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CHEMICAL TRANSFORMATIONS AND ENERGY CHANGES

Different Chemical transformations with their energy changes are represented as :

(A) Evolution of heat with chemical transformation

(i) Burning of coal

$$C(s) + O_2(g) \longrightarrow CO_2(g) + \text{heat}$$

(ii) Reaction of some metals with Acids

$$Zn(s) + H_2SO_4(aq) \longrightarrow ZnSO_4(aq) + H_2(g) + \text{Heat}$$

(iii) Burning of Petroleum

$$C_6H_{14}(l) + 19/2\ O_2(g) \longrightarrow 6CO_2 + 7H_2O + \text{heat}$$

(B) Emission of light with chemical transformation.

Burning of magnesium, candle or petroleum produces light as well as heat *e.g.*,

$$2\ Mg + O_2 \longrightarrow 2MgO + \text{heat} + \text{light}$$

$$C_{18}H_{38} + 55/2\ O_2 \longrightarrow 18CO_2 + 19H_2O + \text{heat} + \text{light}$$

(Candle)

(C) Mechanical work (energy) form chemical transformations

Heat engines are the best examples of this process.In heat engines, coal or petroleum are used as reactants, which on activation in the presence of oxygen produces energy. This energy can easily be converted into the mechanical work. In addition to the chemical transformations, the physical transformations are also accompanied by energy changes *e.g.*,

(*a*) Insoluble solid in contact of liquid
(*b*) Mixture of two or more immiscible liquids.

State Variables or State Properties

The conditions of a system is referred as its state and the quantities whose values serve to describe the system completely are called thermodynamic properties. These properties are sometimes called state variables or state properties.

Temperature,volume,pressure and concentration are four important variables that fix the energy state of the system. These variables are inter - related with each other and by assigning two or three of these variables, others are automatically fixed.

The question now arises as how many variables must be used to define a system completely.The answer to this question can, therefore, be given by considering the following example:

A homogeneous system consists of a single substance, having fixed composition, can be defined by only three variables *e.g.*, pressure, volume and temperature. For a gaseous substance, these three variables are related with $PV = RT$. Hence for defining the state of a gaseous substance, if two of these variables are defined , the third will be automatically fixed.

Similarly, we can also define the state of a homogeneous system having more than one components by using these state variables.

Properties of a System

The observable properties of a system are of two types and they are :

(*a*) **Extensive Properties:** These properties are size dependent properties *i.e.*, the values these properties are proportional to the mass of the portion of the system.

Examples are volume, weight, number of moles, energy, quantity of electricity, entha entropy etc.

(*b*) **Intensive properties:** These properties are always independent of the amount o substance but depend upon their nature.

Examples are temperature, pressure, density, concentration, surface tension, viscosity, b point, melting point, refractive index etc.

Mode of Energy exchange between the system and the Surroundings

There are several ways through which a system can exchange energy with its surroundin are:

(*a*) **Heat:** It is the most common mode of energy exchange when the system and surr are at different temperatures (exchange of heat is not possible for an isolated system). When equilibrium is established between the system and its surroundings, the further exchange not possible.

(*b*) **Work:** It is the another mode of energy exchange between the system and its su

It is known that **energy is the ability to do work**. An appreciation of this definit an understanding of the fact that work includes movement.If the energy of the system is that of its surroundings, work is done by the system and vice versa. For example, if a g in a cylinder with a piston, has higher pressure than the surroundings, the piston will until the pressure inside and outside become equal. Then the work done by the system by W *i.e.*,

$$W = \text{force} \times \text{displacement}$$
$$= P \times (V_2 - V_1) = P\Delta V$$

because the expansion takes place against the constant pressure P.

If a system performs work on the surroundings, work is always positive but if the system by the surroundings, a negative sign is given to the work.

