

# Lecture 4

Petrochemicals Engineering

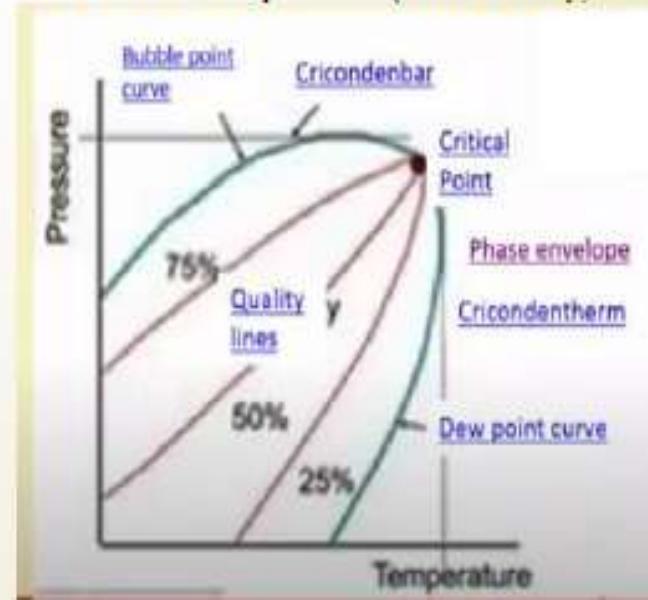
Phase diagram



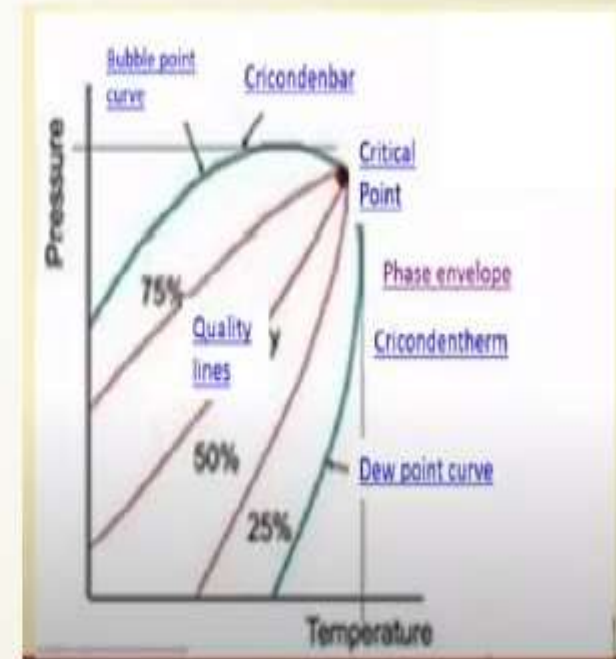
## □ natural gas phase diagram

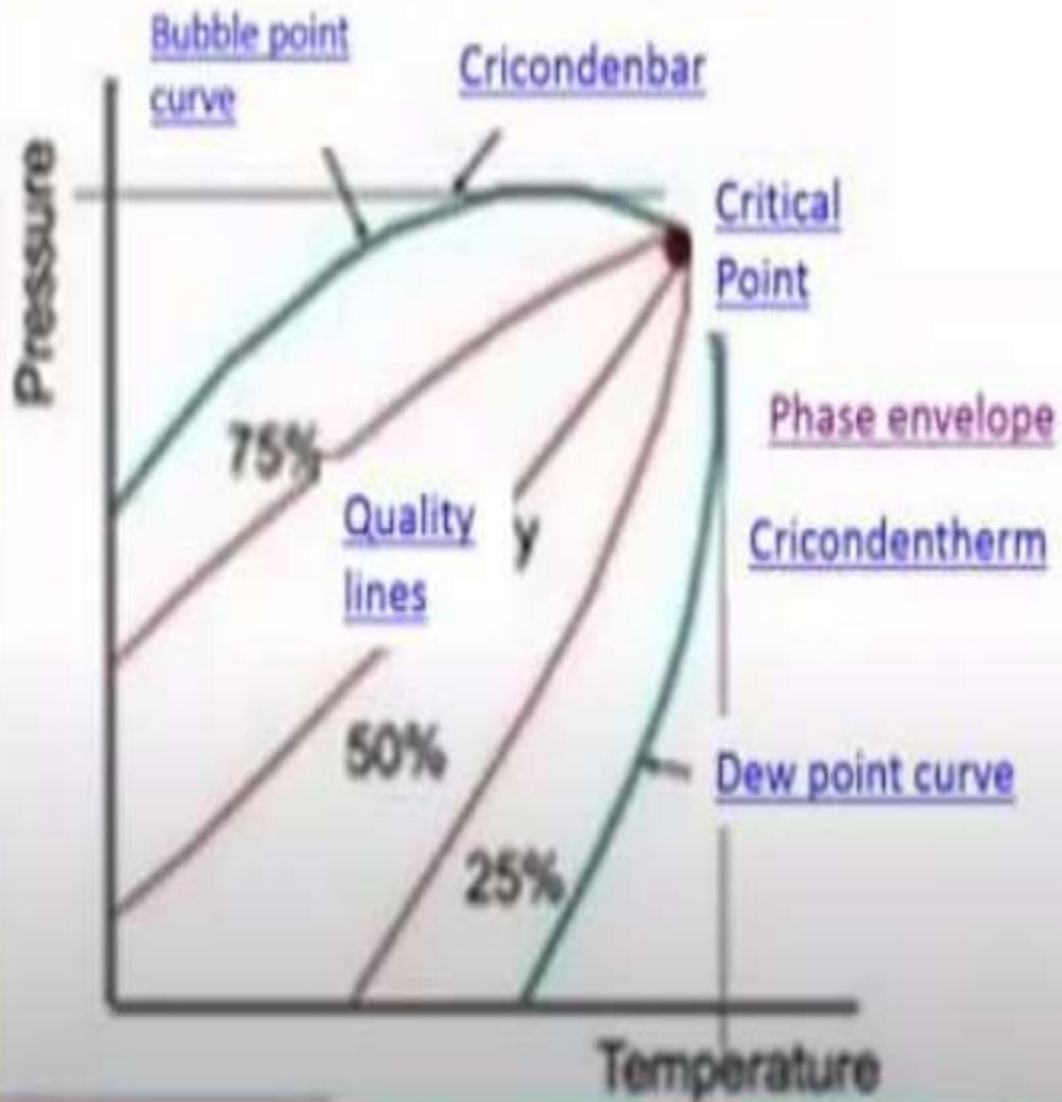
natural gas phase diagram consist of:

