SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
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DEPARTMENT OF MECHANICAL ENGINEERING

23MET201 ENGINEERING THERMODYNAMICS

UNIT 2 –PROPERTIES OF PURE SUBSTANCES

TOPIC – P-V, T-V,T-s, h-s and P-V-T diagrams

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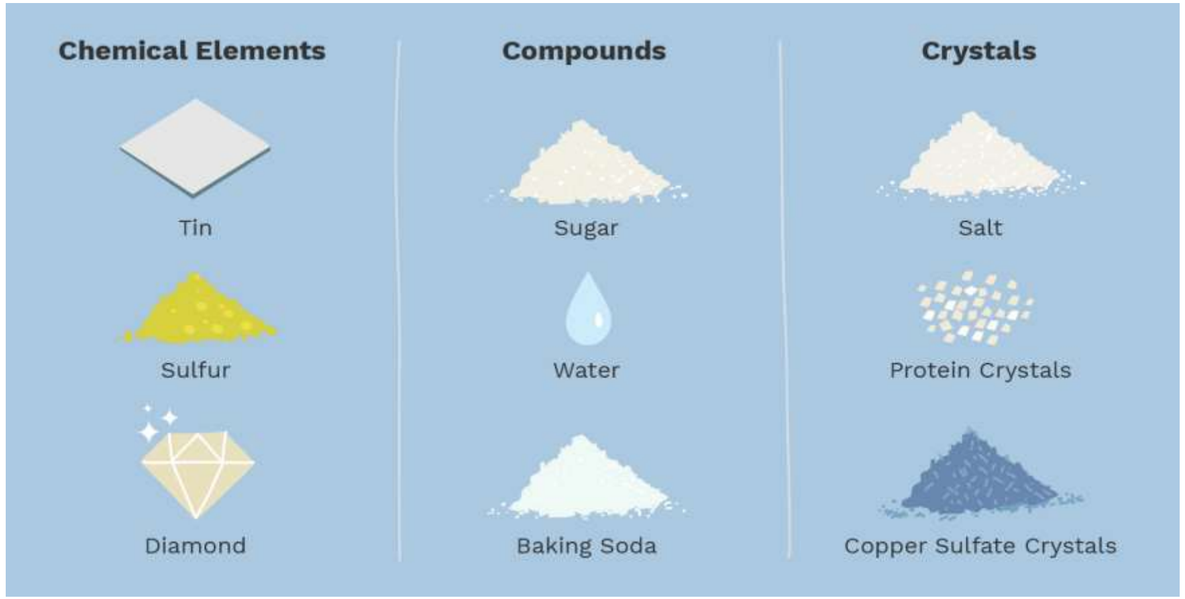
Coimbatore - 35

What is Pure substance?



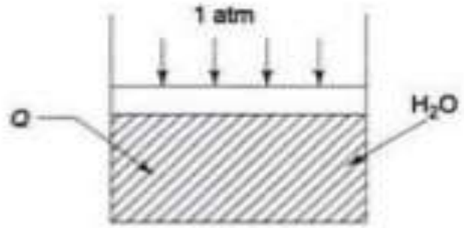
- A substance, in which same chemical composition throughout its mass, but it may exist in different phases (solid, liquid or vapour)

