1. (20 pts) A nice round-number estimate of all the excess carbon dioxide pumped into the atmosphere in the world due to burning fossil fuels is 10 Gtonne per year. This is also approximately the amount of CO\textsubscript{2} added to the atmosphere each year, since fossil fuels come from the ground and are no longer part of the carbon cycle, unlike breathing, burning wood, etc. Suppose we were able to somehow capture all that extra CO\textsubscript{2} and convert it into coke (not the soft drink, and not the drug, but the other coke, which is pretty much pure carbon).

(a) What is coke, and how is it made? What is its density?

(b) Coke is porous, and if we were able to grind it into a powder, we could almost double its density, which would be the most useful for storage. For consistency in the following calculations, assume the density of coke powder is 1200 kg/m\textsuperscript{3}. If we converted all of the carbon from the excess carbon dioxide into powdered coke and put it in a big cubical box, how big (length, width, and height) would the box need to be?

Note: Be careful; you will need to consider only the portion of the CO\textsubscript{2} that is carbon, and assume that all of the carbon is turned into coke.

(c) Repeat for a conical stockpile of powdered coke, assuming that the stockpile is a cone with an angle of repose of 37.5\textdegree. Calculate the radius and height of the required conical pile.

(d) Is this feasible? What else might you do instead of piling it up?

2. (15 pts) Ethyl alcohol vapors and air are mixed. The partial pressure of the ethyl alcohol is 0.550 kPa. The pressure and temperature of the ideal gas mixture are 96.0 kPa and 25.0\,\textdegree\textnormal{C} respectively. Calculate the mol fraction (PPM), the mass concentration (mg/m\textsuperscript{3}) and the molar concentration (mol/m\textsuperscript{3}) of the ethyl alcohol.

3. (15 pts) "Dry air" is defined as air with no water vapor, and the molecular weight of air, \(M_{\text{air}} = 28.97\) kg/kmol, is for dry air (zero humidity). "Wet air" is typically defined as air with 100\% humidity.

(a) Calculate the mol fraction of water vapor in wet air at SATP conditions. Give your answer in units of PPM to three significant digits.

(b) Compare the molecular weight of dry air and wet air at STP conditions. Which air is heavier? Explain. Comment about how humid air feels compared to dry air. In particular, in the summer time most people say that high-humidity air feels "thicker" or "heavier" than low-humidity air at the same temperature. Does this feeling agree with your calculations?

Note: There is another page. →
4. (20 pts) As discussed in class, everyone has biases that often come out in our speech and writing, sometimes intentionally and sometimes unintentionally. In this problem you are to read newspapers and/or search (“surf”) the Internet for a recent news item, report, article, paper, etc. in which you can spot and point out bias by the author(s). This is open-ended, but the article needs to have some connection to our course (air pollution concentrations, global warming, smoke from smokestacks, health effects of air pollution, etc.). The bias can be in the form of exaggerated language (e.g., “The air was agonizingly bitter and toxic…”) and/or exaggerated units (e.g., “The amount of contaminant in the air exceeded 2000 parts per billion!”). Specifically, do the following:

(a) Find a recent article with some identifiable bias. Provide a complete reference (title, author, date, publication, etc. as if you were writing a paper and referencing the article in the List of References). For Internet articles, give the entire URL (http://xxx.xxx.xxx.xxx.xxx). Copy and paste or include a picture of the portion of the article that contains and highlights the biased sentence(s), and attach that portion to your homework. You do not need to attach the entire article. Note that the homework itself can be typed or handwritten, but the grader must be able to clearly see the original biased statement(s).

(b) Briefly discuss why you feel the author showed bias.

5. (30 pts) The amount of carbon dioxide in the atmosphere is growing and is approximately 414 PPM (0.0414%) at the time of this writing. Consider a sample of humid air as an ideal gas mixture that consists of the following gases, in percent by volume: O2 (20.85%), N2 (76.55%), H2O (1.6291%), Ar (0.9295%), and CO2 (0.0414%). The gas mixture is at a total pressure of 99.5 kPa, and the temperature is 30.0°C. Note: To calculate the molecular weight of each molecule, use data from the on-line periodic chart on the course website for greatest accuracy and consistency. I suggest that you use Excel or Matlab or some other software to avoid calculation errors and for neatness; Excel is especially useful for these kinds of repetitive calculations with summations, etc. Give all answers to at least 4 significant digits.

(a) Calculate the mol fraction of each species, both as a unitless number and in “units” of PPM. Verify that \( \Sigma \gamma_j = 1 \), and \( \Sigma \gamma_j,\text{ppm} = 1000000 \).

(b) Calculate the partial pressure of each species in kPa. Verify that \( \Sigma P_j = P \).

(c) Calculate the mass fraction of each species. Verify that \( \Sigma f_j = 1 \).

(d) Calculate the mass concentration \( \left( c_j \right) \) of each species in mg/m^3.

(e) Calculate the total (or average) molecular weight of the gas mixture \( \left( M_t \right) \).

(f) Calculate the specific gas constant for this (total) gas mixture \( \left( R_t \right) \).

(g) Calculate the percentage difference between \( R_t \) for this particular gas mixture and that of standard dry air, \( R_{air} \).

(h) Calculate the total (or average) density for this gas mixture \( \left( \rho_t \right) \).

(i) Assuming standard saturation pressure values for water vapor in air, calculate the relative humidity of this air \( \left( RH \right) \) as a percentage.