

ATS 621, Fall 2011

HOMEWORK #8: due Tuesday, November 15, 2011

Please provide solutions with complete calculations for full credit. Use SI units.
Point values listed in brackets for each question.

Q1 (40): Aerosol nitrate formation

We examine here the conditions under which atmospheric nitric acid produced by oxidation of NO_x is incorporated into the aerosol. Consider an air parcel at $T = 290$ K containing a fixed gas-phase HNO₃(g) concentration of 1 ppbv at 1 atm in equilibrium with an otherwise pure-water aerosol. The relevant equilibria are:



1.1 Calculate the pH of the resulting aerosol. You should find $\text{pH} = 1.3$. Is aerosol nitrate present mainly as NO₃⁻ or as HNO₃(aq)?

1.2 For a typical aerosol liquid water content $L = 1 \times 10^{-11}$ liter of liquid water per liter of air, calculate the ratio $(\text{NO}_3^-)/(\text{HNO}_3(\text{g}))$ where () denotes the concentration in moles per liter of air. You should find that that only about 1% of the nitric acid in the air parcel is incorporated into the aerosol.

1.3 Explain how the presence of ammonia would facilitate the incorporation of nitric acid into the aerosol phase. What would then be the composition of the resulting aerosol?

1.4 A typical cloud has a pH of 5 and a liquid water content $L = 1 \times 10^{-7} \text{ m}^3$ of liquid water per m^3 of air. Show that under such cloudy conditions nitric acid is over 99% scavenged by the cloudwater, in contrast to clear-sky conditions where scavenging by aqueous aerosol is negligible.

Problems from Jacob:

Q2 (20): 13.1

Q3 (40): 13.4