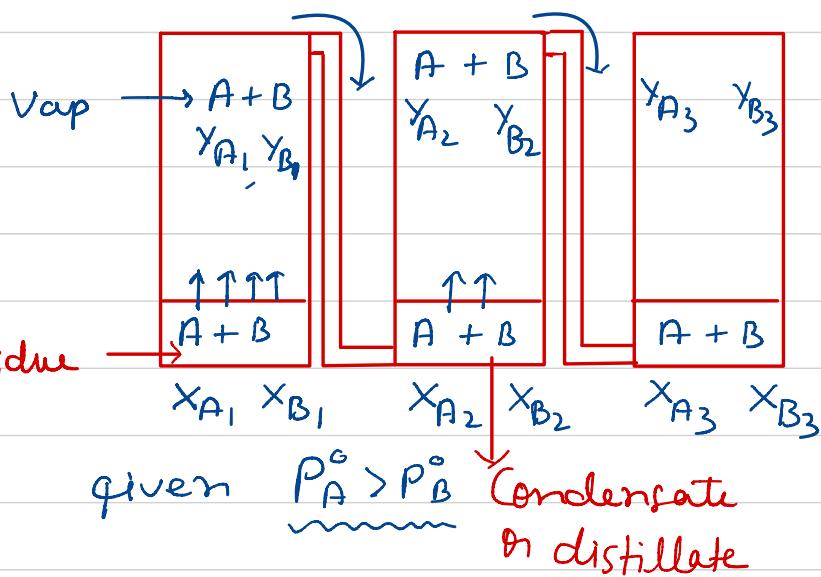


Distillation:-



Method for separation of more volatile component from a mix of volatile components

(I) $P_{T_1} = P_A^o X_{A_1} + P_B^o X_{B_1}$

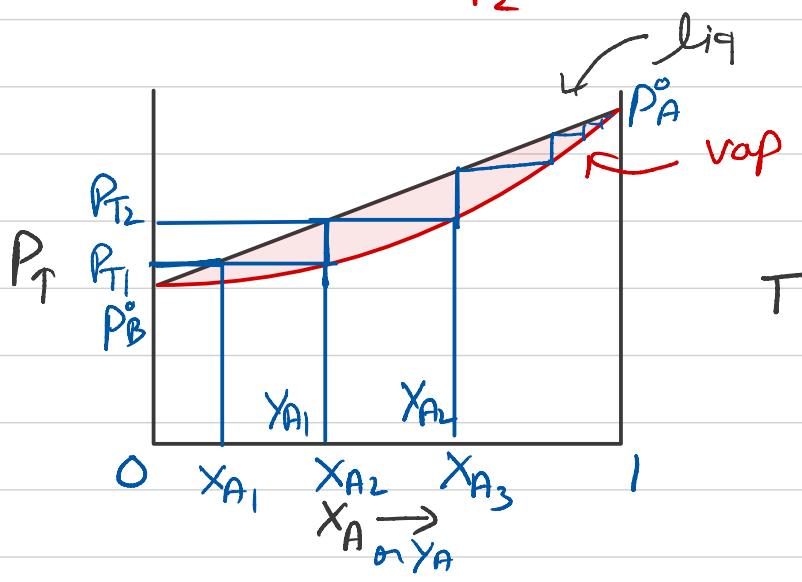
$$Y_{A_1} = \left(\frac{P_A^o X_{A_1}}{P_{T_1}} \right) ; Y_{B_1} = 1 - Y_{A_1}$$

$$\underline{X_{A_3} > X_{A_2} > X_{A_1}}$$

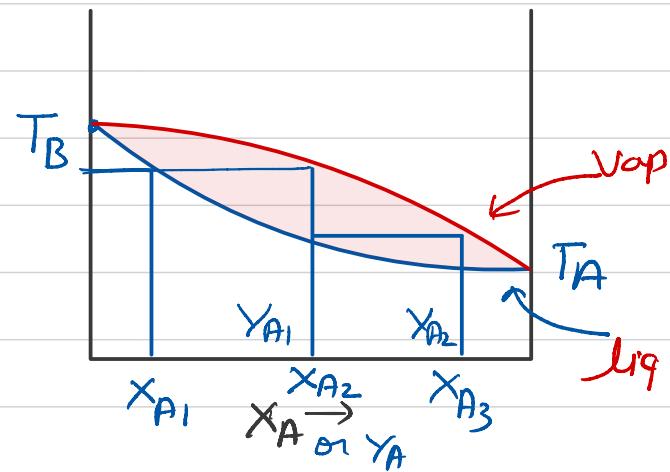
(II) $X_{A_2} = Y_{A_1}, X_{B_2} = Y_{B_1}$

