Homework 2

Aerosol Physics, Chemistry, Clouds and Climate

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Problem 1 Condensation

1.a

Assumed values:

- $T = 298.15K$
- $P = 1atm$
- $C_\infty = 5E7\ molecules\ cm^{-3} = 8.14E(-12)\ kg\ m^{-3}$
- $C_s = 0$
- $D_g = 1E(-5)\ m^2\ s^{-1}$
- 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:

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

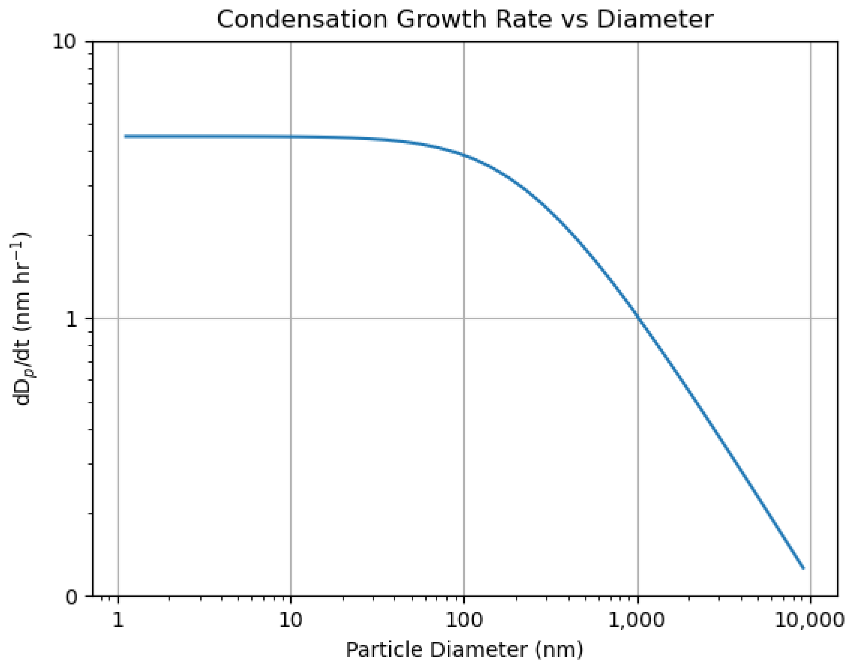

Figure 1: Problem(1) part(a) Condensation diameter growth rate vs diameter

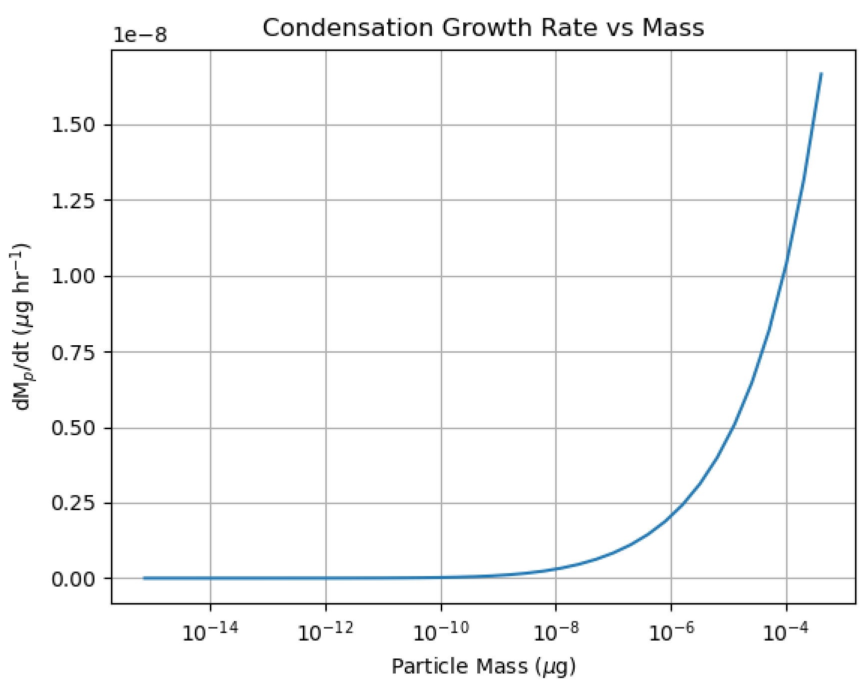

Figure 2: Problem(1) part(b) Condensation mass growth rate vs particle diameter

Problem 2 Coagulation

2.a Coagulation kernel and rate

Assumed values:

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

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

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

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

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

$J_{12} = K_{12} N_1 N_2 = 2.85E(-2)\ cm^{-3} s^{-1}$

2.b Frequency of collision

The frequency of collision with the smaller particles= $K_{12} N1 = 7.13E(-5)$

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

2.c Growth rate due to coagulation

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

$$\frac{dV_{p2}}{dt} = k_{12} N_1 V_{p1}$$
$$\frac{dD_{p2}}{dt} = k_{12} N_1 V_{p1} \frac{2}{\pi D_{p2}^2}$$
$$\frac{dD_{p2}}{dt} = 8.56E(-3) nm\ hr^{-1}$$

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%

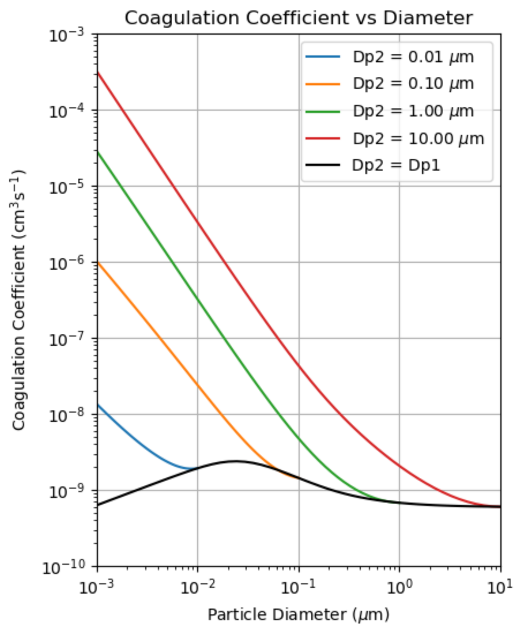

Figure 3: Fuchs Coagulation the code

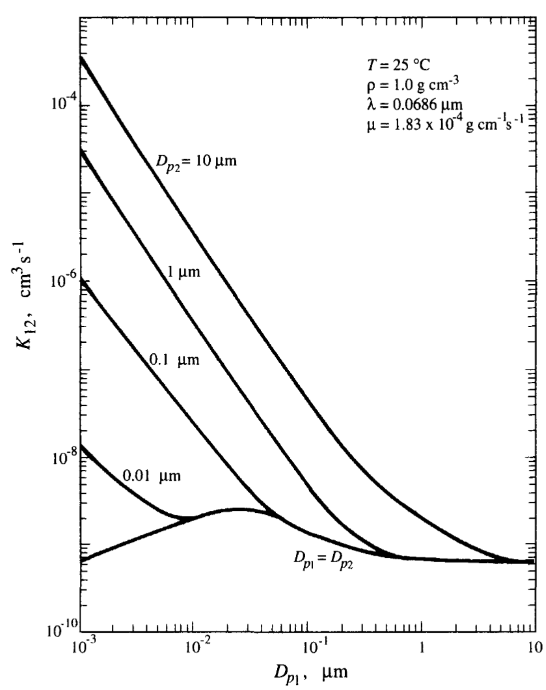

Figure 4: Table_13_5 Fuchs Coagulation plot