Heat and work are not state functions (state functions are those properties o change during any process depends upon initial and final state of the system).Her

(*i*)**Conversion of solid NaOH into aqueous NaOH.**

$$NaOH(s) + aq \longrightarrow NaOH\ (aq) + \text{heat}$$

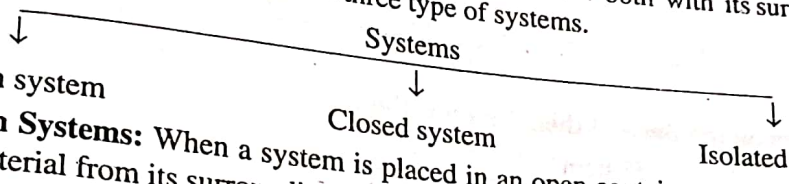
(*ii*) **Compression of a gas:** When the gases are compressed, their volume will decrease and the energy change during this process will appear in the form of heat.

Hence, the term "Energetics" is used for various types of energy changes during the physical and chemical transformations.

TERMS USED IN ENERGETICS

1. **System and Surroundings :** Any part of the universe under consideration is known as *system* and the rest part is known as *surroundings.*

The system may exchange, either heat or material or both with its surroundings. Depending upon the mode of exchange,there are three type of systems.



Open Systems: When a system is placed in an open container, the system exchanges heat as well as material from its surroundings.

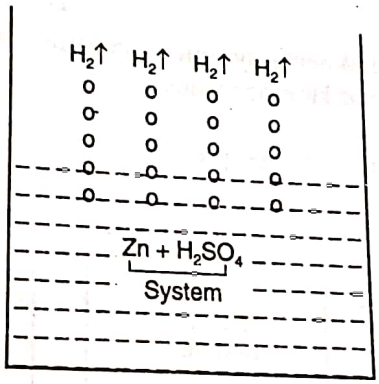
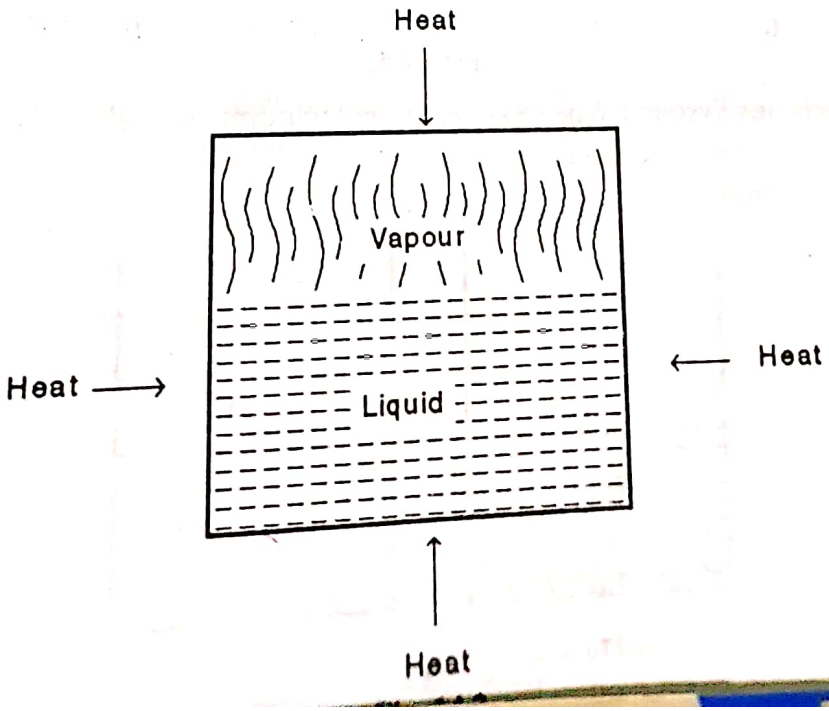


Fig. 14.1.

This system is known as an open system.

Closed System: A system placed in a closed container is known as closed system, if the wall of the container allows the heat exchanges with the surroundings .



Isolated System: A system placed in a closed container having insulated wall is known as an isolated system. The wall of the container neither allows the heat exchange nor allows the material exchange with the surroundings and is known as insulated boundary.