$$P_{T_2} = P_A^o X_{A_2} + P_B^o X_{B_2}$$

$$Y_{A_2} = \frac{P_A^o X_{A_2}}{P_{T_2}} ; Y_{B_2} = 1 - Y_{A_2}$$



Isothermal Curve



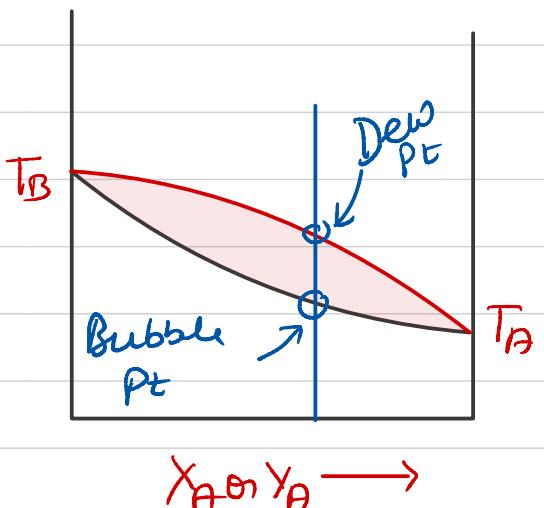
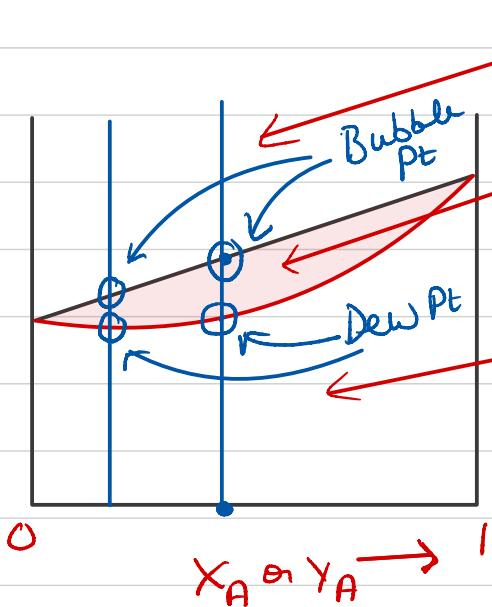
Isobaric Curve

Bubble Pt :-

Point at which formation of first vapour bubble take place is called bubble Pt

Dew Point :

Point at which first drop of liquid form is called dew Pt.