Source: https://cienciadehoy.com/

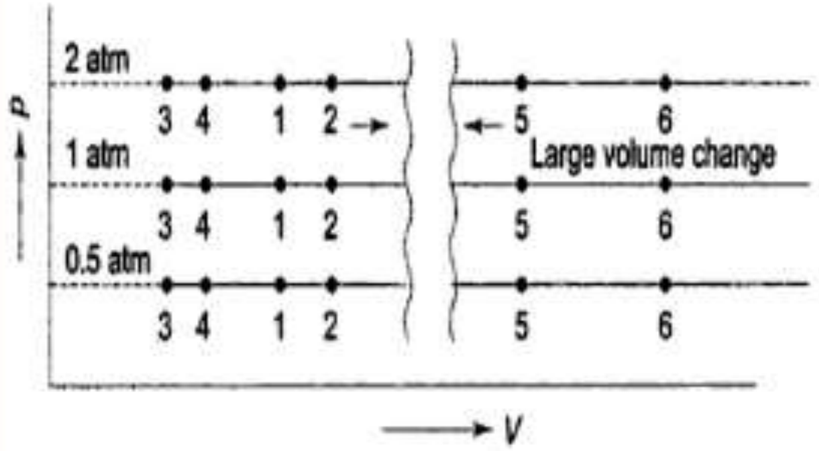
P-V diagram

PV diagram for pure substances

- **Heating of water from -10 degree Celsius to 100 degree Celsius boiling and above**
- 1-2 – heating at constant pressure from -10 to 0 degree Celsius. Volume ice increases. Temperature also increases.
- 2-3 – melting of ice. Volume decreases from 2 to 3 which is peculiarity of water. Temperature and pressure remains constant.
- 3-4- Water is heated from 0 to 100 degree Celsius. Volume of water increases. Pressure constant at 1 atm.
- 4-5- Boiling of water at 1 atm pressure and constant temperature of 100 degree Celsius. Volume increases from 4 to 5 . Saturated liquid converts to saturated vapor.
- 5-6- Superheating at constant pressure. Volume increases from 5 to 6. Temperature increases from 100 to some other temperature say 250 degree Celsius.



Heating of H_2O at a constant pressure of 1 atm



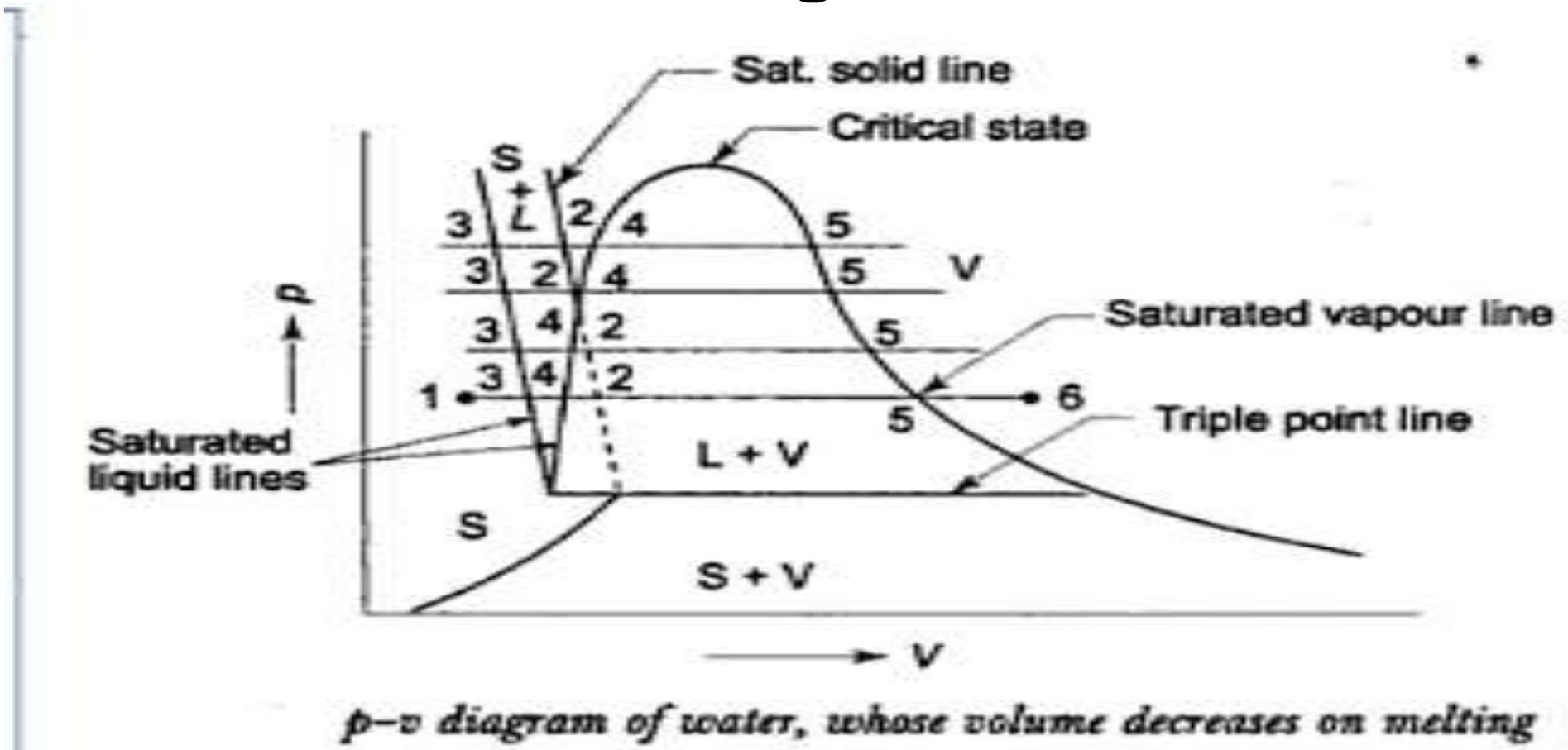
Changes in the volume of water during heating at constant pressure

