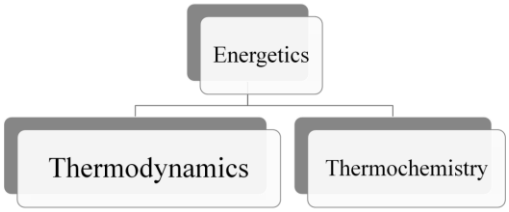
Chapter 8

Energetics

Day - 1

Energetics is the branch of science which deals with the properties of energy and the way in which it is redistributed in physical, chemical, or biological processes.

1. If we put two or more substances ,will they react
2. What will be the energy change in this reaction
3. Will equilibrium be establish in this reaction, if yes the concentration of reactants of products at the equilibrium

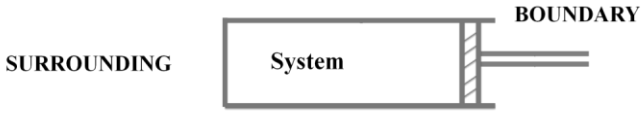


THERMODYNAMICS

It does not tell us

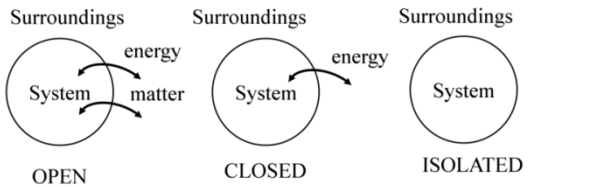
1. The rate at which this reaction take place
2. The microscopic or atomic change in the system. (thermodynamics applies only to bulk and not internal structure of atoms/molecules)

System, surrounding and boundary



System: Is the specific part of universe which is under study or experimental investigation
Surrounding: the rest of the universe, which is not system is surrounding.
System + Surrounding = Universe
Boundary: System & surrounding are separated by boundary. The boundary may be real or imaginary; rigid or flexible; conducting or non-conducting.

TYPES OF SYSTEM



System	Exchange of energy	Exchange of matter
Open	Yes	Yes
Closed	Yes	No
Isolated	No	No

Types of system based on composition:

1. **Homogeneous** system: is that which is completely uniform throughout. …. It exists in one phase only ex: true solution, mixture of gases
2. **Heterogeneous** system: is that which not uniform throughout and It may have two or more than two phase. ex. sand water; mud and water

Types of variables

Variables: are those parameters which are studied or recorded for the system

Types of variable

Intensive	Extensive
Those properties whose value is independent of quantity, or size of matter Ex. Temperature, density	Those properties whose value depends on the quantity or size of matter Ex. Volume , interned energy

can also be classified in following way

state variable	non-state variable
1. These depend on the state of system but not on how it has been reached ex. Pressure , temperature, Internal energy, enthalpy	These depend on the path of system and also the state work done , heat transfer

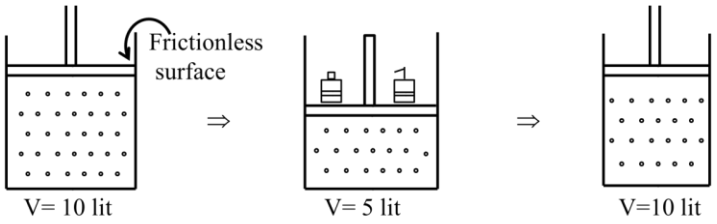
PROCESS OR PATHS

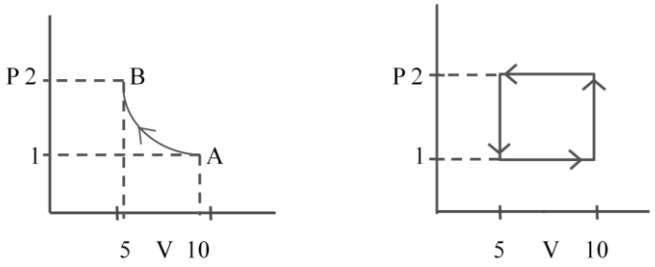
1. Isothermal: where temperature is constant or
   $\Delta T = 0$
2. Isobaric: where pressure is constant or
   $\Delta P = 0$
3. Isochoric: where volume is constant or
   $\Delta V = 0$
4. Adiabatic: where there is not transfer of heat to and fro from system
   $q = 0$
5. Cyclic: where we return to same point after some time. There are no changes in state variables