- ❖ **Phase envelope:** Region enclosed by the bubble-point curve and dew – point curve, where gas and liquid coexist in equilibrium
- ❖ Shape and location of the phase envelop change with the composition of the natural gas and also with the impurities.
- ❖ **Bubble –point curve** separates the pure liquid ( oil) phase from the two phase ( natural gas and oil) region.
- ❖ **Dew –point curve** separates the pure gas(natural gas ) from the two phase ( natural gas and oil) region.
- ❖ **Quality lines:** loci constant percentage of vapour.
  - converges at critical point.



- ❖ **Cricondenbar** is the highest pressure at which a liquid and vapor can coexist.
  - The maximum pressure above which no gas can be formed regardless the temperature
  - Both CO<sub>2</sub> and H<sub>2</sub>S lower, while N<sub>2</sub> raises the Cricondenbar.
  - phases vanish and phases become indistinguishable.
  
- ❖ **Cricodentherm** is the highest temperature at which a liquid and vapor can coexist.
  - The maximum temperature at which condensation take place at dew point curve
  - The mixture will be gas irrespective of pressure when the temperature is larger than cricodentherm.
  - Increase with increase in molar mass of mixture.
  -
- ❖ **Critical point** is the point where the bubble point curve meets the dew point curve.
  - The pressure and temperature at the critical point are called critical pressure and temperature, respectively.





### ❖ Retrograde condensation

- Unique phenomenon that appears only among hydrocarbon mixtures.
- Formation of liquid hydrocarbons in a gas reservoir as the pressure in the reservoir decreases below dew point pressure during production.

- ❖ As pressure decreases from point B to the shaded area, the gas starts liquefying and the amount of liquid in the reservoir increases.
- ❖ As pressure decreases further, liquid starts to vaporize
- ❖ Between the dew point and the point where the liquid re-vaporises is the region of **Retrograde condensation**.

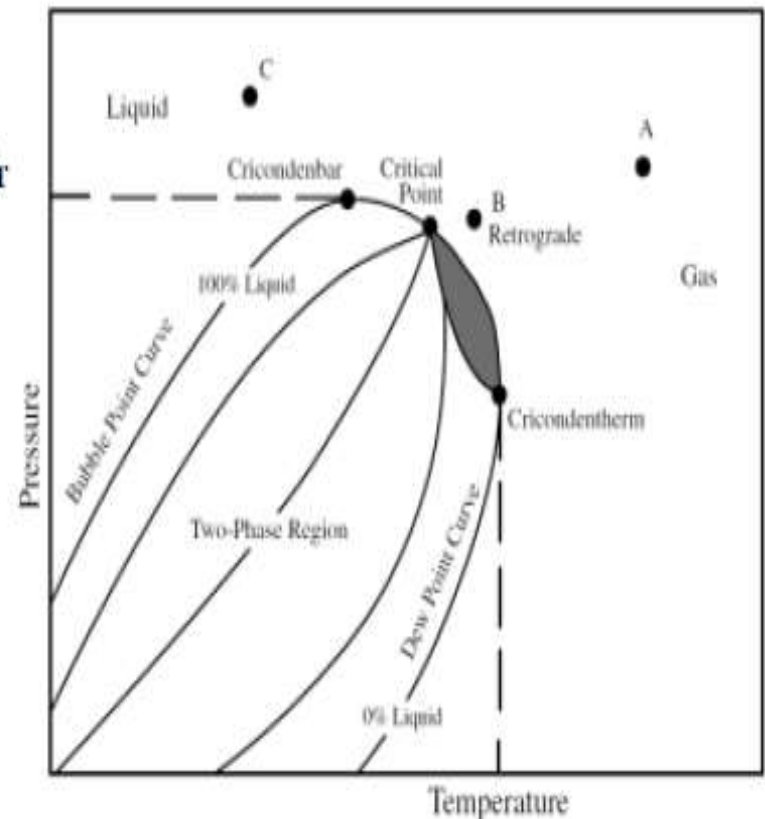


Figure 2: Pressure-Temperature Diagram for A Typical Natural Gas Mixture



## ❖ Significance of Retrograde condensation

- Slow down or completely cease the gas production.
- Liquid condensation forms a condensate bank around the wellbore that reduces the gas relative permeability.

## ❖ Prevention of Retrograde condensation

- Maintain the following well bottom hole pressure above the dew point pressure.
- inject methane gas into the production well ( also known as gas cycling).
- the gas dissolves and sweeps the liquid condensate into the reservoir.
- the approach is repeated several times in the life of the well.
- inject both nitrogen and methane.





Thank you