Problem Set 2

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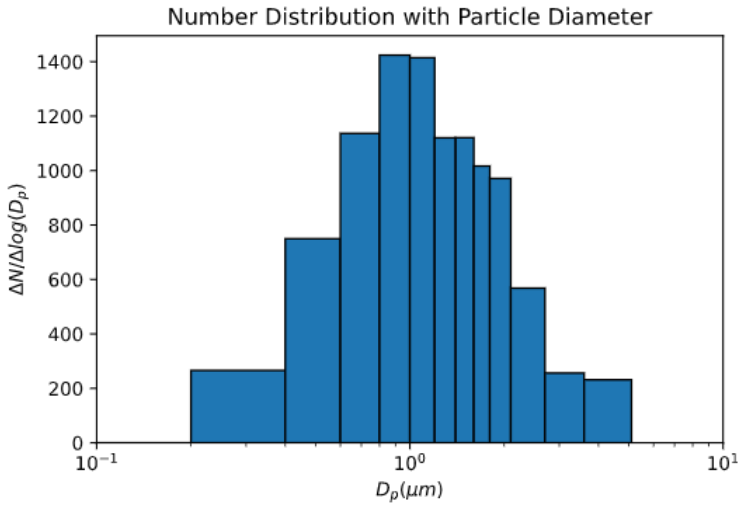
A) Given the data below, plot the following as discrete histograms: $\Delta N/\Delta log(D_p)$ versus $log(D_p)$ where ΔN is the number of particles in a bin and D_p is the mean diameter of the bin (i.e. mean of size interval).



B) Complete the table above by computing the following quantities: ΔS and ΔV, where ΔS and ΔV represent the surface area and volume of particles in a bin, respectively. Hand in your completed table for marks.

The total surface area in a bin (assuming spherical particles close to the mean size in the bin) is given by:

$$SA_T = 4\pi \left(\frac{D_p}{2}\right)^2 \Delta N$$

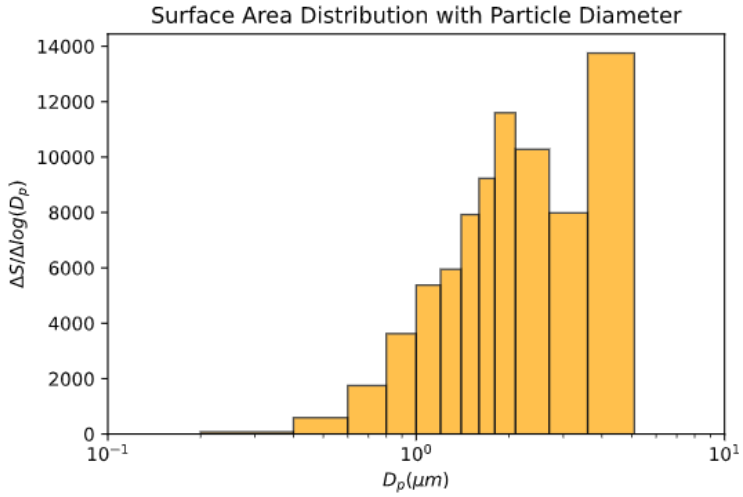
i.e. the surface area of an average particle multiplied by the total count. Volume is similarly:

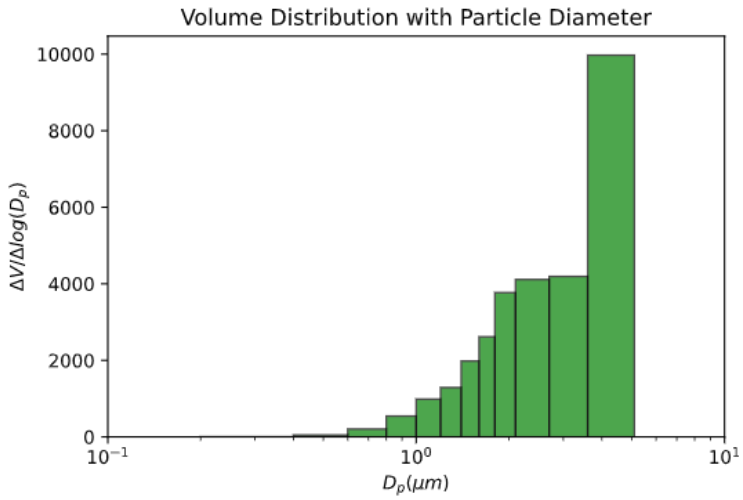
$$V_T = \frac{4}{3}\pi \left(\frac{D_p}{2}\right)^3 \Delta N$$

