

Homework 2

Aerosol Physics, Chemistry, Clouds and Climate

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Problem 1 Condensation

1.a

Assumed values:

- $T = 298.15K$
- $P = 1atm$
- $C_{\infty} = 5E7 \text{ molecules } cm^{-3} = 8.14E(-12) \text{ kg } m^{-3}$
- $C_s = 0$
- $D_g = 1E(-5) \text{ m}^2 \text{ s}^{-1}$
- Equation used for the condensation diameter growth rate:

$$\frac{dD_p}{dt} = \frac{4D_g}{\rho D_p} (C_{\infty} - C_s) \beta$$

The figure 1.a shows the condensation diameter growth rate vs diameter. The condensation growth rate is independent of the diameter of the particle in the kinetic regime ($D_p < 10nm$). Whereas in the continuum regime ($D_p > 1000nm$), the condensation diameter growth rate is inversely proportional to the diameter of the particle. In the transition regime ($10nm < D_p < 1000nm$), the condensation diameter growth rate is a function of the diameter of the particle and behaves similar to a sigmoid function between the kinetic and continuum regimes.

1.b

In order to calculate condensation mass growth rate the following equation was used:

$$\frac{dM_P}{dt} = J = 2\pi D_g D_p (C_{\infty} - C_s) \beta$$

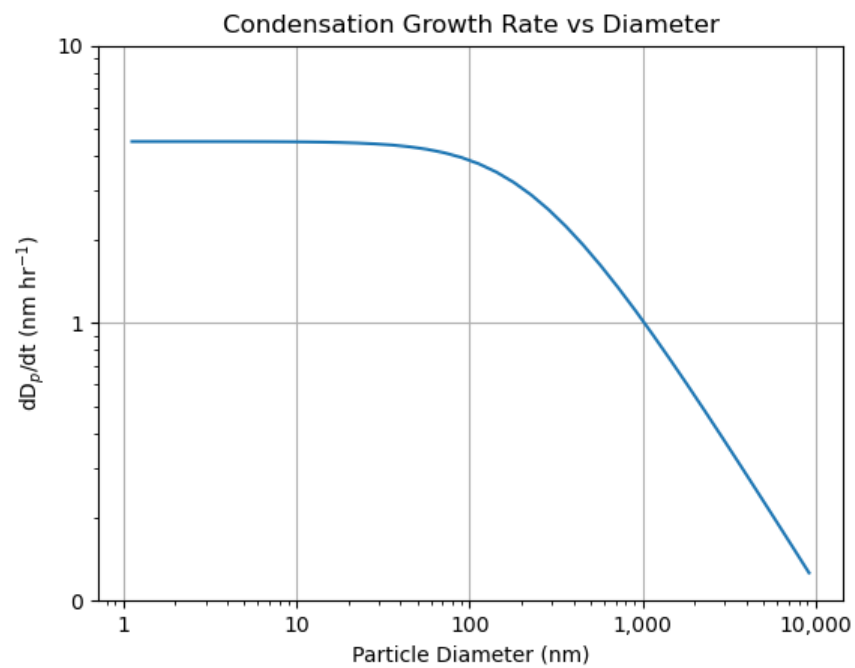


Figure 1: Problem(1) part(a) Condensation diameter growth rate vs diameter

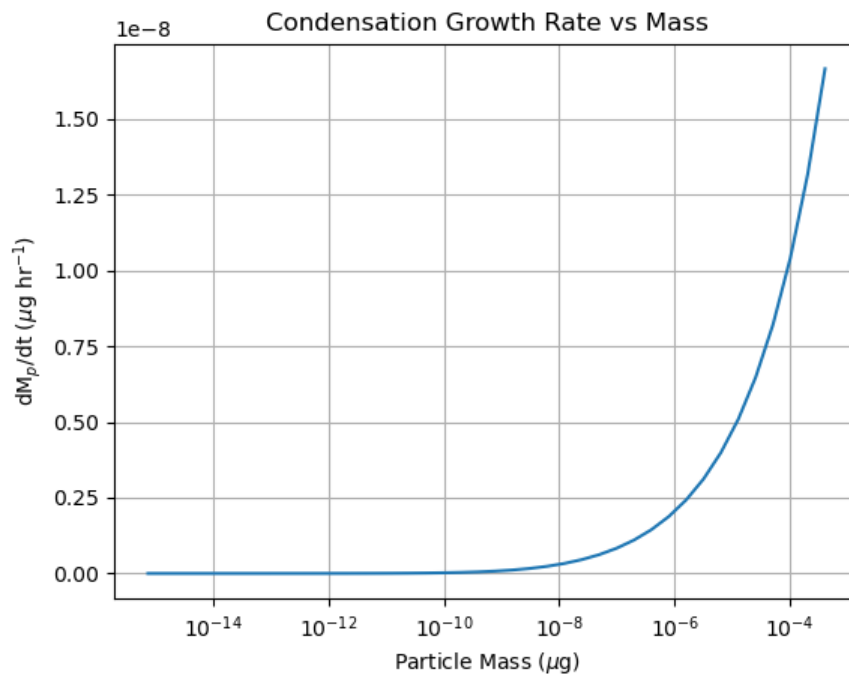


Figure 2: Problem(1) part(b) Condensation mass growth rate vs particle diameter

Problem 2 Coagulation

2.a Coagulation kernel and rate

Assumed values:

