

1 Write short note on ① reversible process and  
② irreversible process.

Ans:

① Reversible process:

A process occurs in which the system proceeds from an initial state  $i$  to a final state  $f$ ; the suspended object is lowered to an extent that  $W$  units of work are performed on the system. And a transfer of heat  $|Q|$  takes place from the system to the series of reservoirs. If at the conclusion of this process, the system may be restored to its initial state  $i$ , the object lifted to its former level and the reservoirs caused to part with the same amount of heat  $|Q|$ , without producing any changes in any other mechanical device or reservoir.

in the universe, the original process is said to be reversible. In other words, a reversible process is one that is performed in such a way that, at the conclusion of the process, both the system and the local surroundings may be restored to their initial states without producing any changes in the rest of the universe.

#### (ii) Irreversible process:

A irreversible process is one that is performed in such a way that, at the conclusion of the process, both the system and local surroundings may ~~not~~ be restored to their initial states. A process that does not fulfill these stringent requirements is said to be irreversible.

Q7] State the kinetic theory of gases:

The kinetic theory of gases was the result of the early nineteenth century work of Avogadro and Loschmidt, who calculated the number of atoms or molecules in a molar volume of a gas. In order to formulate a microscopic theory of gases, which will be limited to monatomic gases, several simplifying assumptions about the behavior of atoms of the ideal gas are made:

- i) Any small sample of gas consists of an enormous number of particles N. For any one chemical species, all atoms are identical and inert. If m is the mass of each atom, then the total mass is

$mN$ . If  $M$  denotes the molar mass in kilograms per mole then the number of moles  $n$  is given by

$$n = \frac{mN}{M}$$

The number of particles per mole of gas is called Avogadro's number  $N_A$ .

$$N_A = \frac{N}{n} = \frac{M}{m} = 6.0221 \times 10^{23} \frac{\text{particles}}{\text{mole.}}$$

(ii) The atoms of an ideal gas are assumed to exert no forces of attraction or repulsion on other atoms except when they collide with one another and with a wall. Between collisions, they therefore move with uniform rectilinear motion.

(iii) The atoms of an ideal gases are supposed to resemble small hard spheres that are in perpetual random motion. Within the temperature and pressure range of an ideal gas, the average distance between neighboring atoms is large compared with the size of an atom. The diameter of an atom is of the order of  $2 \text{ or } 3 \times 10^{-10} \text{ m}$ .

(iv) The portion of a wall with which an atom collides is considered to be smooth and the collision is assumed to be perfectly elastic. If  $w$  is the speed of an atom approaching a wall, only the perpendicular component of velocity  $w_+$  is changed upon collision with the wall, from  $w_+$  to  $-w_+$ , or a total change of  $-2w_+$ .

(v) When there is no external field of force, the atoms are distributed uniformly throughout a container. The number density  $N/V$  is assumed constant, so that in any small element of volume  $\delta V$  there are  $\delta N$  atoms, where

$$\delta N = \frac{N}{V} \delta V.$$

(vi) There is no preferred direction for the velocity of any atom, so that at any moment there are as many atoms moving in one direction as in another.

(vii) Not all atoms have the same speed. A few atoms at any moment move slowly and a few move very rapidly, so that speeds may be considered to

cover the range from zero to the speed of light.

(viii) The experimental equation of state of the ideal gas is given by

$$PV = nRT$$

$$(ix) T = \frac{2N}{3mR} \left( \frac{1}{2} m \langle w^2 \rangle \right) \dots \dots \text{(a)}$$

Equation (a) provides an interpretation of temperature based on kinetic theory: Temperature is proportional to the average kinetic energy of the atoms in the ideal gas. In kinetic theory, it is assumed that atoms behave as noninteracting particles, so the potential energy of their interaction may be neglected. Therefore, the internal energy  $U$  of the ideal monatomic gas

is the sum of the kinetic energies of all its atoms :

$$U = \sum_j \frac{1}{2} m w_j^2 = N \left( \frac{1}{2} m \langle w^2 \rangle \right).$$

Using equation (a) to replace the kinetic energy, we obtain a calculated expression for the internal energy of a monatomic ideal gas,

$$U = \frac{3}{2} n R T \dots \dots \text{(b)}$$

$n = \frac{N}{N_A}$ , where  $N_A$  is Avogadro's number,

thus,  $k = \frac{R}{N_A} = 1.3807 \times 10^{-23} \text{ J/K}$ ,

where  $k$  is Boltzmann's constant, given by

$$U = \frac{3}{2} \frac{N}{N_A} R T = \frac{3}{2} N k T$$

So, we can rewrite eq(a) for the average kinetic energy per particle,

$$\frac{1}{2}m\langle w^2 \rangle = \frac{3}{2}kT \dots \textcircled{c}$$

In this derivation, the average energy per atom  $\frac{1}{2}m\langle w^2 \rangle$ , is wholly kinetic energy of translation. This is only kind of energy that a hard, spherical atom, uninfluenced by its neighbors or fields, can possess.

It is worthwhile, at this point, to compare the symbolism used in our treatment of kinetic theory with that used in thermodynamics. This is shown in the equation of state for the ideal monatomic gas has a simple form, namely,

$$PV = nKT.$$

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state and explain the zeroth law of thermodynamics.