Source: P.K.Nag

Processes involved

Process	Description
Process 1-2	Solid ice being heated from **-10°C to 0°C** (Volume increases)
Process 2-3	Ice starts melting at **0°C** (Volume decreases) (Latent heat of fusion) (Solid → Liquid)
Process 3-4	Liquid being heated from 0°C to 100°C (Volume increases)
Process 4-5	Vaporization process at 100 °C (Liquid → Vapour) (Volume increases)
Process 5-6	Vapour being heated from 100 °C to 250 °C (Volume increases) (Large Volume Change)

P-V diagram



p–v diagram of water, whose volume decreases on melting

Critical Pressure(P_c) =221.2 bar

Critical Temperature(T_c)=374.15°C

Source: P.K.Nag

P- T diagram

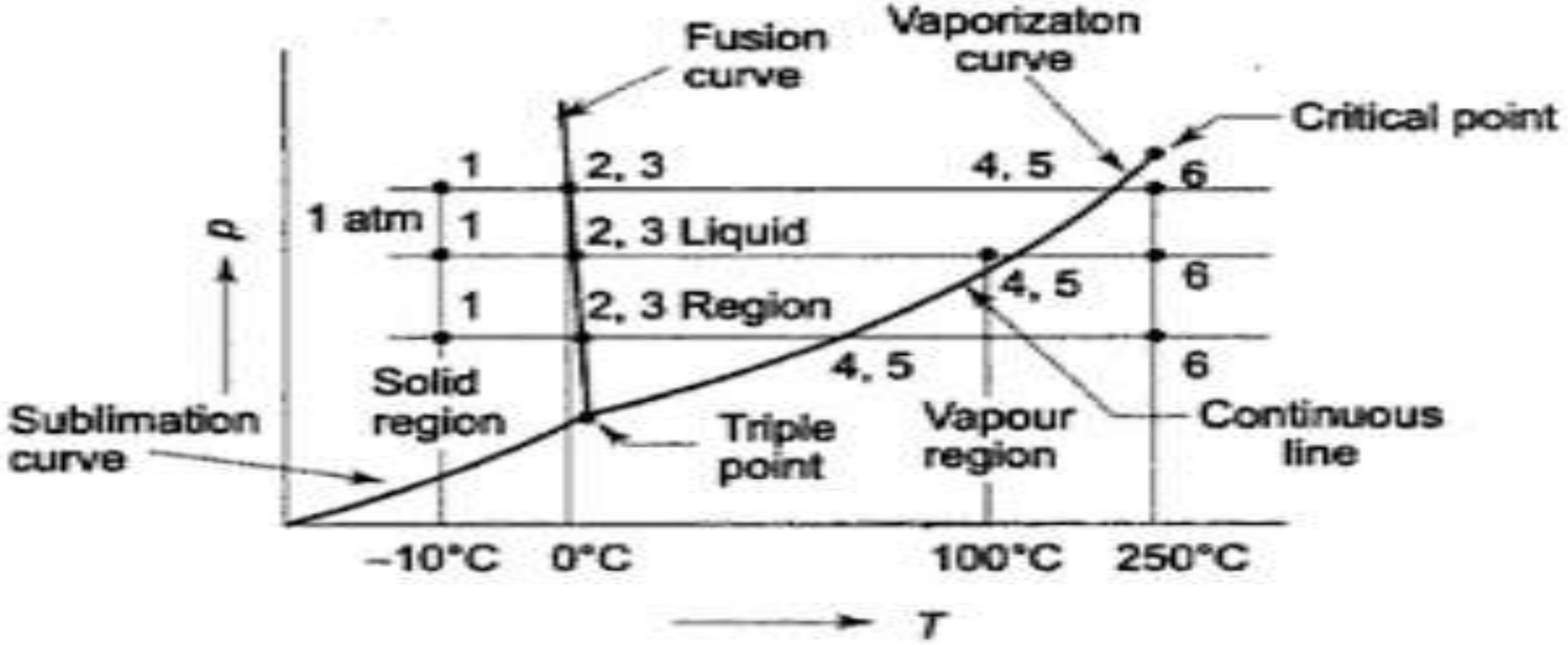
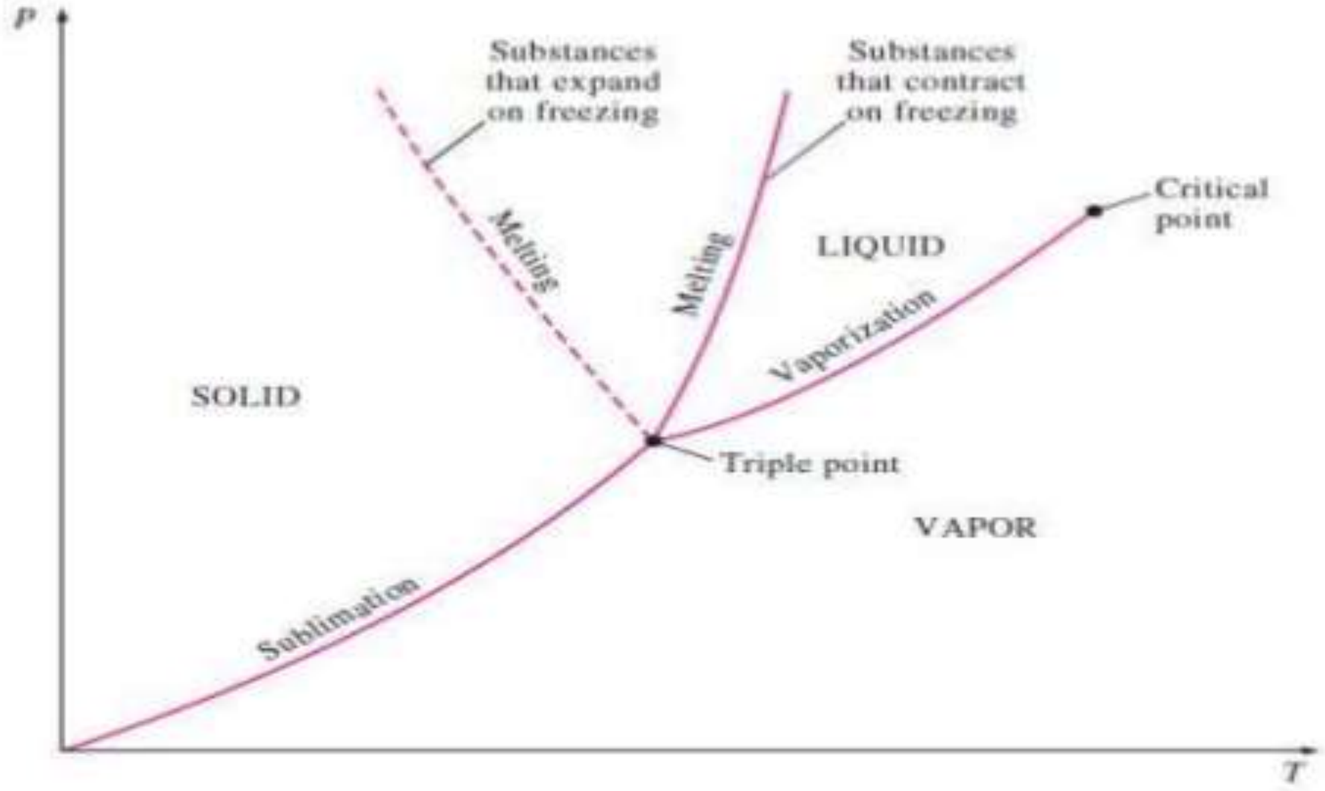