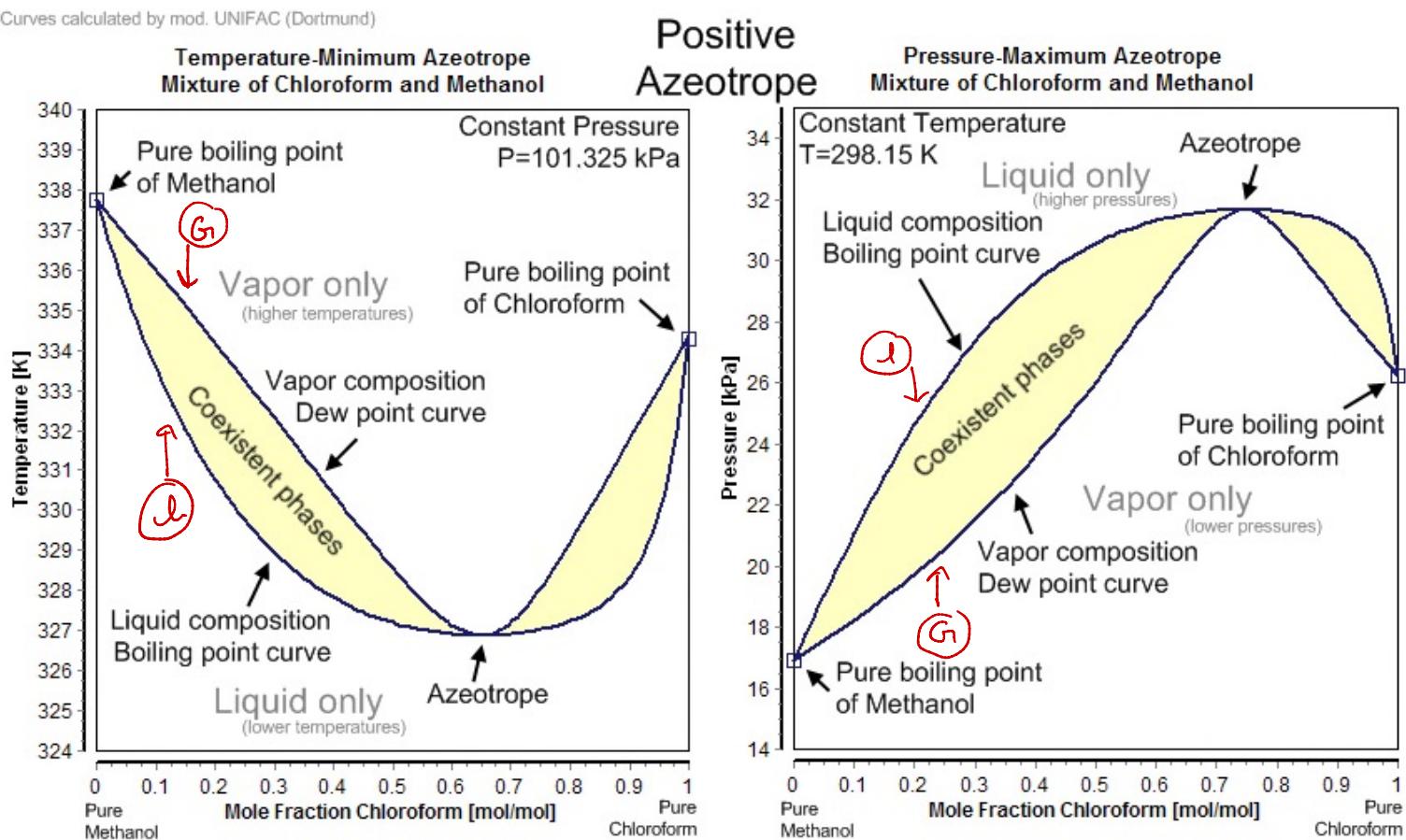
Azeotropic mix:- (Constant Boiling mix.)

Composition of liq mix is same as composition of vapour.

Non ideal Solution showing large deviation from ideal nature

Minimum Boiling Azeotropic:- (+ve deviation)

Curves calculated by mod. UNIFAC (Dortmund)

