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PHYSICS 222 - SECTION 1

EXAM 2

March 2, 2008

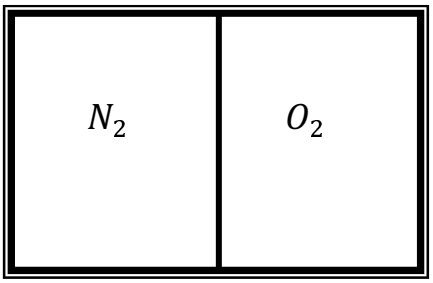
Instructions: When you are told to begin, check that this examination booklet contains all the numbered pages from 2 through 6. Read each problem carefully so that you are certain what it is asking. Do not panic or be discouraged if you cannot do every part of every problem. If a part of a problem depends on a previous answer you have not obtained, define a symbol for it and proceed to maximize your credit. Keep moving to finish as much as you can!

You must show your work. The purpose of this exam is to show how well you understood the material we have covered. You must include an adequate explanation, including correct equations where applicable, for full credit. A number with no explanation will not get credit. **Show your answer's units**, and give an adequate number of significant digits. Completely numerical solutions showing no equations are not eligible for partial credit. Do not use scratch paper. Indicate any work on the backs of the pages that you wish to be considered.

Box your answers.

This examination is administered under the Cadet Honor Code. All suspected violations must be reported appropriately. The seat next to you must be unoccupied. No talking is permitted during the examination, apart from questions to the instructor. You may use a scientific calculator, but may not use "advanced features", including graphing, solving, derivatives, integrals, symbolic manipulation, or equation storage capabilities. Any other electronic devices, including headphones, cell phones, PDAs, and MP3 players, may not be used during the exam in any way. You may use the equation sheet distributed with the exam. No other notes or textbooks may be open during the exam.

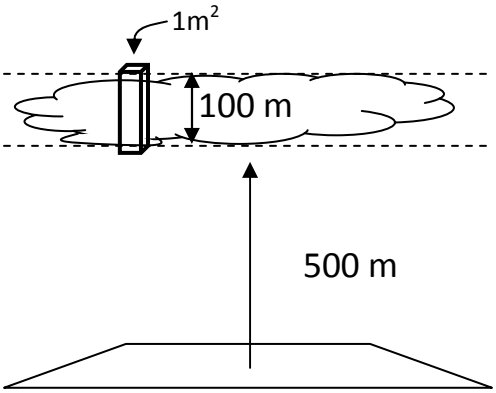
1. [10pt] A 2-liter container is divided into two equal parts. One side contains N_2, and the other O_2. Both are at 1 atm and 27^o C, and insulated from the surroundings. The partition is removed and the gas is allowed to mix freely.



(a) [3pt] What is the temperature of the mixture of gases after they come to equilibrium? Explain your answer.

(b) [7pt] What is the change in entropy of the system when the gases mix?

2. [20pt] A 100 m thick layer of clouds covers a region with the cloud base at an altitude of 500 m above the ground. The air below the clouds is clear, and may be approximated as charge free. However, static charge has built up in the clouds. An airplane measures an electric field of 110 N/C directed downward at the base of the clouds, and and 80 N/C downward at the top of the clouds.



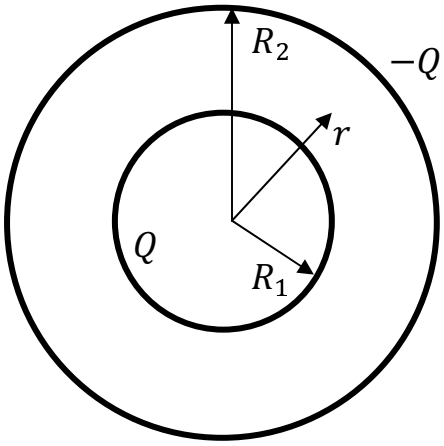
(a) [5pt] What is the electric flux through a rectangular box of base 1 m^2 and height 100 m extending from the bottom of the cloud to the top? Assume the electric field is vertical throughout the cloud.

(b) [5pt] What is the average electric charge density (C/m^3) inside the cloud? Include the correct sign.

(c) [5pt] What is the average surface charge density (C/m^2) on the earth's surface below the cloud? Include the correct sign.

(d) [5pt] If the ground is taken to have an electric potential of zero volts, what is the electric potential at the base of the clouds?

3. **[20pt]** An air-filled spherical capacitor is constructed with an inner shell of radius $R_1 = 10.4\ \text{cm}$ and an outer shell of radius $R_2 = 13.6\ \text{cm}$.



(a) [6pt] If a charge of Q is placed on the inner conductor, and $-Q$ on the outer conductor, find the electric field as a function of r for all three regions:

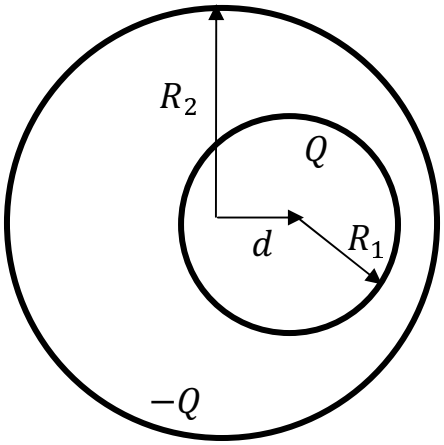
$$r < R_1, \quad R_1 < r < R_2, \quad r > R_2.$$

Use $1/4\pi\epsilon_0$ for the electric force constant.

(b) [5pt] Find the electric potential difference between the inner and outer conductor, symbolically.

(c) [5pt] What is the capacitance of the spherical capacitor? Give a numerical result with units.

(d) [4pt] If the inner conductor is moved a distance d to the right, as in the figure, how does each of the following change? The answer to each is "increases", "decreases", or "stays the same". No explanation is requested.



- The attractive force between the spheres?
- The energy stored in the capacitor's electric field?
- The potential difference between the conductors?
- The capacitance?