Chemistry, Class 11th, 21/08/2020, Gaseous State

Test :- 6 - 7
(Saturday)

Liquefication of Gases :-

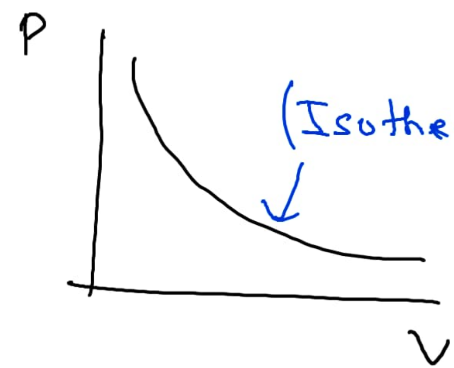
* Gases can be liquefied by decrease in temp. & increase in pressure.

Isothermal ⟶ Temp. Constant

Isobaric ⟶ Pressure Constant

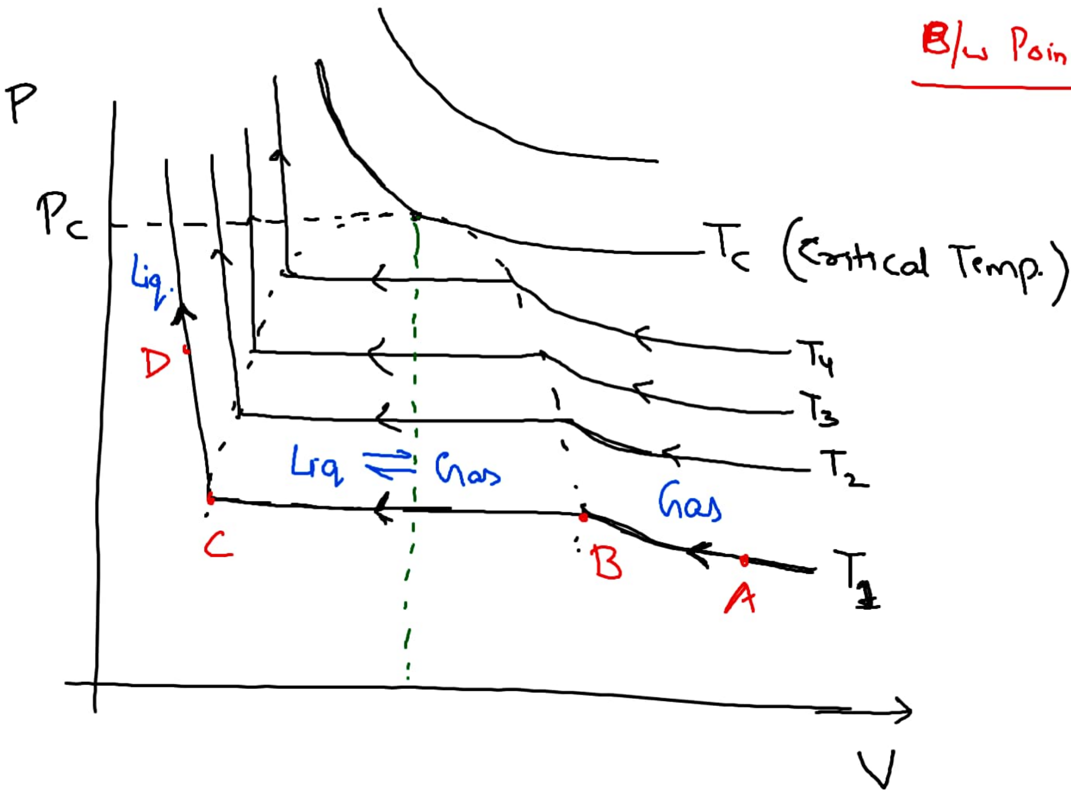
Isochoric ⟶ Volume constant

eg



(Ideal gas)
(At constant temp.)