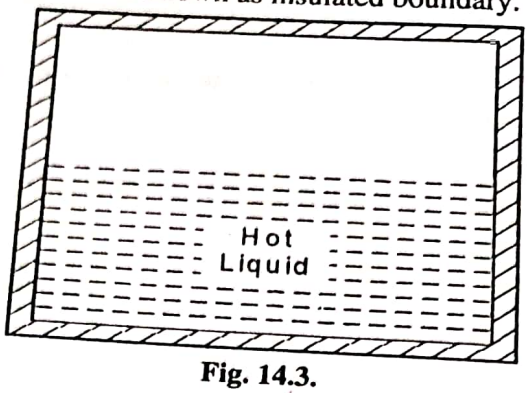


Fig. 14.3.

Classification of system on the Basis of their Composition.

System

↓ Homogeneous

↓ Heterogeneous

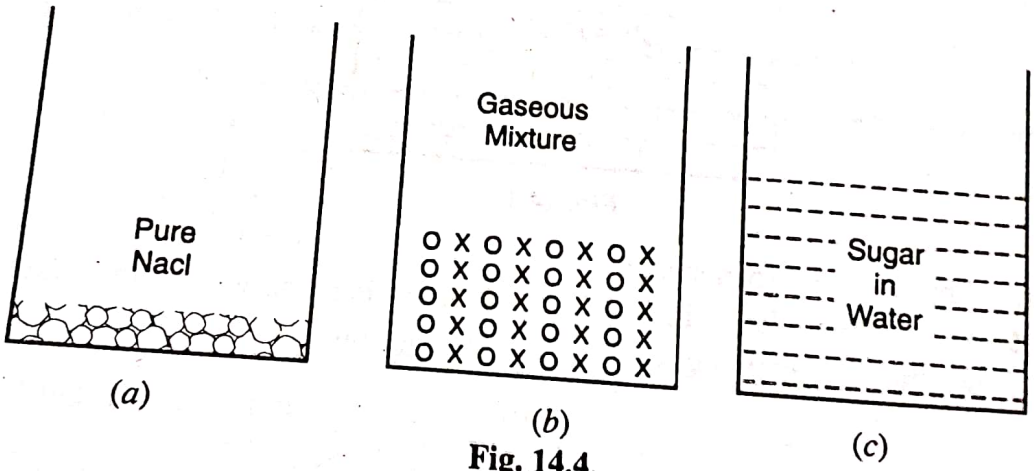
(A) **Homogeneous System :** When a system is uniform throughout *i.e.*, when a system has single phase, the system is termed as Homogeneous.

The various examples are :

(*a*) a pure solid or a pure liquid or a pure gas

(*b*) mixture of gases and

(*c*) a true solution.

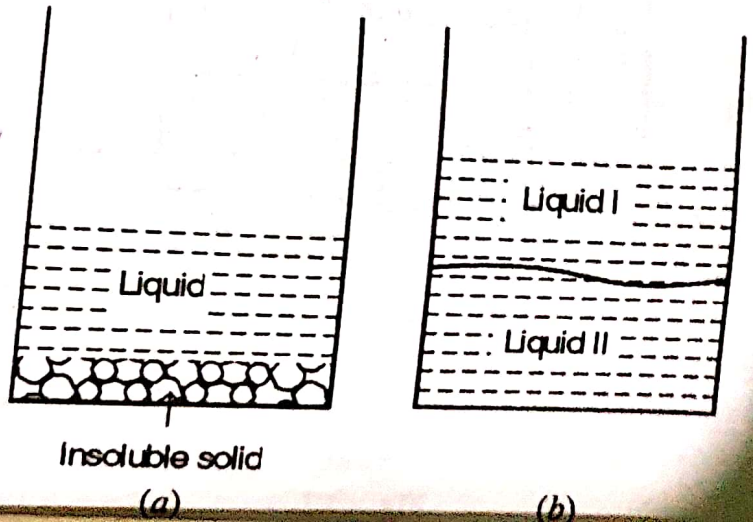


(*a*) (*b*) (*c*)

Fig. 14.4.

(B) **Heterogeneous System :** When a system is not uniform throughout *i.e.*, when it has two or more phases, it is termed as heterogeneous.

The various examples are :



(*a*) (*b*)