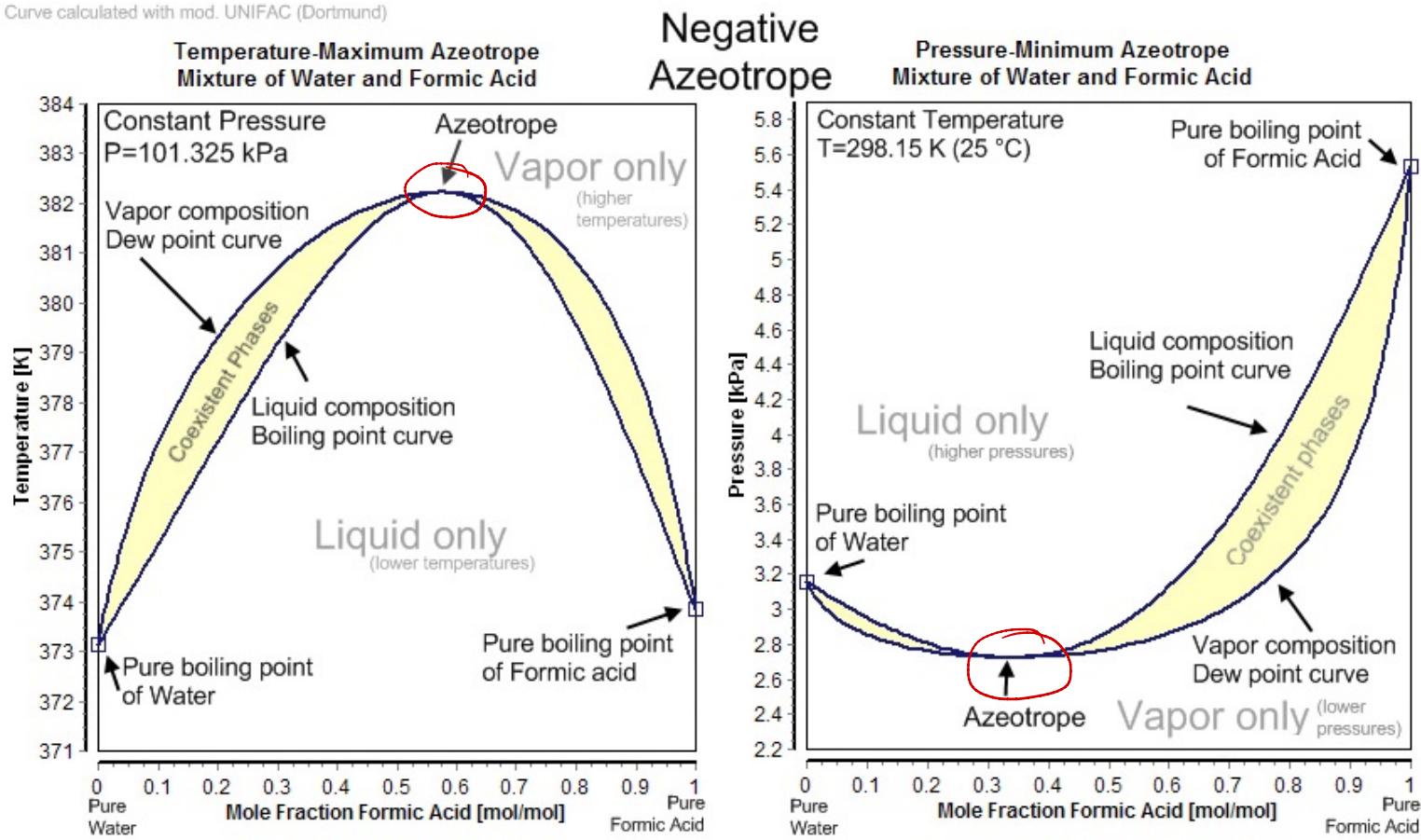


Minimum boiling point Azeotropic

Mixture	% Composition of azeotrope	Boiling point (pressure = 1atm)
1. Water-Ethanol	96 Ethanol	78.15°C
2. Pyridine-Water	57.00 Pyridine	92.60°C
3. Ethanol-Benzene	32.4 Ethanol	67.80°C
4. Acetic acid-Toluene	28.0 Acetic acid	105.40°C

Maxm Boiling Azeotropic:- (-ve deviation)

Curve calculated with mod. UNIFAC (Dortmund)



Maximum boiling point Azeotropic

Mixture	% Composition of azeotrope	Boiling point (pressure = 1atm)
1. Nitric acid-Water	68% Nitric acid	125.5°C
2. Acetic acid-Pyridine	65% Pyridine	139.0°C
3. Chloroform-Acetone	80% Chloroform	65.0°C
4. Hydrogen chloride-Water	79.8 Water	108.6°C

Solution of gas in liquid:-

Solubility of gas in liquid can be written in X, m etc

Factors affecting solubility :-

① Effect of temperature:-



$$T \uparrow \Rightarrow \xleftarrow{Rxn}$$

At constant pressure,

$$\ln \frac{C_2}{C_1} = \frac{\Delta H_{sol}}{R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right) = \frac{-\ln k_2}{k_1} \Rightarrow \text{Solubility} \downarrow$$

where C = molar concentration of gas in solution

$$K_{eq} = \frac{[A]}{P_A}$$

② Effect of pressure:-



$$P \uparrow \Rightarrow n_g \downarrow \xrightarrow{Rxn} \Rightarrow \text{Solubility} \uparrow$$

Solubility of gas in liquid follow Henry's Law at low Pressure

Henry's Law:- $P_{gas} \propto X_{gas} \Rightarrow P_{gas} = K_H X_{gas}$

Where P = Partial Press of Gas , K_H = Henry's Cont

X_{gas} = Mole fraction of gas liquid

If $P = \text{Cont}$ $\Rightarrow K_H \uparrow \Rightarrow X_{gas} \downarrow$

If $P = \text{Cont}$ $\Rightarrow T \uparrow \Rightarrow X_{gas} \downarrow \Rightarrow K_H \uparrow$

Limitations of Henry's Law :

- (1) It is valid only for ideal behaviour of gas. As none of the gas is ideal, this law may be applied at low pressure and high temperature.
- (2) It gives better result when the solubility of gas in the liquid is low.
- (3) The gas should neither dissociate nor associate in the liquid.

