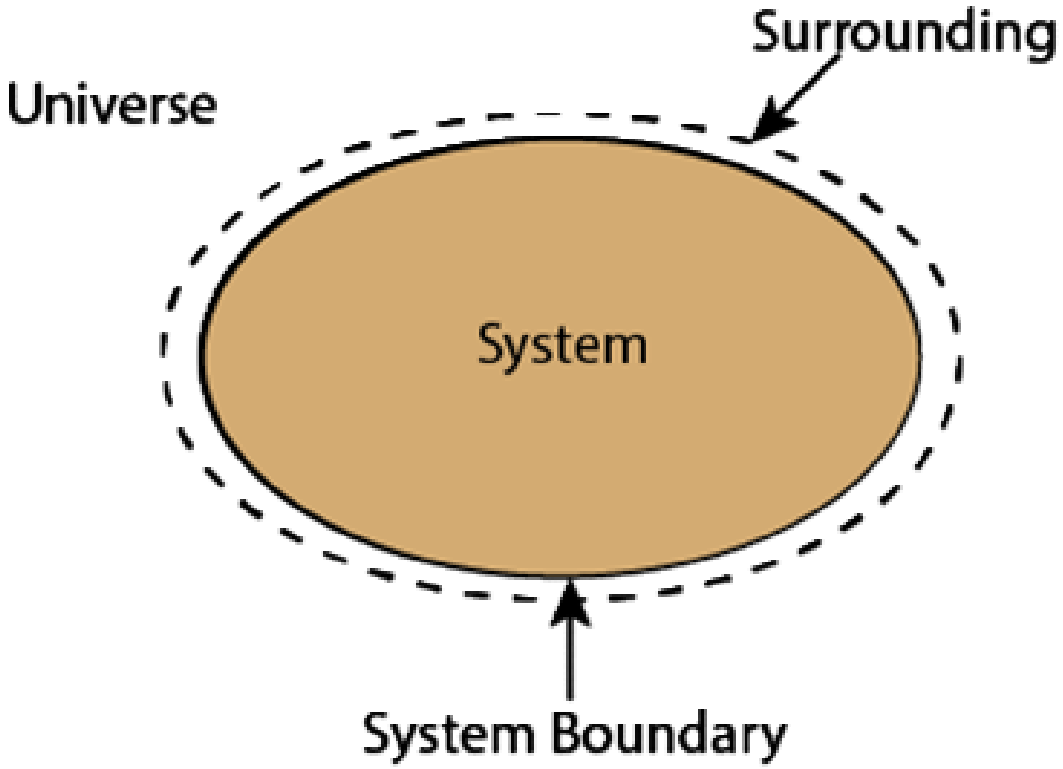
Apparatus used to measure the relation between heat energy and mechanical energy. See Insight