- $T = 298.15K$
- $P = 1atm$
- $N_1 = 3000 \text{ cm}^{-3}$, $D_{p1} = 10nm$
- $N_2 = 400 \text{ cm}^{-3}$, $D_{p2} = 100nm$
- $D_g = 1E(-5) \text{ m}^2 \text{ s}^{-1}$

Fuchs form of the brownian coagulation coefficient K_{12} :

$$K_{12} = 2\pi(D_1 + D_2)(D_{p1} + D_{p2})\left(\frac{D_{p1} + D_{p2}}{D_{p1} + D_{p2} + 2(g_1^2 + g_2^2)^{1/2}} + \frac{8(D_1 + D_2)}{(c_1^2 + c_2^2)^{1/2}(D_{p1} + D_{p2})}\right)^{-1}$$

$$K_{12} = 2.38E(-8) \text{ cm}^3 \text{ s}^{-1}$$

$$K_{table13.3} = 2.5E(-8) \text{ cm}^3 \text{ s}^{-1}$$

$$J_{12} = K_{12}N_1N_2 = 2.85E(-2) \text{ cm}^{-3} \text{ s}^{-1}$$

2.b Frequency of collision

The frequency of collision with the smaller particles = $K_{12}N_1 = 7.13E(-5)$

$$\text{The frequency of collision} = \frac{\text{Collision rate}}{N_1}$$

2.c Growth rate due to coagulation

The growth rate due to coagulation is given by the following equation:

$$\frac{dV_{p2}}{dt} = k_{12}N_1V_{p1}$$

$$\frac{dD_{p2}}{dt} = k_{12}N_1V_{p1}\frac{2}{\pi D_{p2}^2}$$

$$\frac{dD_{p2}}{dt} = 8.56E(-3)nm \text{ hr}^{-1}$$

2.d Growth in 1 week

The percent change in diameter in 1 week = 1.44%

The percent change in mass in 1 week = 4.31%

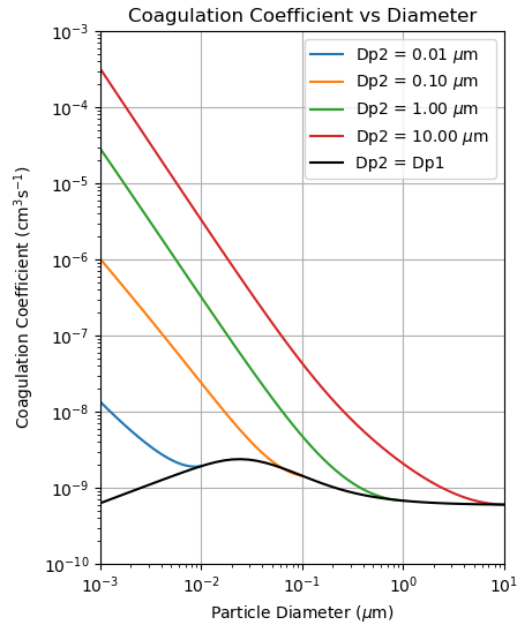


Figure 3: Fuchs Coagulation the code

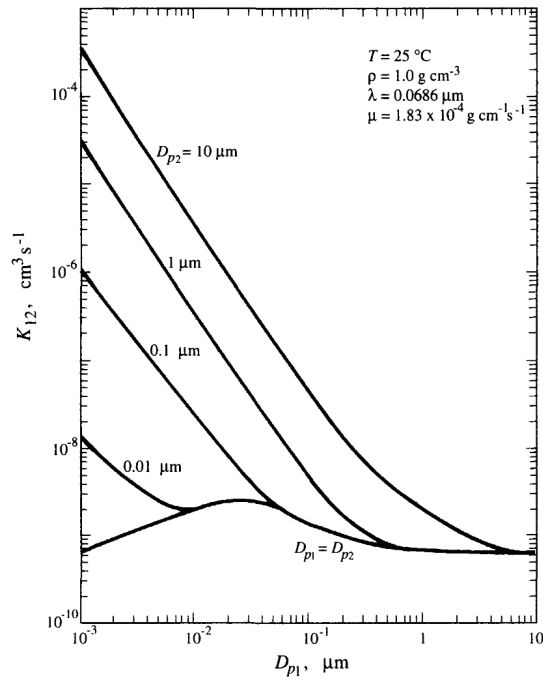


Figure 4: Table_13.5 Fuchs Coagulation plot