國立臺灣大學 104 學年度碩士班招生考試試題

Physical laws you might need:

$$PV=nRT$$

$$\theta = T \times \left(\frac{P}{1000hPa}\right)^{\frac{-R_d}{C_p}}$$

$$e_s = 2.53 \times 10^9 \exp\left(\frac{-5420}{T}\right)$$

P : pressure (Pa)
V : volume of gas (m^3)
n : moles of gas (mol)
T : temperature (K)
θ : potential temperature (K)
e_s: saturation water vapor pressure (hPa)

Physical constants you might need:

R: Universal Gas Constant 8.314 J $mol^{-1}K^{-1}$
R_v: Gas Constant of Water Vapor 461 J K^{-1} kg^{-1}
R_d: Gas Constant of Dry Air 287 J K^{-1} kg^{-1}
C_p : Specific Heat Capacity at Constant Pressure 1004 J K^{-1} kg^{-1}
L_v: Latent Heat of Vaporization at 298 K 2.3×10^6 J kg^{-1}
M_a: Molecular Mass of Dry Air 29 g mol^{-1}
M_w: Molecular Mass of Water 18 g mol^{-1}
M_{as}: Molecular Mass of Ammonium Sulfate 132 g mol^{-1}
ρ_{as}: Density of Dry Ammonium Sulfate 1.769 g/cm^{-3}
N: Number of Air Molecule at 1 atm 298 K 2.5×10^{19} cm^{-3}
Assume all gases are ideal.

1. Moisture contents in the atmosphere and the growth of aerosol particles.

Consider the following three pristine conditions with no condensed water:

[a] Relative Humidity (RH) = 99%, P = 1000 hPa, T = 25 °C

[b] RH = 100%, P = 700 hPa, θ = 298 K

[c] RH = 103%, P = 1000 hPa, T = 20 °C

(1.1) (15pt) Please calculate the mass of water vapor (in unit of g) contained in one kilogram of moist air for each of the conditions above. Please list the steps of your calculation in detail.

(1.2) (8pt) Ideally mixing 3 kg of moist air from condition [a] with 1 kg of moist air from condition [c], keeping constant pressure and no condensation, what is the mean RH of the mixture air?

(1.3) (8pt) Fig. 1 shows the Köhler curve of an ammonium sulfate particle. Please explain what physical effects determine the shape of the Köhler curve and how.

(1.4) (5pt) Please derive the values of the critical diameter and critical supersaturation for the particle in Fig. 1 from the Köhler equation.

(1.5) (9pt) Based on Fig. 1, please describe how the wet size of the aerosol particle will respond when this dry particle is inserted into the conditions [a], [b], and [c], respectively.

(1.6) (5pt) If inserting 3×10^5 dry ammonium sulfate aerosol particles with the same diameter of 0.045 μm into the mixture air of (1.2), will cloud formation occur? Please explain why. (You may ignore the change of water vapor concentration owing to the wet growth of the aerosol particles)

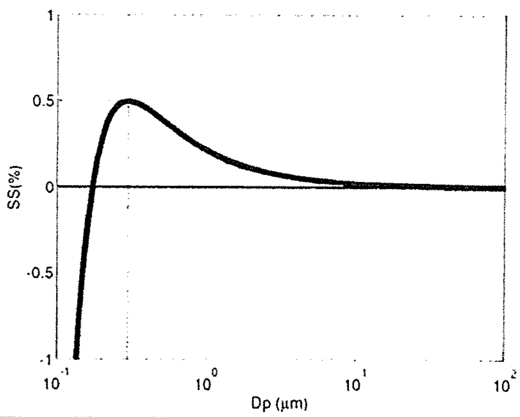


Fig. 1 The Köhler curve of an ammonium sulfate aerosol particle with dry diameter of 0.045 μm at 298 K. The black dashed lines show the "critical diameter" and "critical supersaturation".

The Köhler equation for this particle:

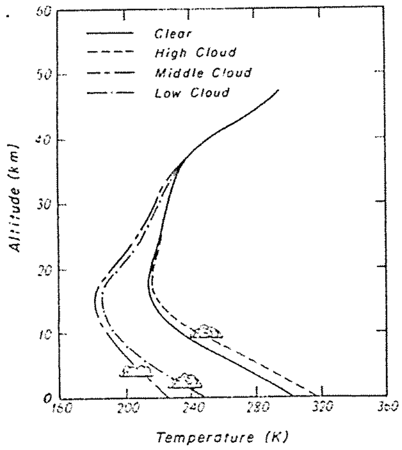
$$SS = \left(\exp\left[\frac{0.66}{TD_p} - \frac{6.59\times10^{-5}}{D_P^3}\right] - 1\right) \times 100\%$$

in which
SS: ambient supersaturation (%)
D_p: particle diameter (μm)

見背面

2. 請解釋大氣窗 (atmospheric windows) (10%)

3. 請解釋下圖. 指出不同高度的雲對輻射之影響，為什麼？(20%)



4. 請解釋 $I_\lambda(s_1) = I_\lambda(0)e^{-\tau_\lambda(s_1,0)}$，　$\tau(s_1,0) \equiv \int_0^{s_1} k_\lambda \rho ds$ (20%)

試題隨卷繳回