Reversible and Irreversible Process or paths

A reversible process is a process in which the system and environment can be restored to exactly the same initial states that they were in before the process occurred; if we go backward along the path of the process Processes other than reversible processes are known as irreversible processes

Reversible process:





Reversible process	Irreversible
It is s slow process going through a series of smaller stages with each stage maintaining equilibrium between the system and surroundings. In all the intermediate	It this process the system attains final state from the initial state with a measurable speed. During the transformation, there is no equilibrium maintained between the system and surroundings.
A reversible process can be made to process can be made to proceed in forward or backward direction.	Irreversible process can be take place in one direction only.
The driving force for the reversible process is small since the process proceeds in smaller steps.	There is a definite driving force required for the progress of the irreversible process.
Work done in a reversible process is maximum possible.	Work done is less than reversible process.
A reversible process can be brought back to the initial state without making an change in the adjacent surroundings.	An irreversible process cannot be brought back to its initial state without making a change in the surroundings

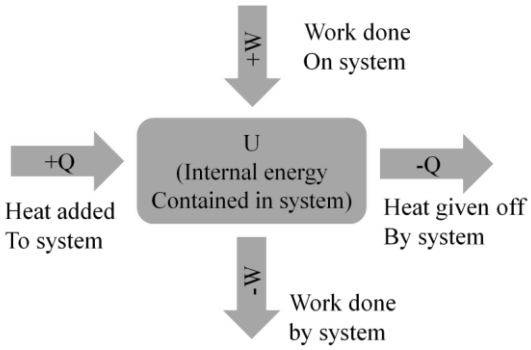
THERMODYNAMICS

Heat and work:
Both are forms of energy.
Both are non state variable.

QUESTIONS TO PONDER

Which travels faster Heat or Cold?
When you work on an exercise bicycle are you doing work?
Q + ve Endothermic system
Q + ve Exothermic system

SIGN CONVENTION OF HEAT



WORK

Work is of three types

1. Gravitational = weight x Δh = mgh
2. Electrical = charge x voltage = Q Xv
3. Mechanical = force x distance = F x Δx

W = F .Δx = P. Area.Δx = PΔV

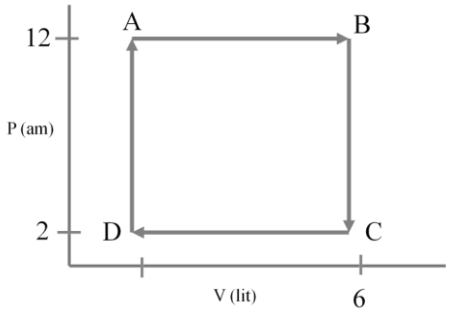
$W = -\int_{V_1}^{V_2} P_{ext} dv$ (-ve sign for convention)

Unit of w = joule, ergs cal. and Lit.atm

$1J = 10^7$ ergs

1 cal = 4.18 J

1 lit atm = 101.3 J = 24.2 cal.



Name the process in each line. find out work done in each (in Joules)

1. A → B
2. B → A
3. C → D
4. D → A
5. A → B → C → D

WORK

1. A → B Isobaric
   W = P (v2-v1) = 12 x (6-1) = - 60 lit atm
   = -6079.5 J

2. B $\rightarrow$ C Isochoric W = 0
3. C $\rightarrow$ D Isobaric W = -2(1-6) = + 10 litams
   = 1013.2 J
4. D $\rightarrow$ A Isochoric W = 0
5. Cyclic W = (W_{AB} + W_{BC} + W_{CD} + W_{DA})
   = -50 lit atm
   = - 5066.3 J.

WORK IN DIFFERENT PROCESSES

1. Isobaric :
   $$W = -\int_{v1}^{v_2} Pext\ dv = -P \int_{V1}^{V_2} dv$$
   = - P(V_2-V_1) or -PΔV
2. Isochoric : W = 0 as dv = 0
3. Isothermal reversible W = -$\int$ Pdv
   (for ideal gas) W = $-\int \frac{nRTdv}{v} = -nRT \int \frac{dv}{v}$
   = -nRT.ln $\frac{v_2}{v_1}$
   = -2.303 nRT log $\frac{v_2}{v_1}$
   For isothermal $P_1V_1 = P_2V_2$ W $\Rightarrow$ 2.303 nRT log $\frac{p_1}{p_2}$