Fig. *Phase equilibrium diagram on p–T coordinates*

P- T diagram



- For substances like water which expand on freezing .slope of fusion curve is negative.

Source: P.K.Nag

T-s diagram

Temperature – Entropy plot

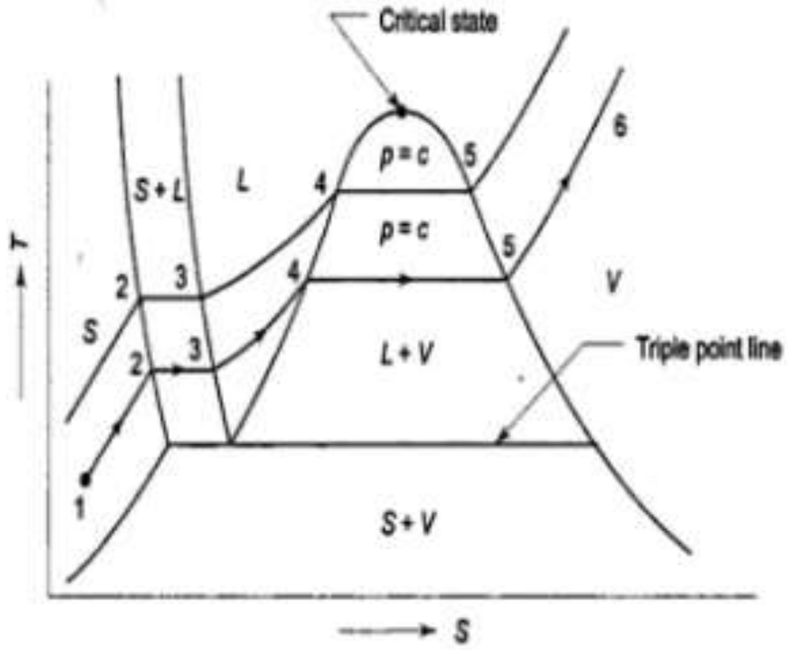
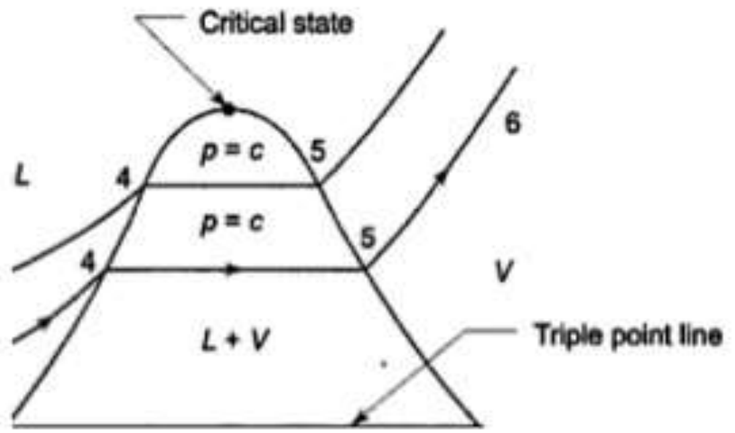
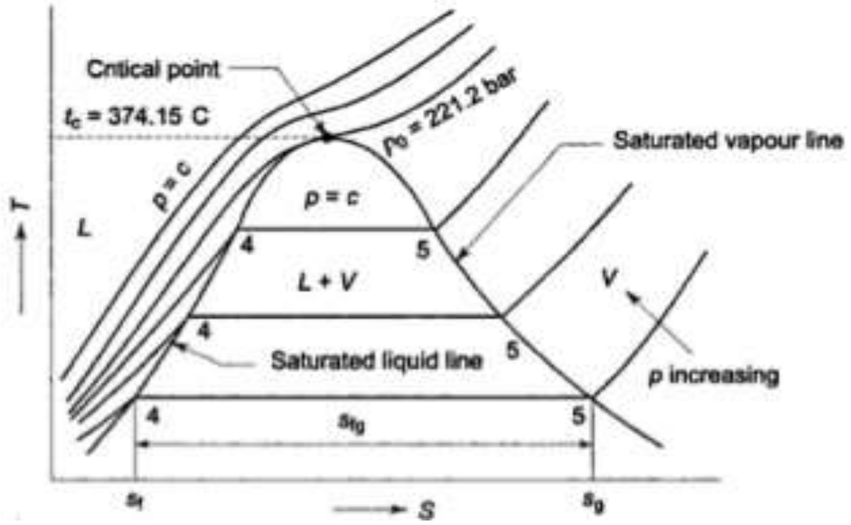


Fig. 9.12 *Phase equilibrium diagram on T-s coordinates*





Source: P.K.Nag

h-s diagram

From the first and second laws of thermodynamics, the following property relation was obtained.

