Phase Diagram

Using an appropriate thermometer study the phase diagram of a binary mixture of phenol and the supplied aqueous solution (PD) and find the critical solution temperature and composition (w/w percent) of the mixture at that temperature.

A. Theory:- A diagram which represents different phases of forms of the substrate or mixture of substances at equilibrium is called phase diagram. If the degree of freedom(F) is dependent on the variables such as pressure(P), temperature(T) and concentration (C) but not dependent on the variables such as surface tension, gravity, etc then degree of freedom(F) can be related with component (C) of the system and number of phases of the system (P) according to phase rule,

$$F=C-P+2$$

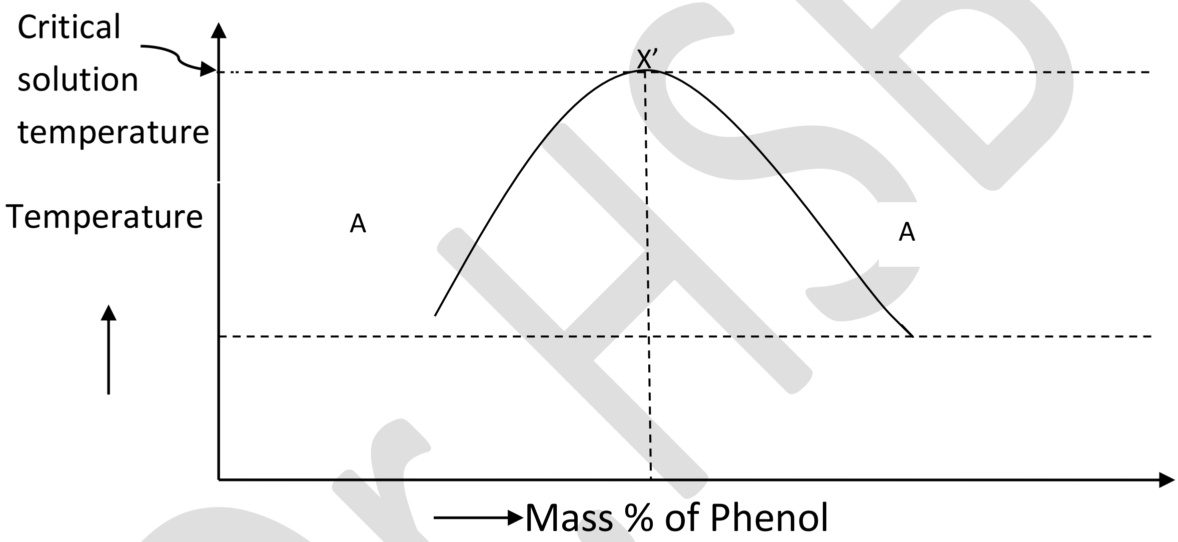
'2' for 'pressure' and 'temperature' variables.

For a binary mixture of two partially miscible liquids e-g phenol and water the 'certain condition' heterogeneous phase is formed under it studied by continuous adding of water in phenol until a saturated solution of water in phenol obtained. Thus continuous adding of water in phenol results saturated solution of phenol in water after a certain time. So two phases form. On increase in volume of water first phase (i.e water in phenol) decreases and second phase (i.e phenol in water) increases.

Here component 2, phase 2, so degrees of freedom (F)=2-2+2=2 i.e Bivariant . In this experiment if pressure remain constant then, F=2-2+1=1 i.e univarient system.With increase in temperature mutual solubility increases . At a certain temperature the mutual solubility curve attain maximum, this temperature is called critical solution temperature (CST)or consolute temperature (CT) and corresponding composition is called consolute composition .

Under a constant pressure above the CST the homogeneous phase is obtained.

For phenol water system the critical solution temperature is 65.9℃ and consolute composition is 34% The expected mutual solubility curve is as follows-



Phase 1 is heterogeneous phase consisting of binary mixture of phenol and water. Phase 2 is homogeneous phase. The composition can be calculated by drawing tie line in the curve 'between A and A'. In the point A and A', no of phase two, component 2 so degrees of freedom F=C-P+1 = 2-2+1= 1 i.e univarient so this expressed as line. In the phase 2, no of phase (p) = 1 component 2, so F=2-1+1=2 i.e bivarient so it is expressed by area. In the point x' i.e critical solution temperature, F=0 i.e invariant so this expressed as point.

Under constant pressure, we carry out the experiment by adding water in phenol and for each solubility temperature will be noted. Then the temperature vs. Weight percentage of phenol will be plotted. From the graph, obtained maximum solubility temp and its corresponding composition; those will be critical solution temperature(CST) and con solute composition of phenol respectively. And this will be studied using the law of rectilinear motion.

Experimental data:-

Table 1: **Recording of room temperature:**

Before experiment	After experiment	Mean temperature
29°C	29°C	29°C

Table 2: **weight of phenol taken**:

Initial weight (g)	Final weight(g)	Weight taken(g)
12.418	8.307	12.418-8.307=4.111

Table 3: **Recording of volume of PD solution added and temperature of disappearance and reappearance of turbidity:-**

Density of the supplied solution (PD) be 1.0 g/ml.

No of obs.	Volume of PD solution added (ml)	Total volume of pd solution added (ml)	Weight % of phenol	Weight % of phenol	Temp of disappearance of turbidity (°C)	Temp of reappearance of turbidity (°C)	Mean temperature(°C)

1	2	2	32.7	67.3	49.5	48	48.75
2	1	3	42.2	57.8	62	62	62
3	1	4	49.3	50.7	68	67.5	67.75
4	1	5	54.9	45.1	69.5	69	69. 25
5	1	6	59.3	40.7	70	70	70
6	1	7	63.1	36.9	70.5	70.5	70.5
7	1	8	66.1	33.9	70	69.5	69.75
8	1	9	68.6	31.4	69	68.5	68.75
9	2	11	72.8	27.2	67	67	67
10	2	13	75.9	24.02	66	65.5	65.75
11	3	16	79.6	20.4	64	64	64
12	3	19	82.2	17.8	62.5	62.5	62.5

Table 4: Data for plotting the mean temperature (of disappearance and reappearance of turbidity) versus weight percentage of phenol:-

NO of obs	Weight percentage of phenol	Mean temperature of disappearance and reappearance of turbidity
1	67.3	48.75
2	57.8	62
3	50.7	67.75
4	45.1	69.25
5	40.7	70
6	36.9	70.5
7	33.9	69.75
8	31.4	68.75
9	27.2	67
10	24.1	65.75
11	20.4	64
12	17.8	62.5

Conclusion: from the graph, it is obtained that the point (p) indicates the critical solution temperature in ‘y’ axis and corresponding composition along x axis will be consolute composition of phenol – PD solution system.

So, for phenol-PD solution system the critical solution temperature (CST) is 70.5℃ and the corresponding composition is 36.9≃37 (w/w). [$weight\ percentage\ of\ phenol$].