Henry's Law application :

- (1) To increase the solubility of CO₂ in soft drinks and soda water, the bottle is sealed under high pressure.
- (2) Scuba divers must cope with high concentrations of dissolved gases while breathing air at high pressure underwater. Increased pressure increases the solubility of atmospheric gases in blood. When the divers come towards surface, the pressure gradually decreases. This releases the dissolved gases and leads to the formation of bubbles of nitrogen in the blood. This blocks capillaries and creates a medical condition known as bends, which are painful and dangerous to life. To avoid bends, as well as, the toxic effects of high concentrations of nitrogen in the blood, the tanks used by scuba divers are filled with air diluted with helium (11.7% helium, 56.2% nitrogen and 32.1% oxygen).
- (3) At high altitudes the partial pressure of oxygen is less than that at the ground level. This leads to low concentrations of oxygen in the blood and tissues of people living at high altitudes or climbers. Low blood oxygen causes climbers to become weak and unable to think clearly, symptoms of a condition known as anoxia.

Problem

If N₂ gas is bubbled through water at 293 K, how many millimoles of N₂ gas would dissolve in 1 litre of water? Assume that N₂ exerts a partial pressure of 0.987 bar. Given that Henry's law constant for N₂ at 293 K is 76.48 kbar.

$$P_{\text{gas}} = k_H \times X_{\text{gas}} \Rightarrow 0.987 \times 10^{-3} = 76.48 \times \frac{n_{N_2}}{\left(\frac{1000}{18}\right)}$$

$$\Rightarrow n_{N_2} = 0.987 \times \frac{1}{18} \times \frac{1}{76.48} = 0.7169 \times 10^{-3} \text{ mol} = 0.7169 \text{ mmol}$$

Problem

The air is a mixture of a number of gases. The major components are oxygen and nitrogen with approximate proportion of 20% is to 79% by volume at 298 K. The water is in equilibrium with air at a pressure of 10 atm. At 298 K, if the Henry's law constants for oxygen and nitrogen are 3.30×10^7 mm and 6.51×10^7 mm respectively, calculate the composition of these gases in water.

$$P = k_H X$$

$$\frac{10 \times 0.2}{10 \times 0.79} = \frac{3.3 \times 10^7 \times n_{O_2}/n_{H_2O}}{6.51 \times 10^7 \times n_{N_2}/n_{H_2O}} \Rightarrow \frac{n_{O_2}}{n_{N_2}} = \frac{0.2 \times 6.51}{0.79 \times 3.3} = 0.499$$

$$\therefore O_2 = 0.5$$

Nature of gases:-

⇒ Interaction force ↑ ⇒ Solubility ↑
e.g.: O₂ < CO₂

⇒ liquidation ↑ ⇒ Solubility ↑
 T_c (Critical temp) ↑ ⇒ Solubility ↑
 $= \left(\frac{8a}{27Rb} \right)$

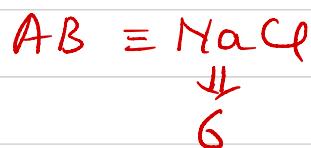
60 g of a non-volatile solid AB (having crystals like NaCl or CsCl) is dissolved in 0.50 kg water. The normal boiling point of solution is found to be 102.08° C. The molal elevation constant for water is 0.52 K·kg mol⁻¹. The density of solid AB is 6.25 g/cm³ and the edge-length of unit cell is 400 pm. The coordination number for A⁺ ion in the solid is : (N_A = 6 × 10²³)

$$\Delta T_b = i k_b m$$

$$2.08 = 2 \times 0.52 \times \frac{60}{0.5}$$

$$M = 60$$

$$6.25 = \frac{Z \times \frac{M}{6 \times 10^{23}}}{(4 \times 10^{-8})^3} \Rightarrow Z = 4$$



When 0.1 M Pb(NO₃)₂ solution is titrated with 0.1 M KI solution then what will be the osmotic pressure (in atm) of solution when equivalence point is reached at 300 K.

(Take : R = 0.08 atm L/mol·K)

