5. Azeotrope - This type of liquid mixture which boils at the same temperature without under-going any change in composition is ~~known~~ known as constant boiling mixture or azeotropic mixture or azeotrope. ~~The solute~~ There are two types of azeotropes - Minimum boiling azeotrope and maximum boiling azeotrope. (Table 2.6, 2.7).

5.1. Minimum boiling azeotrope - ~~at~~ These solution shows large positive deviation from Raoult's law at a specific composition.

For example, ethanol - water mixture. (By fermentation)
Ethanol - 95.57 mass %.
Water - 4.43 mass %.

This will be boiling at 351.1 K temperature which is less than boiling point of both ethanol (351.3 K) and Water (373 K).

This is known as minimum boiling azeotrope because the partial vapour pressure of the two components in the mixture are the maximum while their boiling point are the minimum. So, alcohol and water will behave as if they were constituents of a pure liquid and they will distil together

5.2. Maximum boiling azeotrope- These solution shows large negative deviation from Raoult's law at a specific composition.

i) In this case, the vapour pressure will be lowered and consequently the boiling point will be raised.

ii) The partial vapour pressure of the two constituents present will be minimum and boiling points the maximum.

iii) Ex: HCl - 20.2 mass %, H_2O - 79.8 mass %.
It boils at 383 K and this temperature is more than the bp temperature of both HCl (185 K) and water (373 K).

Thus, In the case of minimum boiling azeotrope, the boiling point of the azeotropic mixture is less than the boiling points of any of the two pure components. In the case of boiling point of the mixture is more than the boiling point of any of the two components in pure state.

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▼ TABLE 2.6. Minimum Boiling Azeotropes

Components		Mass % of B in the azeotrope	Boiling points (K)		
A	B		A	B	Azeotrope
Water, H_2O	Ethanol, C_2H_5OH	95·57	373	351·3	351·1
Chloroform, $CHCl_3$	Ethanol, C_2H_5OH	67·00	334	351·3	332·3
Benzene, C_6H_6	Ethanol, C_2H_5OH	32·40	353·2	351·3	341·2
Acetone, $(CH_3)_2C{=}O$	Carbon disulphide, CS_2	67·00	329·25	319·25	312·25

▼ TABLE 2.7. Maximum Boiling Azeotropes

Components		Mass % of B in the azeotrope	Boiling points (K)		
A	B		A	B	Azeotrope
Water, H_2O	Hydrochloric acid, HCl	20·20	373	188	383
Water, H_2O	Nitric acid, HNO_3	68·00	373	359	393·5
Chloroform, $CHCl_3$	Acetone, $(CH_3)_2CO$	20·00	334	329·25	347·7
Chloroform, $CHCl_3$	Methyl acetate, CH_3COOCH_3	23·00	334	330	347·8

Q.8) The vapour pressure of pure liquids A and B are 450 and 700 mm Hg respectively, at 350 K. Find out the composition of the liquid mixture if total vapour pressure is 600 mm Hg. Find the composition of the vapour phase.

Sol: Vapour pressure of pure liquid A $(P^\circ_A) = 450$ mm
Vapour pressure of pure liquid B $(P^\circ_B) = 700$ mm
Total vapour pressure of solution $(P) = 600$ mm

According to Raoult's law,

$$P = P^\circ_A x_A + P^\circ_B x_B = P^\circ_A x_A + P^\circ_B (1 - x_A)$$

$\Rightarrow 600\,mm = 450\,mm \times x_A + 700\,mm\,(1 - x_A)$

$\Rightarrow 600 = 700\,mm + x_A\,(450 - 700)\,mm$

$\Rightarrow 600 = 700 - x_A\,(250\,mm)$

$\Rightarrow x_A = \dfrac{(600 - 700)\,mm}{-250\,mm} = 0.40.$

Mole fraction of A $(x_A) = 0.40$
Mole fraction of B $(x_B) = 1 - 0.40 = 0.60.$

$$p_A = p^\circ_A x_A = (450\,mm) \times 0.40 = 180\,mm$$

$$p_B = p^\circ_B x_B = (700\,mm) \times 0.60 = 420\,mm.$$

Mole fraction of A in vapour phase $= \dfrac{P_A}{P_A + P_B} = \left(\dfrac{180}{180 + 420}\right)$ mm

$= 0.30.$

Mole fraction of B in the vapour phase =

$$= \frac{P_B}{P_A + P_B} = \frac{420}{180+420} = 0.70$$