"PROPERTIES OF PURE SUBSTANCES"

3.1 DEFINITION OF THE PURE SUBSTANCE

A pure substance is a system which is **(i) homogeneous in composition, (ii) homogeneous in chemical aggregation, and (iii) invariable in chemical aggregation.** Example in figure 1.

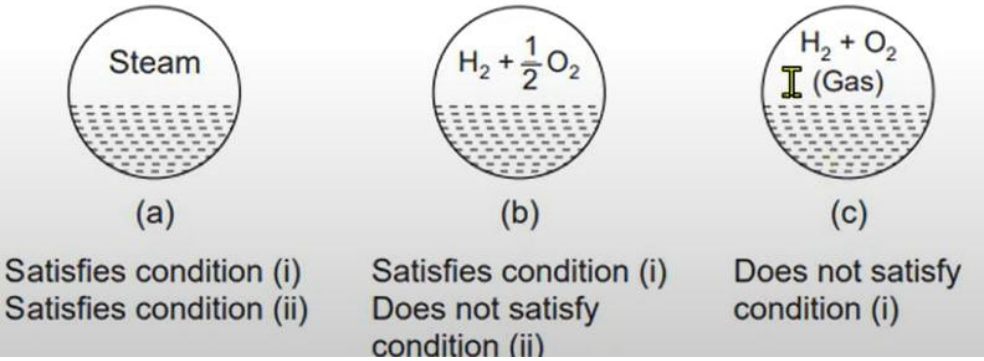

Fig. 1. Illustrating the definition of a pure substance

3.2 PHASE CHANGE OF A PURE SUBSTANCE

Let us consider 1 kg of liquid water at a temperature of 20°C in a cylinder fitted with a piston, which exerts on the water a constant pressure of one atmosphere (1.0132 bar) as shown in Fig. 2 (i).

As the water is heated slowly its temperature rises until the temperature of the liquid water becomes 100°C. During the process of heating, the volume slightly increases as indicated by the line 1-2 on the temperature-specific volume diagram (Fig. 3).

The piston starts moving upwards.

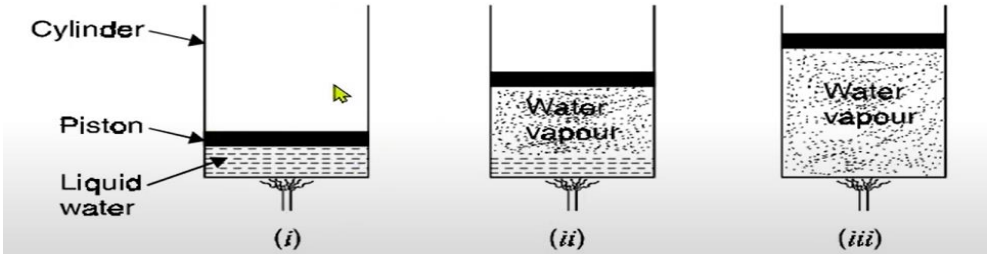

Fig. 2. Phase change of water at constant pressure from liquid to vapour phase.

