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Atmospheric Chemistry 2024: Final Exam

Format: During the examination you will be asked to provide a clear and straight-forward answer to the class for some of the questions given below. You may bring nothing to class to help with your answers; however, you can use blank paper to outline your answer before presenting your answer to the class. You will have a minute to think about how you want to answer the question. Your answer should take approximately 1-3 minute to present at the white board in the front of the room. You may use the white board to illustrate your answer. Be as detailed as possible. After completing your answer, your have one questions from the instructor.

Grading: The list of questions below are broken into three sections. Questions 1-7 are related to the last part of the class. Questions 8-14 are related to the middle of the class. Questions 15-21 are from the beginning of class. There will be three rounds of questions; with round one having questions 1-7, round 2 questions 8-15 and round 3 questions 16-21. Student will take turns picking questions until all questions of the round have been selected For each question, the rubric has 3-4 parts to answer. Student receive full credit if they provide the answers during their presentation. Student receive partial credit if they provide the answer during after being asked a questions.

Below are the questions to address. Please read each question carefully.

1a.) Illustrate the amount of SO_4^{-2} dissolved within cloud drops when sulfur dioxide <u>does not</u> dissolved in and react within the drop but only H_2SO_4 dissolves. 1b.) Illustrate and discuss how this compares to the amount of SO_4^{-2} dissolved within cloud drops when sulfur dioxide <u>does</u> dissolved in and react within the drop and also H_2SO_4 dissolves. 1c.) Include discussion of how long it takes for conversion of $SO_{2.}$

2a.) Describe the conversion of S(IV) to S(VI) in aerosol particles, cloud drops, and precipitation drops. 2b.) What is the major result of the conversion and where is the conversion important? 2c.) How does conversion of S(IV) to S(VI) change the pH of rainfall?

3a.) Provide an equation for the characteristic time (τ) for diffusion of a solute q through a liquid drop in terms of the drop radius (r). 3b.) Describe all parameters in the equation. 3c.) Provide a value for the characteristic time for diffusion within a drop?

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4a.) Describe the naturally occurring stable isotopes of oxygen in the Earth's atmosphere. 4b.) What determines the difference between the isotopes? 4c.) What does the Rayleigh model of vapor depletion of isotopes of oxygen when temperature decreases (for example, in a raising cloud parcel of air) and the fraction of vapor is transferred from the vapor phase to the condensate? 4d.) What atmospheric process can be investigated using atmospheric measurements of oxygen isotopes?

5a.) Discuss the conversion rate of S(IV) to S(VI). What are the important factors that influence the conversion rate of S(IV) to S(VI)? 5b.) How do these factors change between aerosols and cloud droplets? 5c.) What is an example of an oxidant of important for conversion of S(IV) to S(VI)?

6a.) Discuss the conditions when the droplet surface temperature would be different than the ambient temperature? 6b.) What types of cloud and fog conditions would the difference between droplet surface temperature and ambient air temperature be the greatest? 6c.) Provide the physical reason, in terms of energy transfer, for the temperature difference.

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7a.) Describe in terms of time and space, the total stratospheric ozone amount for the past 30 years. 7b.) Provide typical values of the ozone amount, with units, at several key locations, including describing/defining the unit of ozone amount used. 7c.) Describe any season changes in stratospheric ozone

8a.) Describe the conditions necessary for the stratospheric ozone hole, including the root cause. 8b.) List a measurement platform that has been used to study the stratospheric ozone hole. 8c.) Describe how the processes that cause the stratospheric ozone hole are measured and analyzed to determine the chemical process of the result in the stratospheric ozone hole.

9a.) Provide an illustration of the major atmospheric aerosol modes. 9b.) Include the size interval of each mode. 9c.) Include the sources for each mode and the sinks for each mode.

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10a.) Describe the Chapman Mechanism for Stratospheric Ozone. 10b.) How does the Chapman Mechanism agrees with observations. 10c.) What is the reason for any disagreement between the Chapman Mechanism theory and observations.

11a.) Illustrate with a graph the measured concentration of carbon dioxide concentration in the Earth's atmosphere from 1960 to the present. Make sure to label each axis and provide units. 11b.) Include in the illustration any sub-seasonal changes. 11c.) Include the location in the atmosphere where the concentration is made and where measurement is valid.