Add the columns to the table of data (see code below):

	min size (um)	max size (um)	Mean of Size int (um)	Number of Particles in int	Delta log Dp	Delta S	Delta V
0	0.0	0.2	0.10	10	inf	0.314159	0.005236
1	0.2	0.4	0.30	80	0.301030	22.619467	1.130973
2	0.4	0.6	0.50	132	0.176091	103.672558	8.639380
3	0.6	0.8	0.70	142	0.124939	218.592017	25.502402
4	0.8	1.0	0.90	138	0.096910	351.167227	52.675084
5	1.0	1.2	1.10	112	0.079181	425.748636	78.053917
6	1.2	1.4	1.30	75	0.066947	398.196869	86.275988
7	1.4	1.6	1.50	65	0.057992	459.457926	114.864481
8	1.6	1.8	1.70	52	0.051153	472.118544	133.766921
9	1.8	2.1	1.95	65	0.066947	776.483894	252.357266
10	2.1	2.7	2.40	62	0.109144	1121.925568	448.770227
11	2.7	3.6	3.15	32	0.124939	997.518499	523.697212

C) Using the information from above, plot $\Delta S/\Delta log(D_p)$ vs $log(D_p)$, and $\Delta V/\Delta log(D_p)$ vs $log(D_p)$





Code used to generate tables and plots:

```
# %% [markdown]
# # Problem Set 2
#
# ## Andrew Loeppky
# ## CHEM 535a
# ## Spring 2021
#

# %%
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
# %matplotlib inline

# %%
# import the data
in_data = pd.read_csv("C:/Users/Owner/UBC_S2021/atmos_chem/problemset2.csv")

# %%
# We want to plot
#
# a) $\Delta N / \Delta log(D_p)$ versus $log(D_p)$
#
# b) $\Delta S / \Delta log(D_p)$ versus $log(D_p)$
#
# c) $\Delta V / \Delta log(D_p)$ versus $log(D_p)$
#
# So we need to create new columns with $\Delta log(D_p)$, $\Delta S$ and $\Delta V$
#
# The total surface area in a bin (assuming spherical particles close to the mean size in the bin) is given by:
#
# $$
# SA_T = 4 \pi \left(\frac{D_p}{2}\right)^2 \Delta N
# $$
#
# i.e. the surface area of an average particle multiplied by the total count. Volume is similarly:
#
# $$
# V_T = \frac{4}{3}\pi \left(\frac{D_p}{2}\right)^3 \Delta N
# $$

# %%
# create the columns
in_data["Delta log Dp"] = np.log10(in_data["max size (um)"]) - np.log10(
    in_data["min size (um)"]
)
in_data["Delta S"] = (
    4
    * np.pi
    * (in_data["Mean of Size int (um)"] / 2) ** 2
    * in_data["Number of Particles in int"]
)
in_data["Delta V"] = (
    4
    / 3
    * np.pi
    * (in_data["Mean of Size int (um)"] / 2) ** 3
    * in_data["Number of Particles in int"]
)

in_data

# %%
# N plot for (A)
fig1, ax = plt.subplots()
ax.bar(
    in_data["min size (um)"],
    in_data["Number of Particles in int"] / in_data["Delta log Dp"],
    align="edge",
    width=in_data["max size (um)"] - in_data["min size (um)"],
    edgecolor="black",
```

```
)
ax.set_title("Number Distribution with Particle Diameter")
ax.set_ylabel("$\Delta N / \Delta log(D_p)$")
ax.set_xlabel("$D_p (\mu m)$")
ax.set_xscale("log")
ax.set_xticks([1e-1, 1e0, 1e1]);

# %%
# SA plot for (C)
fig2, ax = plt.subplots()
ax.bar(
    in_data["min size (um)"],
    in_data["Delta S"] / in_data["Delta log Dp"],
    color="orange",
    alpha=0.7,
    align="edge",
    width=in_data["max size (um)"] - in_data["min size (um)"],
    edgecolor="black",
)
ax.set_title("Surface Area Distribution with Particle Diameter")
ax.set_ylabel("$\Delta S / \Delta log(D_p)$")
ax.set_xlabel("$D_p (\mu m)$")
ax.set_xscale("log")
ax.set_xticks([1e-1, 1e0, 1e1])

# %%
# V plot for (C)
fig3, ax = plt.subplots()
ax.bar(
    in_data["min size (um)"],
    in_data["Delta V"] / in_data["Delta log Dp"],
    color="green",
    alpha=0.7,
    align="edge",
    width=in_data["max size (um)"] - in_data["min size (um)"],
    edgecolor="black"
)
ax.set_title("Volume Distribution with Particle Diameter")
ax.set_ylabel("$\Delta V / \Delta log(D_p)$")
ax.set_xlabel("$D_p (\mu m)$")
ax.set_xscale("log")
ax.set_xticks([1e-1, 1e0, 1e1]);
```