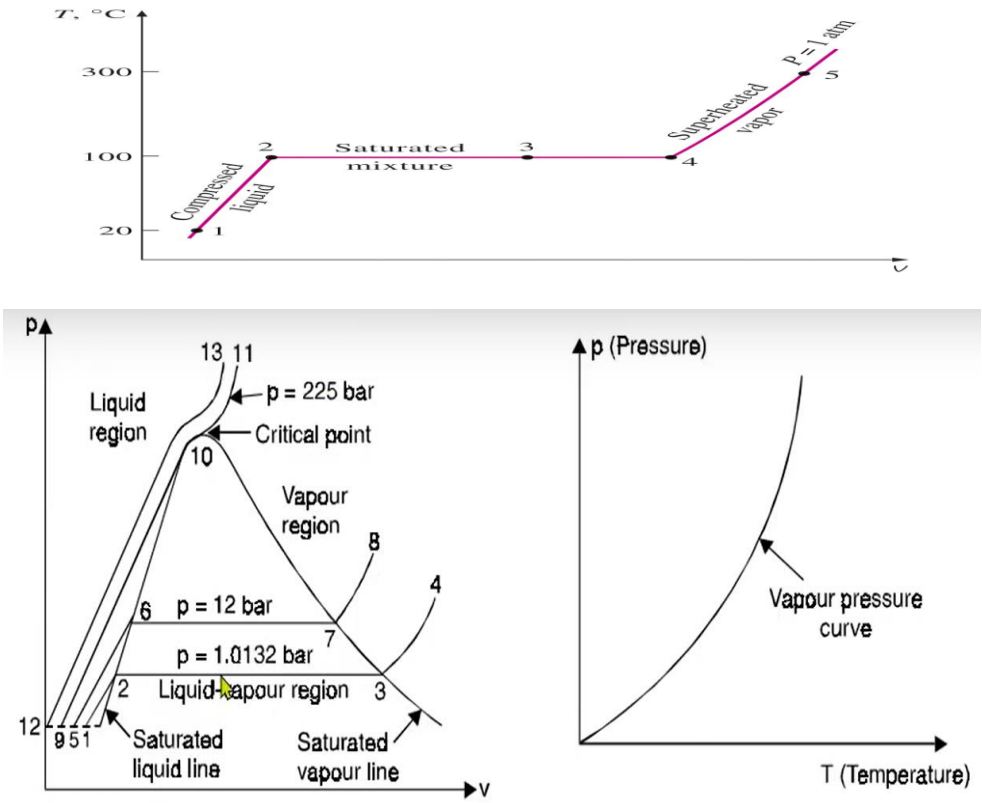

Fig.3

Liquid-vapour terms: Refer Fig. 4

Saturation temperature Tsat: The temperature at which a pure substance changes phase at a given pressure.
Saturation pressure Psat: The pressure at which a pure substance changes phase at a given temperature.

Latent heat: The amount of energy absorbed or released during a phase-change process.
Latent heat of fusion: The amount of energy absorbed during melting. It is equivalent to the amount of energy released during freezing.

Latent heat of vaporization: The amount of energy absorbed during vaporization and it is equivalent to the energy released during condensation.

-The magnitudes of the latent heats depend on the temperature or pressure at which the phase change occurs. -At 1 atm pressure, the latent heat of fusion of water is 333.7 kJ/kg and the latent heat of vaporization is 2256.5 kJ/kg .

Critical point is defined as the point at which the saturated liquid and saturated vapor states are identical.

1.At pressures above the critical pressure, there is not a distinct phase change process.

2.Above the critical state, there is no line that separates the compressed liquid region and the superheated vapor region.

Compressed liquid. Liquid whose temperature is lower than the saturation temperature. Sometimes called a sub-cooled liquid.

Saturated liquid. Liquid at the saturation temperature corresponding to the saturation pressure. That is liquid about

to commence evaporating, represented by the point f on a diagram.

Saturated vapour. A term including wet and dry vapour

Degree of superheat. The term used for the numerical amount by which the temperature of a superheated vapour exceeds the saturation tempera-ture.

Dry (saturated) vapour. Vapour which has just completed evaporation. The pressure and temperature of the vapour are the saturation values.

Wet vapour. The mixture of saturated liquid and dry vapour during the phase change