12a.) Use an illustration to show how particle size (both aerosol and droplets) changes with increases and decreases in relative humidity. 12b.) Define what chemical/physical changes the occur at different relative humidity. 12c.) Describe how changes in relative humidity affects the visibility in the Earth's atmosphere.

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13a.) Discuss the atmospheric mixing and residence time of a chemical compound (for example a particle) that is released at the Earth's surface. 13b.) How does the vertical and horizontal atmospheric mixing change between summer and winter in the United States? 13c.) How does the mixing change with different times of the day and how this daily affect by season.

14a.) Discuss the Haber Process (also called the Haber-Bosch Process) for making ammonia. What geochemical reservoir does the Haber Process remove nitrogen from and what geochemical reservoir(s) does the nitrogen end up in? 14b.) Provide an estimate of the percentage increase in global nitrogen content in the land biota reservoirs and ocean biota reservoirs over the past 100 years? 14c.) Describe why are the percentage increases similar or different?

15a. Discuss the history of atmospheric oxygen concentration. Illustrate changes in atmospheric oxygen concentration over the past 4 billion years. 15b.) What is the main reason for the change in atmospheric oxygen concentration over this time period? 15c.) Why was the change in oxygen concentration been relatively slow?

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16a.) Discuss the observation of particular matter less than 2.5 um (PM2.5) around the U.S., including North Dakota What are the yearly average mass concentrations in different locations? 16b.) What are the major components of PM2.5 measurements. 16c.) What are some sources of PM2.5 aerosols.

17a.) List three different instruments that are used to make a measurements related to atmospheric chemistry which were discussed during class tours, demonstrations, or lectures. 17b.) For each instrument you list, give the name of the instrument, the instrument's measurement principle and 17c.) how the instrument's measurements is used in the understanding of atmospheric chemistry.

18a.) What is a box (Eulerian) chemical model? 18a.) What are the major component of a one-box chemical model? 18c.) What is a puff (Lagrangian) chemical model?

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19a.) How does the mixing (dilution) of a chemical compound that is released at the Earth's surface change between summer and winter in the United States? 19b.) Discuss both vertical and horizontal mixing. 19c.) Explain difference between summer and winter. 19d.) Furthermore, describe how the mixing is different at different times of the day and how this daily mixing changes with season.

20a. Explain how the total (over all sizes) mass of aerosols, or total mass of cloud droplets, is calculated from observations made with an instrument such as an optical particle counter that counts the number of particles over a size interval. 20b. Provide equation with explanation of variables. 20c. Explain how aerosols and droplets are similar, and how they are different for this type of calculation.

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21a. Provide an explanation, based on the class discussed topics, that would explain the observed increase in aerosol concentration on the morning for September 28, 2024 (Figure 1). 21b. Use information from figures 2-6 to justify your explanation in terms of the aerosol measurements. 21c. Use information from figure 2-6 to justify your explanation in terms of meteorological observations.