Ans:

The zeroth law of thermodynamics:

Two systems in thermal equilibrium with a third are in thermal equilibrium with each other. As suggested by Ralph Fowler, this postulate of transitive thermal equilibrium has been numbered the zeroth law of thermodynamics, which establishes the basis for the concept of the temperature and for the use of thermometers.

Explain: Imagine two system A and B, separated from each other by an adiabatic wall but each in contact simultaneously with a third system C through diathermic

walls, the whole assembly being surrounded by an adiabatic wall as shown in Fig-1(b)

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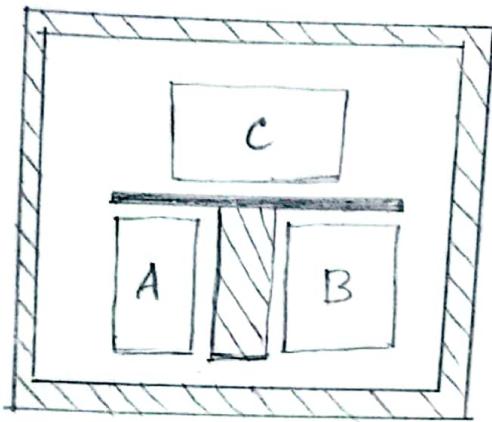


Fig-1 (a)

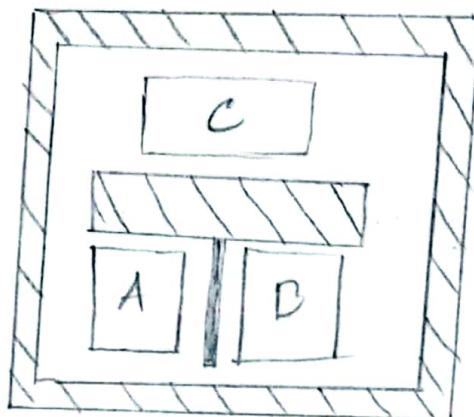


Fig-1 (b)

Experiment show that the two system will come to thermal equilibrium with the third system. No further change will occur if the adiabatic wall separating A and B is then replaced by a diathermic wall, as well as if the diathermic wall separating C from both A and B is also replaced by an adiabatic wall Fig-1(b). If instead of allowing both

systems A and B to come to equilibrium with C at the same time, we first establish equilibrium between A and C and later establish equilibrium between B and C; then, when A and B are brought into communication through a diathermic wall, they will be found to be in thermal equilibrium with each other. We shall use the expression "two systems are in thermal equilibrium" to mean also that the two systems are in states such that, if the two were connected through a diathermic wall, the combined system would be in thermal equilibrium.

Q] State and explain the first law of thermodynamics.

Ans: The first law of thermodynamics: If a ~~closed~~ closed system is caused to change from an initial state to a final state by adiabatic means only, then the work done on the system is the same from all adiabatic paths connecting the two states.

The first law of thermodynamics, also known as the law of energy conservation, is a fundamental principle in physics that deal with the conservation of energy in any thermodynamic process. It state that energy cannot be created or destroyed in an isolated system, but it can be converted from one form to another or transferred.

between different parts of the system.

Mathematically, the first law of thermodynamics can be expressed as follows:

$$\Delta U = Q - W$$

where,

- $\Delta U$  represents the change in the internal energy of the system. Internal energy refers to the sum of the system's microscopic forms of energy, such as the kinetic and potential energy of its particles.
- $Q$  represents the heat added to the system. Heat is the transfer of energy between the system and its surroundings due to a temperature difference.

- $W$  represents the work done by the system or on the system. Work is the transfer

of energy as a result of a force acting through a distance.

According to the first law, the change in internal energy of a system is equal to the heat added to the system minus the work done by the system. If the internal energy of the system increases, it means that more energy is being added to the system than is being transferred out of it as work. Conversely, if the internal energy decreases, more energy is being transferred out of the system as work than is being added as heat.

[5] State and explain the second law of thermodynamics.

Ans: The second law of thermodynamics state as: it is impossible to construct an engine that, operating in a cycle, will produce no effect other than the extraction of heat from a reservoir and the performance of an equivalent amount of work. This statement given us a Kelvin-Planck.

Clausius statement of the second law of thermodynamics: It is impossible to construct a refrigerator that, operating in a cycle, will produce no effect other than the transfer of heat from a lower temperature reservoir to a higher-temperature reservoir.

The second law of thermodynamics states that the total entropy of an isolated system tends to increase over time.

Entropy is a measure of the disorder or randomness in a system. The second law of thermodynamics implies that in any natural or spontaneous process, the total entropy of the system and its surroundings always increases or remains the same but never decreases. In other words, the natural tendency of a system is to move towards a state of greater disorder.

To understand this law it's helpful to consider two important concepts; reversible and irreversible processes.

It's important to note that while the second law of thermodynamics indicates that the entropy of an isolated system tends to increase, it does not imply that local decreases in entropy are impossible as long as they are offset by greater increases in entropy elsewhere in the system or its surroundings.

Overall, the second law of thermodynamics provides a powerful framework for understanding the behavior of energy in systems, emphasizing the tendency towards greater disorder and the limitations on energy conversion processes.