

AOS 330
Homework #7
(Due:12/11/09)

1. Name the three modes that describe aerosol size distribution and explain the physical processes related to each mode. Give an example for each mode of where you expect aerosol particles of that size and the type of aerosols could be found.

2. Compare the size of ice and liquid condensates:

Given number concentration of cloud condensation nuclei is 100 cm^{-3} and that of ice nuclei is $10^{-8} \exp(-0.6 \cdot T_c)$.

Assume i. Condensates are in liquid form for $T \geq 0^\circ\text{C}$. They are in ice form below 0°C .

ii. Liquid water content in air is $r_{\text{condensate}} = 1 \text{ g kg}^{-1}$.

iii. Assume condensates are all of the same size and they are pure spheres.

Useful constants: $\rho_{\text{air}} = 1.25 \frac{\text{kg}}{\text{m}^3}$, $\rho_l = 1.00 \frac{\text{g}}{\text{cm}^3}$, $\rho_i = 0.93 \frac{\text{g}}{\text{cm}^3}$

Find the diameter of the condensates for $T_c = 0^\circ\text{C}$, -10°C , -20°C , -30°C , -40°C .
(HINT: make sure to keep your units consistent i.e. cgs units are preferred!)

Fill in the table below.

Temperature of condensates ($^\circ\text{C}$)	Diameter of condensates (micron)	Number concentration of condensates
0		
-10		
-20		
-30		
-40		

From the calculations in the table, what temperature is more likely that precipitation would be formed? Comment on your choice of temperature.

3. Growth of a single droplet by condensation: The equation describing the diffusional growth of a droplet is given by the equation:

$$r \frac{dr}{dt} = G(T, P) * \left\{ S - 1 - \frac{a}{r} + \frac{b}{r^3} \right\} * f(\text{Re}, \text{Pr})$$

Where $G(T, P)$ is equal to:

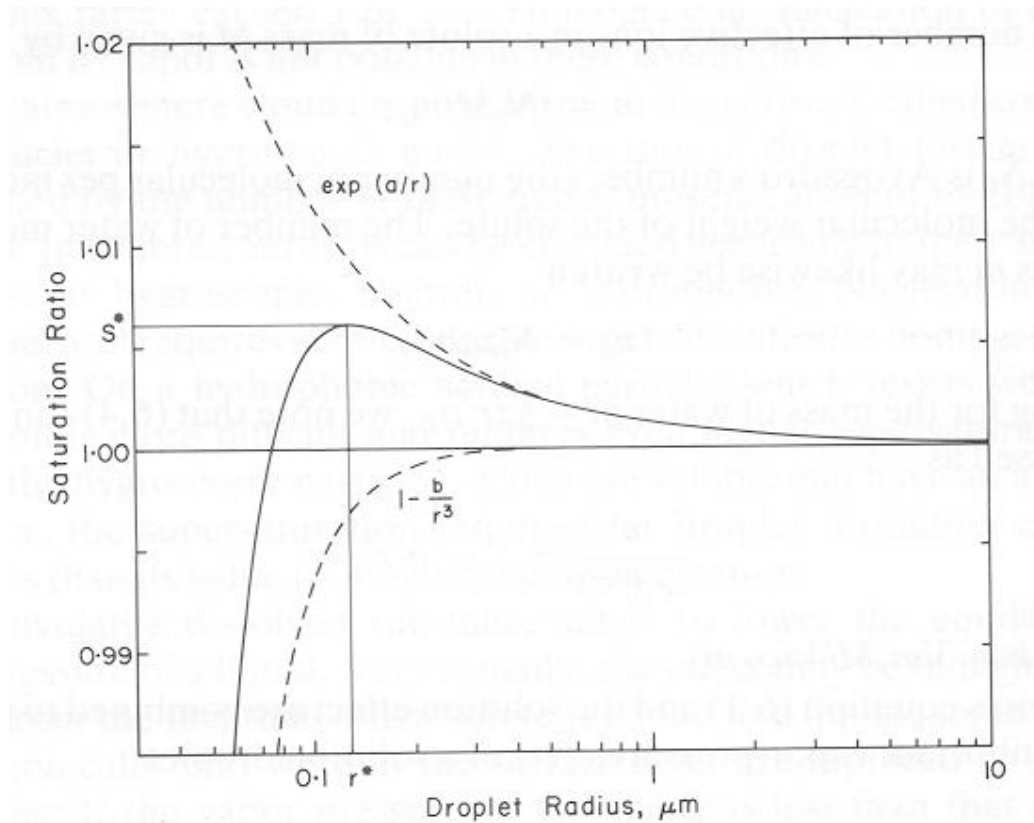
$$G(T, P) = \frac{1}{\frac{\rho_l R_v T}{D e_s(T)} + \frac{L_v^2 \rho_l}{R_v K T^2}}$$

Please derive the equation above stating all assumptions and showing all major steps.

4. Using the equation above (if necessary) please explain the formation of wet haze.

5. The Kohler Curve attached on the following page (From Rogers and Yao 1989) describes the dependence of saturation ratio on the size of a solution droplet. The Kohler equation can be shown in the form of equations (13) or (14) on page 266-267 of our text by combining the Kelvin equation and Raoult's Law. Using the figure on the following page please answer the following questions:

- How do curvature effects change the saturation pressure of water vapor?
- How do solution effects change the saturation pressure of water vapor?
- Please explain what S^* and r^* are.
- Where on the curve is the droplet stable and where on the curve is the droplet unstable?
- When does the droplet become activated?
- Where on the curve would one find haze particles?



6. Describe the two processes below in detail:

- Initiation of Rain in Freezing clouds (Cold Rain)
- Initiation of Rain in Non-Freezing clouds (Warm Rain)