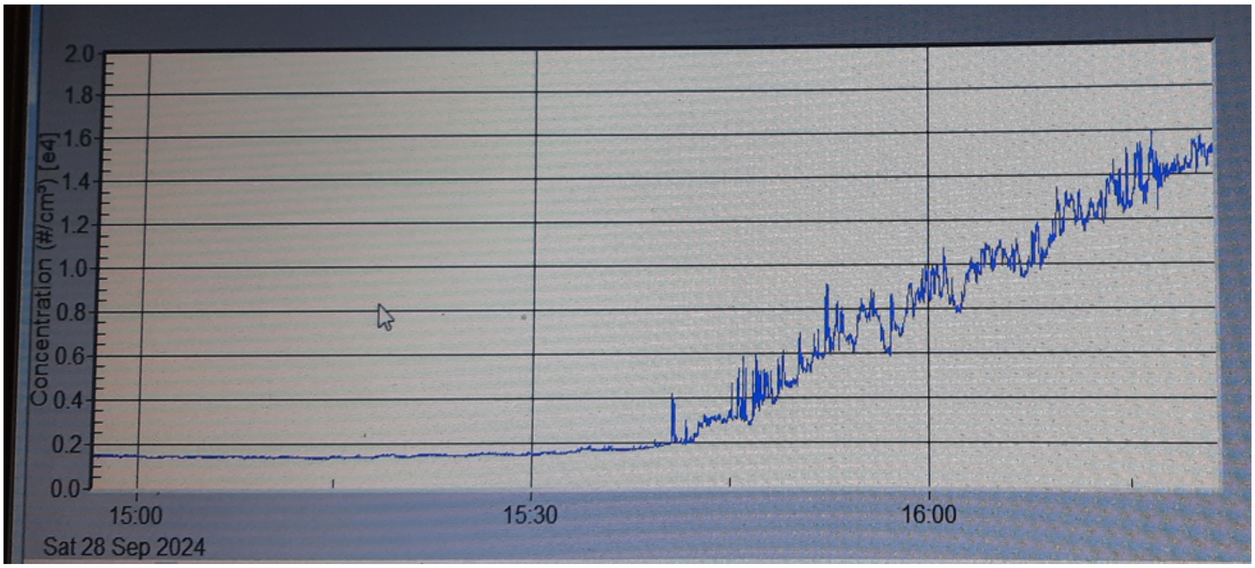

Figure 1: Image showing the time series (UTC) of concentration from a condensation particle counter (CPC, Model 3771) on September 28, 2024. Note that the CPC measures all particles larger than 10 nm. The CPC measurements is made at the surface in rural, North-west Minnesota. Note that the local time is 5 hours behind UTC time; hence, the time series is from approximately 10 am to 11:30 am.

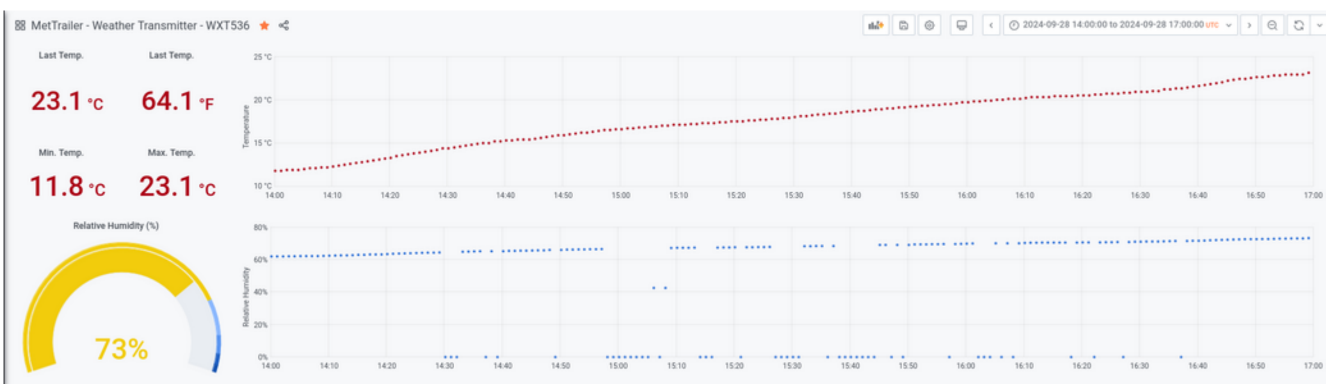

Figure 2: Time series (UTC) showing the temperature and humidity from the Weather Transmitter (WXT536) on September 28, 2024 from 14:00 to 17:00 UTC. The WCT536 measurements is made at the surface in rural, North-west Minnesota at the same location as Figure 1.

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Figure 3: Image showing the skyline September 28, 2024 at 15:00 UTC using a Deeplens camera.. The images is from the surface in rural, North-west Minnesota at the same location as Figure 1.

Figure 4: Image showing the skyline September 28, 2024 at 16:15 UTC using a Deeplens camera.. The images is from the surface in rural, North-west Minnesota at the same location as Figure 1.