$$Tds = dh - vdp$$

$$\left(\frac{\partial h}{\partial s}\right)_p = T$$

Constant temperature heating them slope is constant

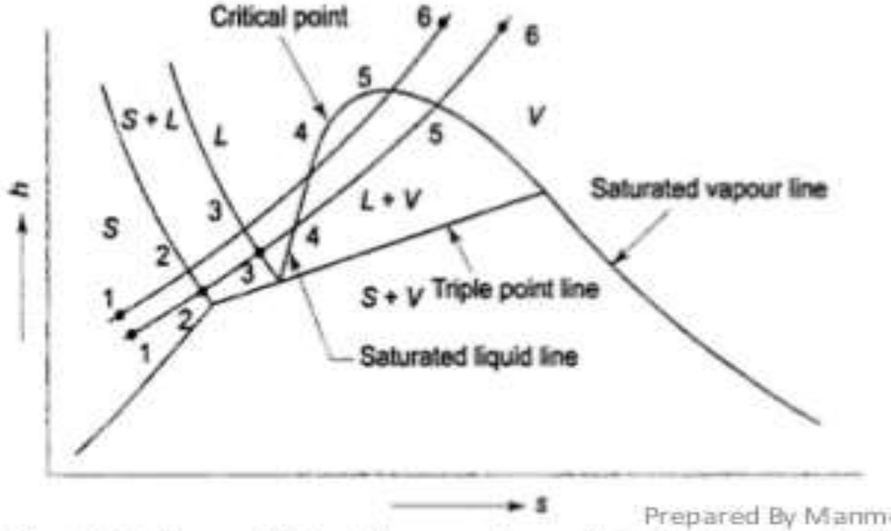


