Meteo 466 -- Homework #2

Due: Thursday, Sept. 6

Earth's "excess volatiles," many of which reside in the oceans and sediments, are present in the following amounts:

Species	Mass (kg)
H_2O	1.4×10^{21}
CO_2	3×10^{20}
N_2	5×10^{18}
S	5×10^{18}
Cl	3×10^{19}

By contrast, many or most of Venus' excess volatiles might be expected to reside in its atmosphere. According to measurements made by Pioneer Venus, the volume mixing ratios of gases in Venus' atmosphere are:

Species	Volume mixing ratio
H_2O	30 ppm
CO_2	0.965
N_2	0.035
SO_2	150 ppm
HCl	0.4 ppm

1. Using the physical data on Venus given below and a surface pressure of 93 bar, calculate the masses of these five species in Venus' atmosphere. Be sure to convert to mass mixing ratios first and to correct for combination of the elements with hydrogen or oxygen. How do these amounts compare with those for Earth? Express your answers in terms of the ratio M_V/M_E, where M is the reservoir mass on the respective planet. Which of these species agree with your preconceptions? What do you suppose may have happened to those that don't?

2. Calculate inventories of Earth and Venus in terms of (g/g planet). How do your values compare with those listed in Table 13-2 below? (Tables copied from *The New Solar System*, J. K. Beatty et al., Ed. 3?, Ch. 13.)

Hint: Remember that the surface pressure must equal the mass of a vertical column of atmosphere times the acceleration due to gravity.

Atomic weights: H -- 1, O -- 16, C -- 12, N -- 14, S -- 32, Cl – 35.5.

Appendix

Planetary physical data:	Venus	Earth	Mars
Mass (kg)	4.865×10^{24}	5.974×10^{24}	6.419×10^{23}
Equatorial radius (km)	6,052	6,378	3,396
Surface gravity (m/s^2)	8.87	9.78	3.69

Table 13-2

Planet	CO_2 (g/g)	H_2O (g/g)	N_2 (g/g)	Ar (10^{-10} cm^3/g)
Venus	9.6×10^{-5}	$>2\times10^{-5}$	2×10^{-6}	20,000
Earth	16×10^{-5}	2.8×10^{-4}	2.4×10^{-6}	210
Mars	$>3.5\times10^{-8}$	$>5\times10^{-6}$	4×10^{-8}	1.6

Table 13-1

Atmospheric Compositions Compared

Planet	*Molecule*	*Abundance (bars)*	*Fraction of total*
Venus	CO_2	86.4	0.96
	N_2	3.2	0.035
	Ar	0.0063	0.000070
	H_2O	0.009	0.000100
Earth	N_2	0.78	0.77
	O_2	0.21	0.21
	H_2O	0.01	0.01
	Ar	0.94	0.0093
	CO_2	0.000355	0.00035
Mars	CO_2	0.0062	0.95
	N_2	0.00018	0.027
	Ar	0.00010	0.016
	H_2O	3.9×10^{-7}	0.00006

Table 1. The atmospheres of Earth, Venus, and Mars contain many of the same gases — but in very different absolute and relative abundances. Some values are lower limits only, reflecting the past escape of gas to space and other factors.