Problem Set 2

1. *An Introduction to Chemistry* (AIC)

   Chapter 9 problems: 30, 36, 47, 53

2. *Consider a Spherical Cow* (COW)

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3. Global warming threatens to raise sea level by melting ice. This problem explores the consequences. *(Assume in parts a and b that there is no change in land area due to sea level rise.)*
   a. By how much would sea level rise if all sea ice were to melt due to global warming? Briefly explain.
   b. If 10% of the 30×10^6 km^3 of land ice were to melt due to global warming, how many meters would sea level rise?
   c. By about what percentage would Earth's land area change under the conditions in part b? *(HINT: You will need to make broad simplifying assumptions. HINT: draw a cross-sectional view of a coastal area where the land meets the ocean.)*

4. The current atmospheric concentration of carbon dioxide is about 390 ppm. This concentration is generally considered as a volume ratio, i.e. 390 ppm(v), but for ideal gases, it also describes the molar ratio of CO_2 in air.
   a. What is the concentration in ppm(w), i.e. parts per million by mass?
   b. How many Gt of carbon are currently in the atmosphere? (There are about 1.8×10^{20} moles gas in the atmosphere.)
   c. Humanity currently emits about 30 billion tonnes of CO_2 each year from fossil fuel combustion. If all of this were to remain in the atmosphere, by how many ppm(v) would the CO_2 concentration rise?

5. An important part of our "ecological footprint" is water consumption.
   a. Estimate the amount of freshwater (in units of gallons per day, liters per day and cubic meters per year) that you use for all your personal domestic uses (if you have access to a monthly water bill, you can use it to cross-check your estimate).
   b. Look up total U.S. water use for all purposes from a reputable source (e.g. the U.S. Geological Survey, http://water.usgs.gov/watuse/). Based on this, what is U.S. daily per

capita use? Approximately what percentage of this per capita use is the domestic use you calculated in part a? Name at least two important water uses that your calculation did not include.

c. Estimate the amount of rain falling on the roof of a typical single family home in Monterey in a year. If all the rainwater were captured, how many square meters of roof area would be required to supply (i) the domestic use estimated in part a, and (ii) the total use estimated in part b? What practical difficulties might be encountered in capturing, storing, and using rainwater? What other approaches might be effective in reducing society's water use "footprint"?

6. Read COW I.6 ("The Greens We Eat") and refer to Appendix XII.2:
   a. Calculate the productivity of the world's cultivated land in $J/m^2/y$ and $Cal/m^2/y$.
   b. Assuming that 80% of what is grown can be used for food or animal fodder (i.e., assuming that 20% of what grows is inedible stalks, etc), estimate the fraction of total cultivated land required to feed the current global human population if everyone eats:

      (i) The US diet (3800 Cal d^{-1}, 1/3 from animal products).

      (ii) A purely vegetarian diet (2500 Cal d^{-1}).

   c. If global population were to double and everyone ate a diet that required 9000 Cal per person per day, and the amount of total cultivated land were to remain the same as it is today, what would productivity need to be to feed everyone?

7. Argon is a noble gas. The concentration of argon in the atmosphere is about 1 percent by volume. Assuming that the only significant stock of this gas is in the atmosphere, and that the size of this stock has not varied for thousands of years, estimate the number of argon atoms exhaled in Julius Caesar's last breath that you would expect to inhale in your next one. State clearly any further assumptions needed to make the problem tractable, and say whether you think such assumptions are justified.