

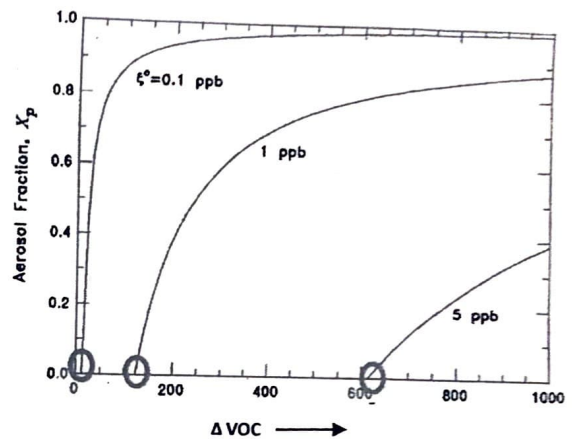
MCL 732 Major B, 22 Marks

As a student of IIT Delhi, I will not give or receive aid in examinations. I will do my share and take an active part in seeing to it that others as well as myself uphold the spirit and letter of the Honour Code.

Problem 1

Attached is the plot [Seinfeld & Pandis] of X_p , the aerosol fraction, versus ΔVOC ($\mu\text{g}/\text{m}^3$), the amount of original emitted VOC reacted for three decomposition products of varying volatility (ρ^0 or ξ^0) as per $VOC \rightarrow \sum a_i P_i$

Indicate the physical significance of the circled quantity (X-intercept) and reason why it is different for the different products. Derive its expression given M_i , M_{VOC} , T , any other parameters as needed. (5)



Problem 2

A measurement station measures total (aerosol + gas phase) NH_3 (ppb), total HNO_3 (ppb) and particulate matter NH_4NO_3 ($\mu\text{g}/\text{m}^3$) in a polluted region as shown in the table. Note ξ_i (ppb) = C_i ($\mu\text{g}/\text{m}^3$) * $25.6/M_i$

However, some of the measurement equipment had downtime at various points, so we need to complete this table with the help of our knowledge of the thermodynamics of aerosols.

Given that RH remains below the DRH for NH_4NO_3 in this duration and the variation of K_p (ppb²) with temperature is of the form: $\ln(K_p) = \alpha - \left(\frac{\beta}{T}\right)$ ($\alpha, \beta > 0$), determine the values of A, B, C, D (6)

T(K)	NH_3 (ppb)	HNO_3 (ppb)	NH_4NO_3 ($\mu\text{g}/\text{m}^3$)
299	A	23	9.375
300	23	14	B
300	17.6	31.6	5
300	21.4	38.4	C
301	30.54	24.39	7
303	33	D	2

Problem 3: Provide three reasons why $\text{PM}_{2.5}$ pollution is more severe in winters than in summers (3)

Problem 4

- A. Ambient NH_4NO_3 aerosol is found in dry/solid state on Day 1 at 65% RH, but is found in aqueous state at same RH later in the same day. Briefly provide the possible reason. (1)
- B. Several months later ambient NH_4NO_3 aerosol is always found in the aqueous state when the ambient RH reaches 65%. Again, provide the possible reason (2)

Problem 5

Recall the combined mathematical statement of the first and second laws thermodynamics as you learnt in your pre-requisites course, $TdS = dU + pdV$, and apply the same to a gas-aerosol system undergoing chemical and/or phase change.

- A. Does the internal energy U or the entropy S depend on the phase or chemical composition of the system? (1)
- B. Based on your answer above, propose any modification to the combined statement (2)

Problem 6

The activity of species A in a practical solution

- A. Tends to the mole fraction of A when the solution approaches pure A
- B. Is a poorer marker than the mole fraction of A when characterizing A's vapor pressure above the solution
- C. Is always less than the mole fraction of A

Choose the correct option(s). No need to provide any reasoning

(2)