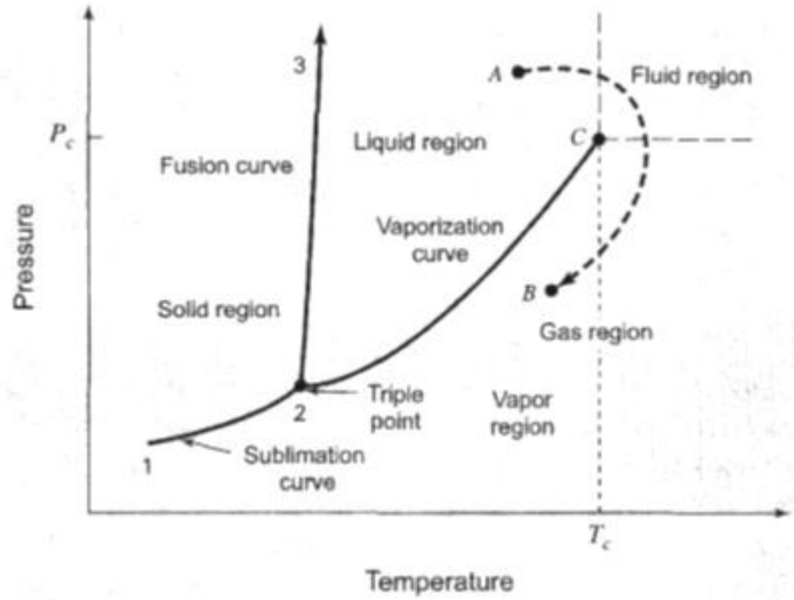
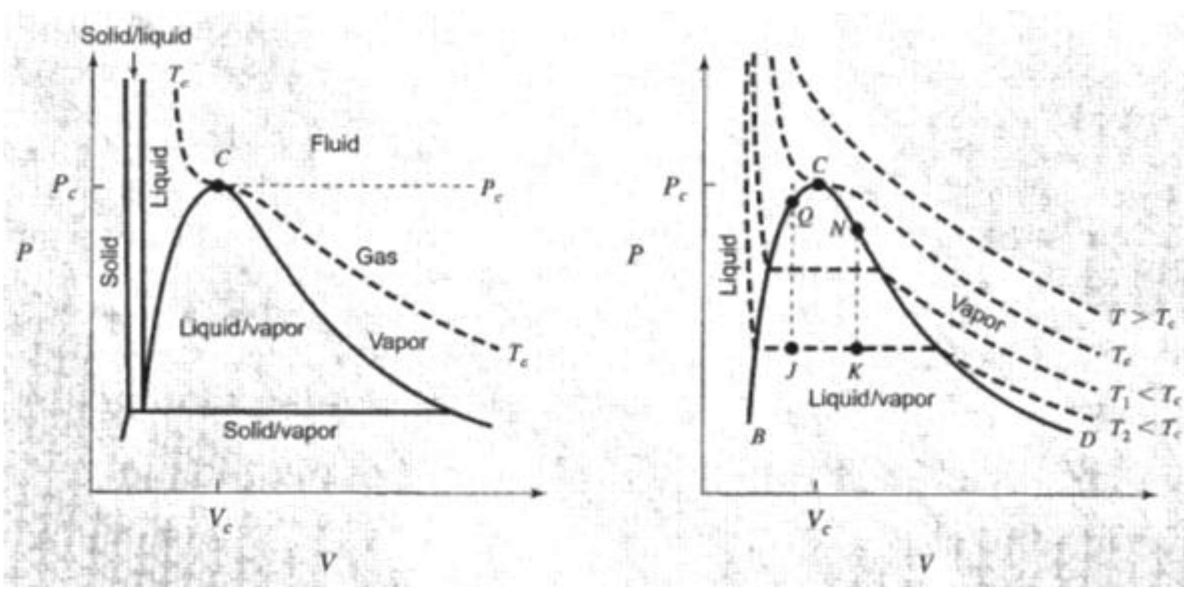
PVT relationship

The below diagram show pressure-volume-temperature for pure substance as below

1-2 Sublimation curve.
2-C Vaporization curve.
2-3 Fusion curve.
Point 2 triple point.
Point C critical point ,
Critical point coordinate maximum temperature and maximum pressure which liquid and vapor found at equilibrium .





Phase rule (degree of freedom) $F = 2 - \pi + N$

At triple point (F=0) , on saturated lines (F =1)

To get liquid from vapor

1- cooling at constant pressure or,

2- compression at constant temperature

To get vapor from liquid

1- Heating at constant pressure or ,
2- Expansion at constant temperate.

B-C saturated liquid curve , C-D saturated vapor curve , while the area under BCD curve two phase region

Single-Phase Region

For the regions of the diagram where a single phase exists, above figure (b) implies a relation connecting P, V, and T which may be expressed by the functional equation:

$$f(P,V,T)=0$$

As assumed volume as a function of pressure and temperature and take derivative

$$V=V(T,P)$$

$$dV=\left(\frac{dV}{dT}\right)_P dT+\left(\frac{dV}{dP}\right)_T dP$$

The partial derivatives in this equation have definite physical meanings, and are related to two properties, commonly tabulated for liquids, and defined as follows

$$\text{volume expansion}: \beta \equiv \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_P$$

$$\text{isothermal compressibility}: \kappa \equiv -\frac{1}{V}\left(\frac{\partial V}{\partial P}\right)_T$$

- β and κ are function of temperature and pressure : $f(P,T)$, for compressible fluid, (increase with temperature and decrease with pressure)
- β for water is deviated in range (0 - 4) $^{\circ}$C
- it can be considered they are constant with small change in temperature and pressure
- β , κ = 0 for incompressible fluids

Combination the above equation lead to : $\frac{dV}{V} = \beta dT - \kappa dP$

$$\ln \frac{V_2}{V_1} = \beta (T_2 - T_1) \ - \kappa (P_2 - P_1)$$

What ideal gas different from non ideal gas

Ideal gas	Non ideal
• No force attraction between molecules • Volume of molecules is very small comparison with total volume • P = 3 bar or less • Equation of state is $PV= nRT$ or $P\bar{V} =RT$ • Compressibility factor $z = 1$	• There is a force attraction between molecules • Volume of molecules cannot negligible • P is more than 3 bar • There are many equations of state used for non ideal gas • $z < 1$