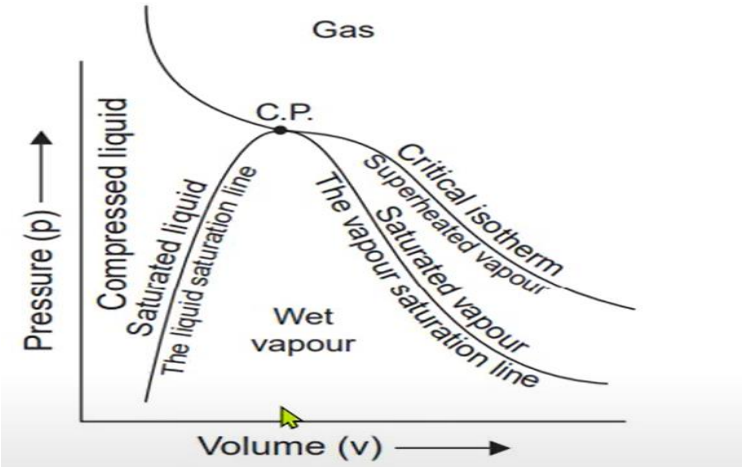

Fig.4. Phase change terminology

p-T (Pressure-Temperature) DIAGRAM FOR A PURE SUBSTANCE

If the vapour pressure of a solid is measured at various temperatures until the triple point is reached and then that of the liquid is measured until the critical point is reached, the result when plotted on a p-T diagram appears as in Fig. 5.

If the substance at the triple point is compressed until there is no vapour left and the pressure on the resulting mixture of temperature will have to be liquid and solid is increased, the changed for equilibrium to exist between the solid and the liquid. Measurements of these pressures and temperatures give rise to a third curve on the p-T diagram, starting at the triple point and continuing indefinitely.

The points representing the coexistence of (i) solid and vapour lie on the 'sublimation curve', (ii) liquid and vapour lie on the 'vapourisation curve', (iii) liquid and solid lie on the 'fusion curve'. In the particular case of water, the sublimation curve is called the frost line, the vapourisation curve is called the steam line, and the fusion curve is called the ice line.

The slopes of sublimation and the vapourisation curves for all substances are positive. The slope of the fusion curve, however may be positive or negative. The fusion curve of most substances have a positive slope. Water is one of the important exceptions.

Triple point

The triple point is merely the point of intersection of sublimation and vaporization curves. are given in Table 1

Table 1: Triple-point data

S. No.	*Substance*	*Temp., K*	*Pressure, mm Hg*
1.	Hydrogen (normal)	13.96	54.1
2.	Deuterium (normal)	18.63	128
3.	Neon	24.57	324
4.	Nitrogen	63.18	94
5.	Oxygen	54.36	1.14
6.	Ammonia	195.40	45.57
7.	Carbon dioxide	216.55	3.880
8.	Sulphur dioxide	197.68	1.256
9.	Water	273.16	4.58

Suffices : Solid i
Liquid f
Vapour g

Phase change	Name	Process	Process suffix
1. Solid-liquid	Fusion	Freezing, melting	*if*
2. Solid-vapour	Sublimation	Frosting, defrosting	*ig*
3. Liquid-vapour	Evaporation	Evaporating, Condensing	*fg*

Triple point—The only state at which the solid, liquid and vapour phases *coexist in equilibrium.*

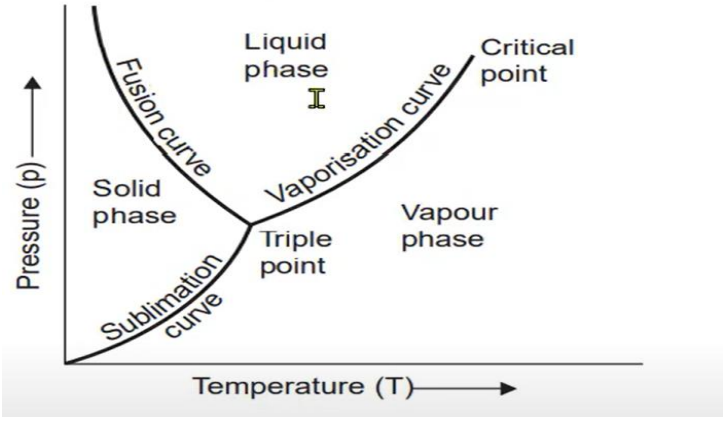

Fig. 5. p-T diagram for a substance such as water