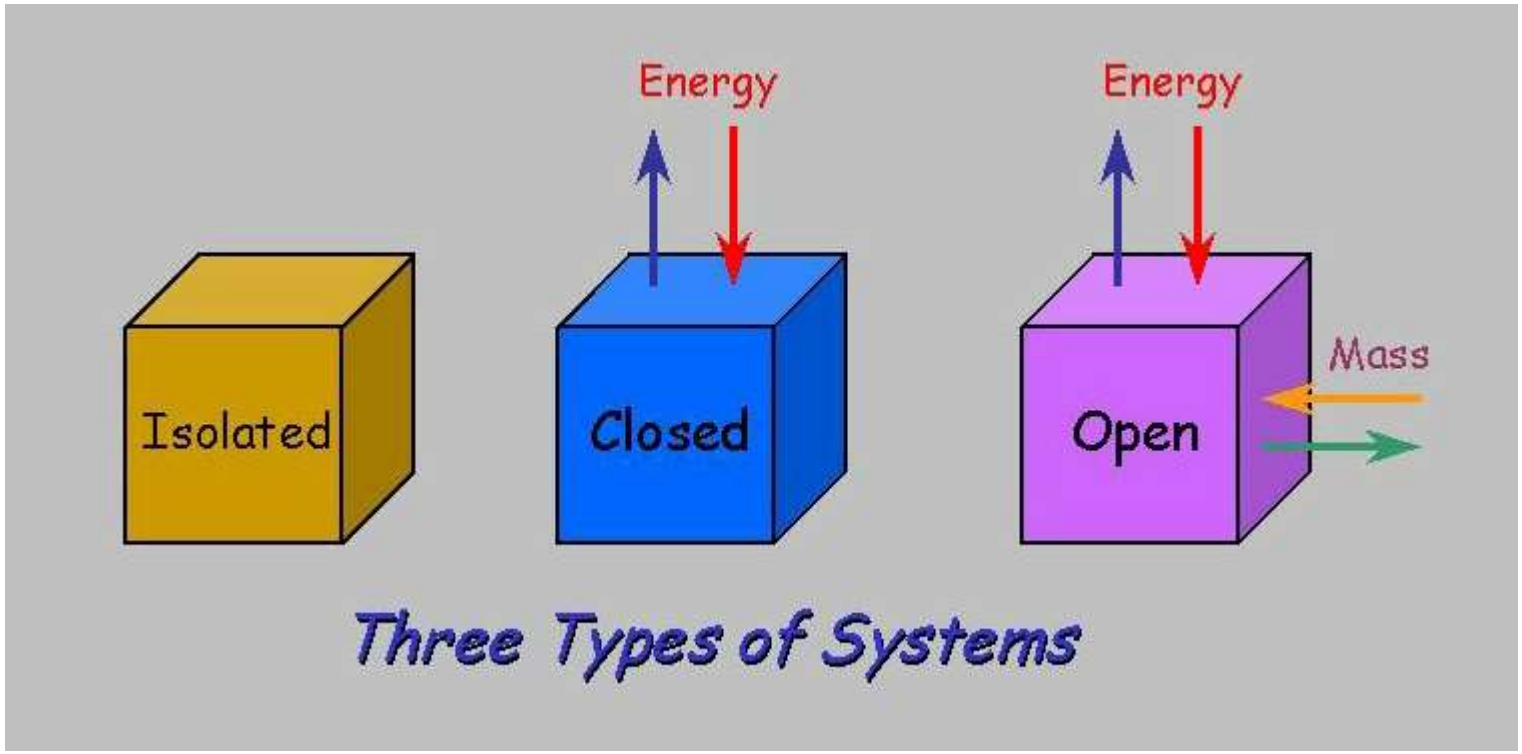
Insight

THE EQUIVALENCE OF MECHANICAL ENERGY AND HEAT ENERGY

In the 1840s, James Joule measured the "mechanical equivalent" of heat energy with an apparatus like the one shown in the figure . As a mass falls through a height z, its potential energy is used to rotate a propeller in a liquid. The propeller's motion heats the liquid, increasing the liquid's temperature. According to the principle of conservation of energy, the change in potential energy of the mass is converted to heat energy. In this way, Joule was able to relate the unit used at that time for heat energy (the calorie) to the unit of mechanical energy (the joule).

System and surrounding




Energy
Energy
Isolated
Closed
Open
Mass
Three Types of Systems

Intensive and extensive properties

- Intensive property: It is the property of matter that is independent of quantity of matter.

  Example: Temperature, specific volume etc.

- Extensive property: It is the quantity of matter that is dependent on quantity of matter.

  Example: volume, heat capacity

State function and path function

- State function: A state function is a property whose value does not depend on the path taken to reach that specific value.
- Path function: Path functions are properties or quantities whose values depend on the transition of a system from the initial state to the final state.

Internal Energy

- The energy stored in the system by virtue of the configuration and motion of the molecules constituting the system is called its internal energy.

First law of thermodynamics:

- Although energy assumes many forms, the total quantity of energy is constant, and when energy disappears in one form it appears simultaneously in other forms.

Enthalpy:

- $H = U + PV$

Reversible and irreversible process:

- Reversible Process: a reversible process is a process whose direction can be reversed by infinitesimal changes in some property of the system.
- Irreversible Process: a process that is not reversible is called irreversible process. A change in the thermodynamic state of a system and all its surroundings can not be precisely restored to its initial state by infinitesimal changes in some property of the system without expenditure of energy.

Phase Rule:

$$F = 2-\Pi+N$$

F = Degree of freedom

Π= No. of phases

N = No. of chemical species