Andrew's Isotherm :-



Point A :- Gas Phase

B/w Point A & B :- Real gas compression occurs.

Point B :- Liquification of gas starts

B/w Point B & C :- Liq. & Gas are in equilibrium

Point C :- Almost gas is liquefied

Point D :- Negligible compression of liquid

Critical Temp. (T_c) :-

The temp. above which a gas cannot be liquefied is called as T_c

Critical Pressure (P_c) :-

The pressure required to liquefy a gas at critical temp. is called as Critical Pressure.

Critical Volume (V_c) :-

The vol. of 1 mole of gas at T_c & P_c is called as Critical Volume.

For 1 mole of gas :-

$$\left(P + \frac{a}{V^2}\right)(V - b) = RT$$

$$PV + \frac{a}{V} - Pb - \frac{ab}{V^2} = RT$$

$$PV^3 + aV - PbV^2 - ab = V^2 RT$$

Divide by P

$$V^3 + \frac{a}{P}V - bV^2 - \frac{ab}{P} = \frac{V^2 RT}{P}$$

① – $$V^3 - V^2\left(b + \frac{RT}{P}\right) + \frac{a}{P}V - \frac{ab}{P} = 0$$

$$(V - V_1)(V - V_2)(V - V_3) = 0$$

At critical point

$$V_1 = V_2 = V_3 = V_c$$

$$(V - V_c)^3 = 0$$

$$V^3 - V_c^3 - 3VV_c(V - V_c) = 0$$

$$V^3 - V_c^3 - 3V_cV^2 + 3V_c^2V = 0$$

$$V^3 - 3V_cV^2 + 3V_c^2V - V_c^3 = 0$$ – ②

From eqn (1) at critical conditions

$$V^3 - V^2\left(b + \frac{RT_c}{P_c}\right) + \frac{a}{P_c}V - \frac{ab}{P_c} = 0 \quad \text{--- (3)}$$

$$V^3 - 3V_cV^2 + 3V_c^2V - V_c^3 = 0 \quad \text{--- (2)}$$

Comparing coefficients of eqn (2) & (3)

$$b + \frac{RT_c}{P_c} = 3V_c \quad \text{--- (4)}$$

$$\frac{a}{P_c} = 3V_c^2 \quad \text{--- (5)}$$

$$\frac{ab}{P_c} = V_c^3 \quad \text{--- (6)}$$

$$b + \frac{RT_c}{P_c} = 3V_c \quad \text{--- (4)}$$

$$\frac{a}{P_c} = 3V_c^2 \quad \text{--- (5)}$$

$$\frac{ab}{P_c} = V_c^3 \quad \text{--- (6)}$$

(6) / (5)

$$\frac{ab}{P_c} \times \frac{P_c}{a} = \frac{V_c^3}{3V_c^2}$$

$$V_c = 3b$$

Substitute value of V_c in eqn (5)

$$\frac{a}{P_c} = 3(3b)^2$$

$$P_c = \frac{a}{27b^2}$$

Substitute value of P_c & V_c in (4)

$$b + \frac{RT_c}{P_c} = 3 \times 3b$$

$$\frac{RT_c}{P_c} = 8b$$

$$T_c = 8b \times \frac{a}{27b^2} \times \frac{1}{R}$$

$$T_c = \frac{8a}{27Rb}$$

** Gas having higher value of T_c can be liquefied easily.

** $$T_c = \frac{8a}{27Rb}$$

$a \Rightarrow$ attraction forces

$a\uparrow$, $T_c\uparrow$, Easily liquefied.

Compressibility factor at Critical Conditions :-

$$Z = \frac{P_c V_c}{RT_c}$$

$$Z = \frac{a}{27b^2} \times \frac{3b}{R \times \frac{8a}{27Rb}}$$

$$Z = \frac{a}{27b^2} \times \frac{3b}{8a} \times 27b$$

** $$Z = \frac{3}{8}$$