Fig. 9.15 *Phase equilibrium diagram on h-s coordinates (Mollier diagram)*

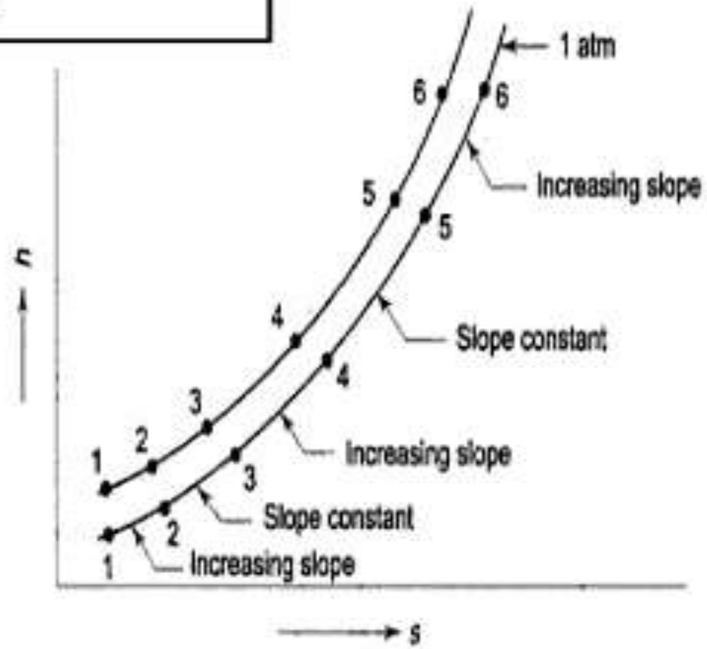
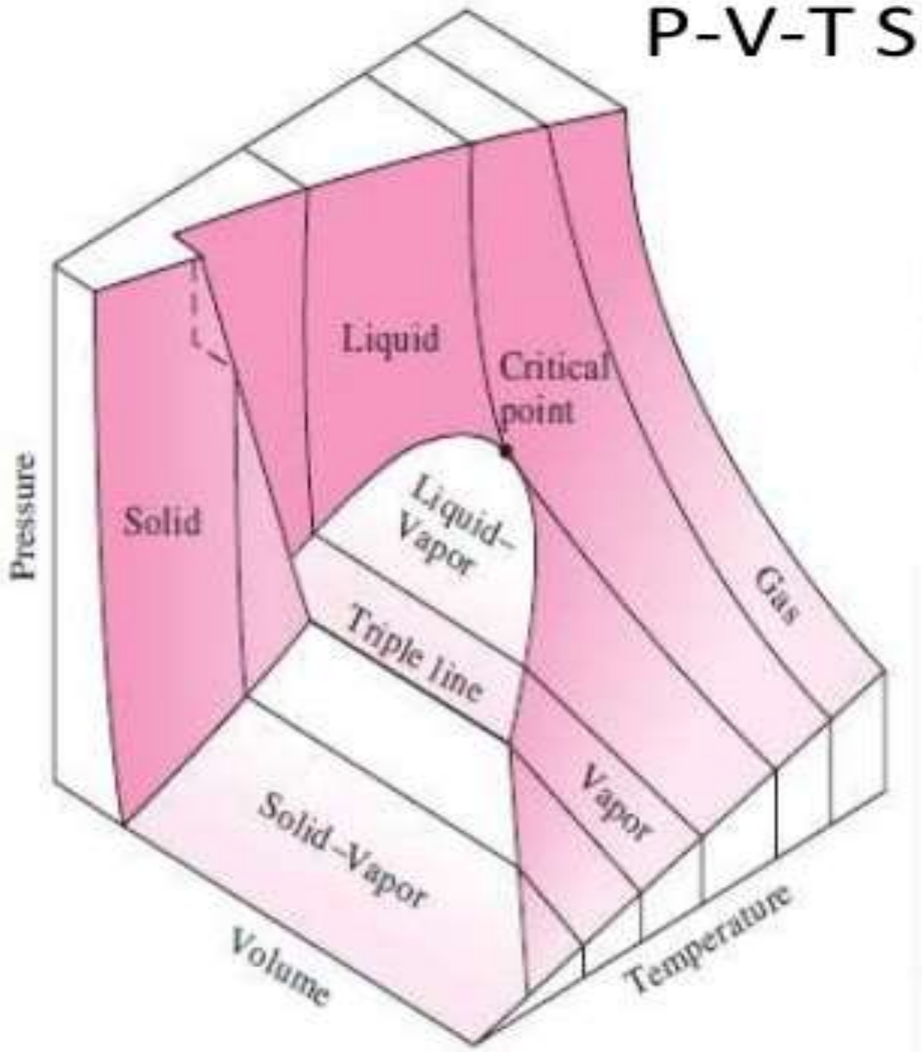
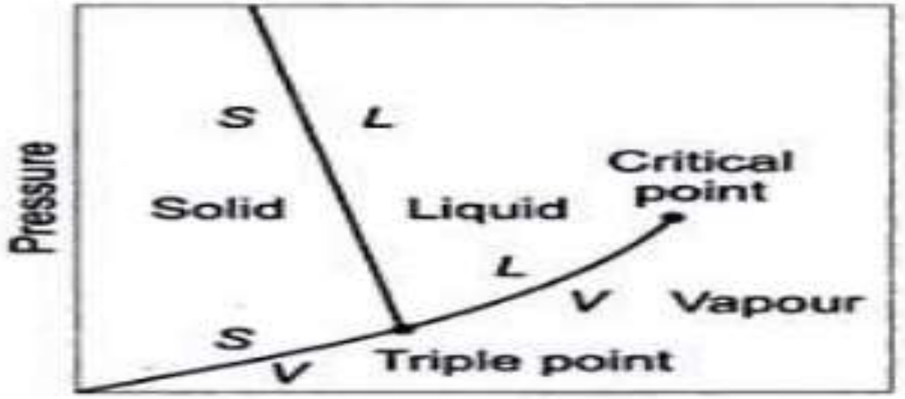