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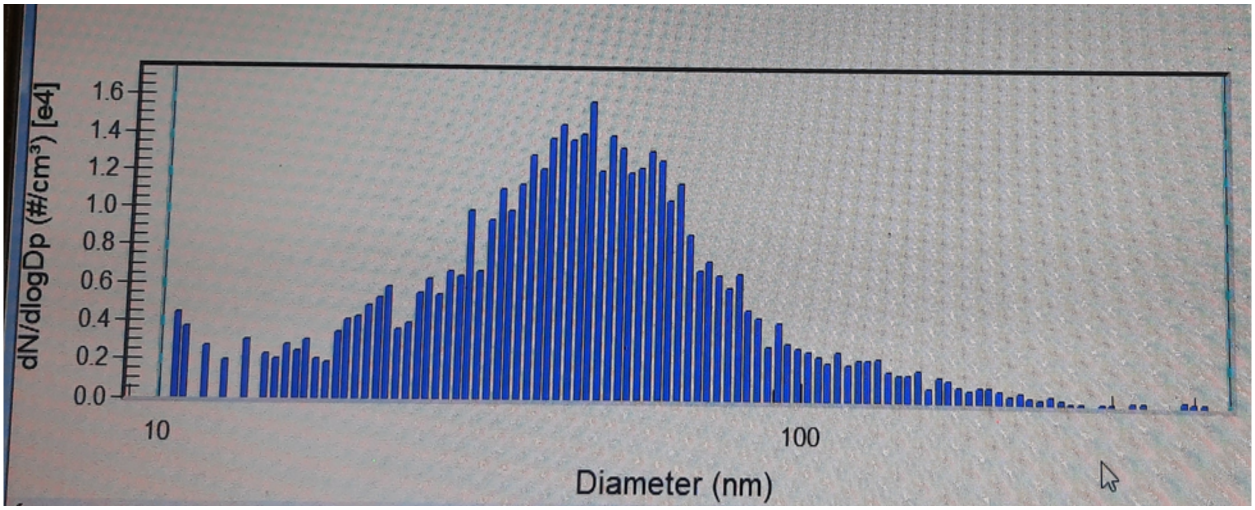

Figure 5: Image showing aerosol size distribution at 15:07:29 UTC on September 28, 2024 obtained with a Scanning Mobility Particle Sizer (SMPS). The SMPS measurements is made at the surface in rural, North-west Minnesota at same location as Figure 1.

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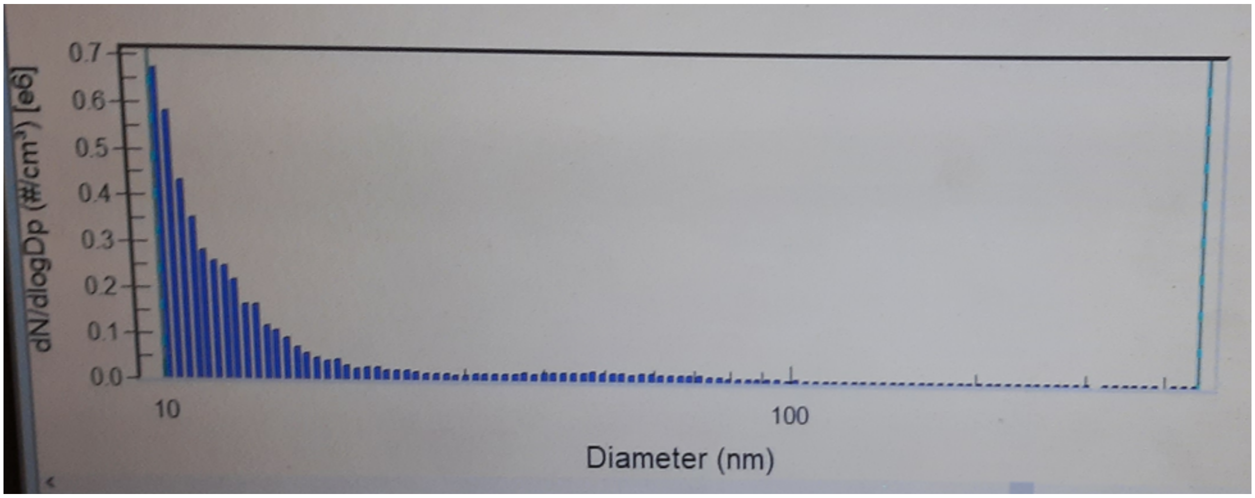

Figure 6: Image showing aerosol size distribution at 16:15:00 UTC on September 28, 2024 obtained with a Scanning Mobility Particle Sizer (SMPS). The SMPS measurements is made at the surface in rural, North-west Minnesota at same location as Figure 1.