CO_2 System

CO_2 system is a one component system in which following equilibrium can exist:

Solid CO_2 (s) = Liquid CO_2 (l) = Vapor CO_2 (g)

The system consists of three phases, viz., solid, liquid and gas, since only one formula (CO_2) can express all the three phases, therefore, it is a one component system. Hence,

$$F = C - P + 2 = 1 - P + 2 = 3 - P$$

i.e, degree of freedom depends on the number of phases present in various cases:

if P=1 ; F=2 , if P=2 ; F= 1 if P=3 ; F= 0

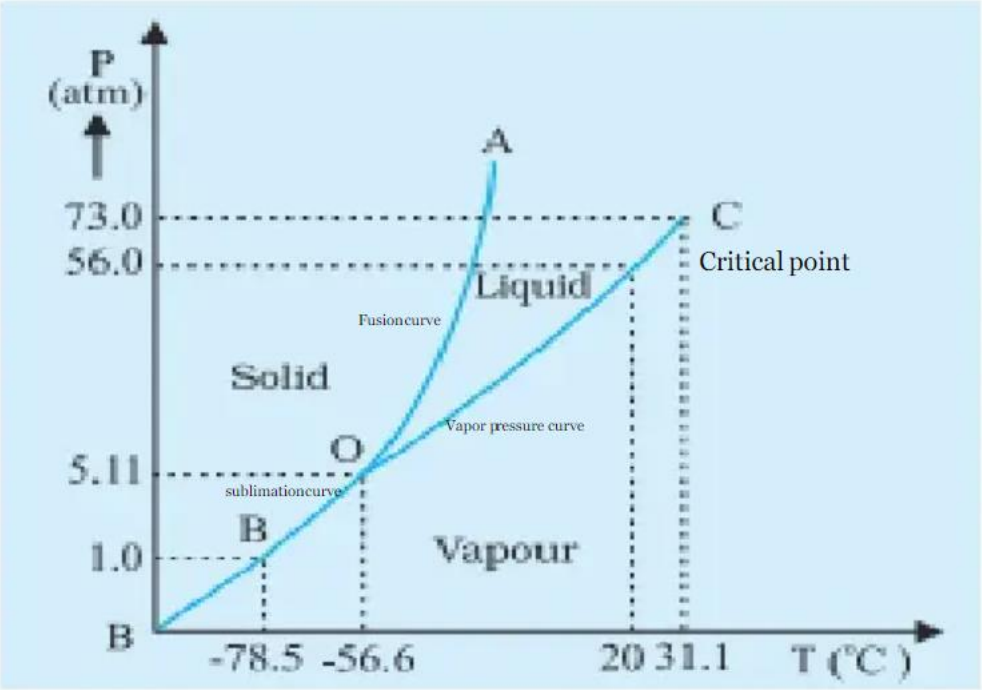

Fig. Phase diagram of CO_2 System

Thus, for one component system the maximum number of the degree of freedom is two.

Such a system can be represented by a two dimensional diagram and two variables in this case are the pressure and temperature.

1. **Areas:**

   Solid CO_2 (area on the left of the curve AOB)
   Liquid CO_2 (area between OC and OA)
   Vapor CO_2 (area below curve BOC)
   Since one phase exists in these areas hence: P=1
   So F = C-P +2
   = 1-1 + 2 = 2

2. **Curves / Boundary lines:** Separating the areas are lines/curves OA, OB, OC. Along the lines/curves two phases can coexist in equilibrium and degree of freedom is one.

   Along curve OB Solid CO_2 ↔ Vapor are in equilibrium

   (It is called **Sublimation curve**)

   F= C- P+ 2 = 1-2+2 =1

Along curve OC CO_2 (l) ↔Vapor (g) , are in equilibrium (called **vapor pressure curve**). The OC has a natural upper limit at 31.1˚C which is the **critical point,** beyond which the liquid phase merges into vapor phase. Along this curve the system is mono variant as predicted from phase rule equation.

F= C-P+ 2 = 1-2+2 =1

Along curve OA solid CO_2 is in equilibrium with liquid CO_2.

CO_2 (s) ↔ CO_2 (l) (It is called **fusion curve)** .

Along this curve the system is mono variant as predicted from phase rule equation.

F= C-P+ 2 = 1-2+2 =1

3. **Triple point (O):** The three curves meet at point o which is called triple point. At this point all the three phases solid, liquid and vapor coexist in equilibrium and degree of freedom is zero (F=3-3=0). At this point the temperature is – 56.4˚C and pressure is 5.1 atm. If any pressure or temperature is altered at this point one phase will disappear.
4. **The critical point 'C':** The point 'C' in the diagram is called the critical point. The temperature and pressure corresponding to this point are 31.1˚C and 73 atm. They are called critical temperature and critical pressure. The effect of increase of the pressure on vapor phase at a temperature lower than critical temperature will eventually cause condensation of liquid CO_2, because above critical temperature it is impossible to condense a gas into a liquid just by increasing pressure. Thus, it is impossible to get any liquid

CO_2 at pressure less than 5.11 atm. It means that at 1 atm pressure CO_2 will sublimate at a temperature of – 78.5˚C. This is the reason that solid CO_2 is often called as dry ice. We cannot get liquid CO_2 under normal conditions.