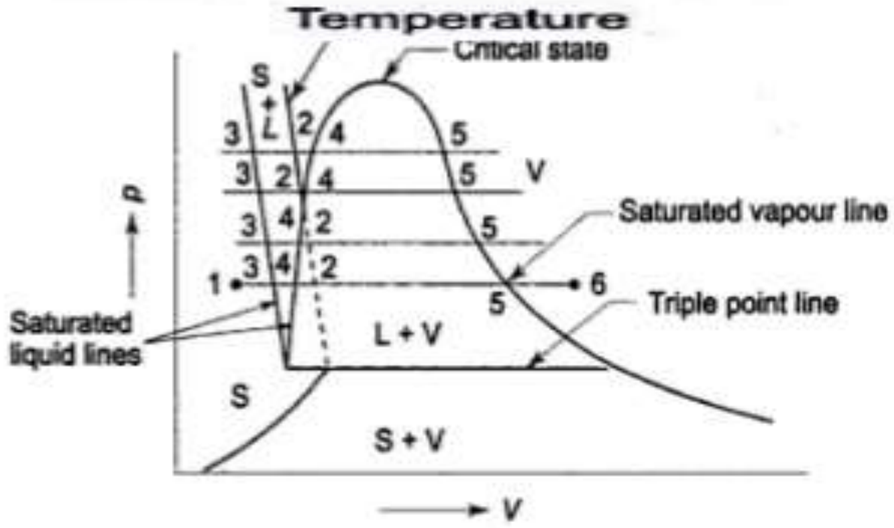
Fig. 9.14 *Isobars on h-s plot*

Source: P.K.Nag

P-V-T diagram







Source: P. K.Nag

h-s diagram

Temperature – Entropy plot

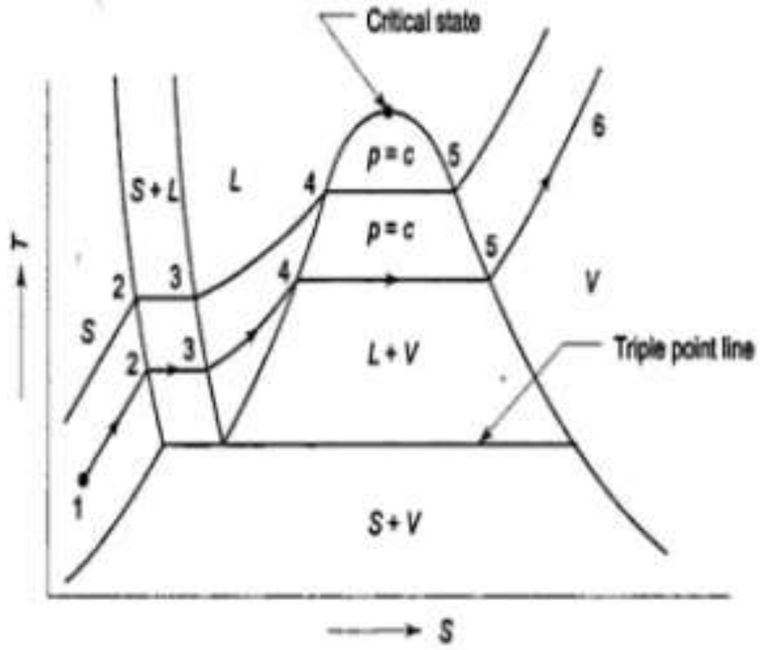
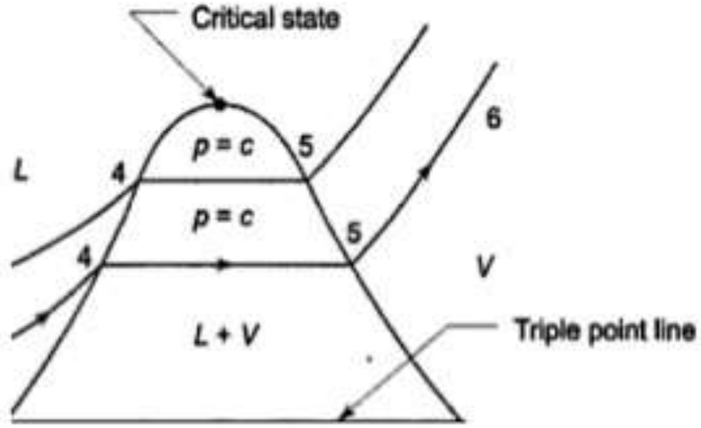
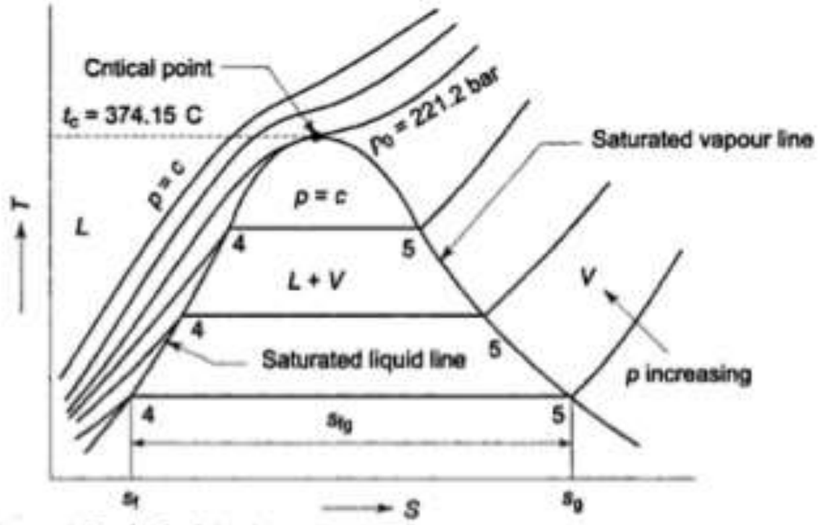


Fig. 9.12 *Phase equilibrium diagram on T-s coordinates*





Prepared By Manmeet Singh, Assistant Professor

Fig. 9.13 *Saturation (or vapour) dome for water*

Assessment -1

1. **Which is a state of a substance from which a phase change occurs without a change of pressure or temperature?**
   a. pure state
   b. phase state
   c. saturation state
   d. critical state
2. **Saturated solid state can be termed as**
   a. a state at which solid can change into liquid at constant pressure but changing temperature
   b. a state at which solid can change into liquid at constant temperature but change in pressure
   c. a state at which solid can change into liquid at constant pressure and temperature
   d. a state at which solid can change into liquid at constant volume

Assessment -2

3. Saturated liquid line and saturated vapor line which meet at one point is called
a) Critical state
b) Saturated liquid state
c) Saturated vapour state
d) Saturated solid stat

4. The amount of heat required to convert from liquid to vapour is called
a) Latent heat of fusion
b) Latent heat of vaporization
c) Latent heat of sublimation
d) Latent heat of condensation

References

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