

SIO217D Atmospheric Chemistry: Problem Set 5

Spring 2004

1. **Binary H₂SO₄/H₂O Nucleation** (Seinfeld and Pandis, 1997, Ch.10): Calculate the H₂SO₄ gas-phase concentration (in molecules cm⁻³) that produces a binary homogeneous nucleation rate of 1 cm⁻³ s⁻¹ at RHs of 20%, 40%, 60%, 80%, and 100% at 273K, 298K, and 323K. Comment on the results.

Hint: You can use Eqn. 10.102 or Fig. 10.11.

2. **Tobacco Coagulation** (Seinfeld and Pandis, Prob. 12.2): Tobacco smoke that enters the lungs by inhalation has about 2 s of potential evolution time before it reaches the alveoli in the lungs. Assume that the inhaled concentration is 10¹⁰ cm⁻³ and that the initial aerosol diameter is 20 nm. By what factor does the average particle size of the tobacco smoke particles increase as a result of coagulation only during the time that it takes for the smoke to travel from the cigarette to the smoker's lungs? Assume the air you breathe is at 298K and 1 atm.

Hint: In class we showed that assuming a constant vapor concentration for this time scale is inappropriate, so you will need to solve the simultaneous differential equations for monomers, dimers, trimers, etc. (Show that you can neglect higher-order n-mers in your calculation.)

3. **DBP Condensation** (Seinfeld and Pandis, 1997, Prob. 11.1): Consider the growth of a particle of dibutyl phthalate (DBP) in air at 298 K containing DBP at a background mole fraction of 0.10. The vapor pressure of DBP is sufficiently low that it may be assumed to be negligible.
- Compute the steady-state mole fraction and temperature profiles around a DBP particle of 1 μm diameter. Assume continuum regime conditions to hold.
 - Compute the flux of DBP (mol cm⁻² s⁻¹) at the particle surface.
 - Can you neglect the Stefan flow in this calculation?
 - Evaluate the temperature rise resulting from the condensation of the vapor on the particle.
 - Plot the particle radius as a function of time starting at 0.5 μm and assuming that the background mole fraction of DBP remains constant at 0.10.

Hint: The following parameters may be used in the calculation

$$\Delta H_v/R = 8930 \text{ K}$$

$$D = 0.0282 \text{ cm}^2 \text{ s}^{-1}$$

$$R/M_{air}c_p = 0.274$$

$$M_{DBP}/M_{air} = 9.61$$