EART164 Homework #2 Due Wednesday 17th April 2013

Show all your working for full credit

1. a) Titan has a solar constant of 15.6 W/m^2 and an albedo of 0.3. What is T_{eq} for Titan? [2]

b) Also predict the surface temperatures (T_s) and stratosphere temperature (T_X) [2]

c) The actual values are (roughly) 95 K and 70 K. Comment on your results [1].

d) Titan's atmosphere has a specific heat capacity of roughly 1 kJ kg^{-1} K^{-1} and gravity is 1.3 ms^{-2}. What is the dry adiabatic lapse rate? [1]

e) Using your answers to b) and d), calculate H_X, the thickness of Titan's troposphere [2].

f) The actual value for H_X is about 40 km. How does this compare with your answer to e), and what is one possible explanation for the discrepancy? [3] [11 total]

2a) The Earth's exobase is at a temperature of about 1000 K. Assuming a molar mass of 0.03 kg, what is the pressure scale height at this altitude? [1]

b) From the definition of the exobase, what is the gas density at this point? You may assume a molecular radius of 0.3 nm. [3]

c) The atmospheric density at the surface is about 1.3 kg m^{-3}. Using your answers to a) and b), what altitude would you predict the exobase to be at? [3]

d) The exobase is actually at 500 km altitude. Give one reason why your answer disagrees with this value. [1] [8 total]

3) Jupiter, Saturn and Uranus/Neptune have present-day masses of 315, 95 and 16 Earth masses, respectively. From the table in your Week 3 notes, J,S and U/N have a C/H ratio roughly 4, 10 and 60 times solar.

a) Using the table from Week 1, what is the solar C/H ratio? [1]

b) CI chondrites have C/H ratios of about 1.7. If J,S,U/N were initially solar, how much mass of CI chondrites (in Earth masses) had to be added to each body to give the observed C/H ratio? (Hint: you'll have to use some algebra here). [5]

c) The solar and CI chondrite D/H ratios are roughly $2x10^{-5}$ and $2x10^{-4}$, respectively. Using your results to b), predict the D/H ratios of Jupiter, Saturn and Uranus/Neptune. How well do your predictions agree with the observations? [2] [8 total]

4. ^{40}Ar is produced by radioactive decay of ^{40}K (half-life 1.25 Gyr).

a) The Earth has produced about $1.5x10^{17}$ kg of ^{40}Ar over its history. If the Earth's atmosphere contains $6.6x10^{16}$ kg of ^{40}Ar at the present-day, what fraction of the Earth's interior has been outgassed? [1]

b) Mars has a mass about one-tenth of the Earth, and its atmosphere contains $4.5x10^{14}$ kg ^{40}Ar. Roughly what fraction of Mars' interior has been outgassed? Why do you think this fraction is different to that of the Earth? [3]

c) Titan's mass is 2% of Earth's, and it has $3.5x10^{14}$ kg ^{40}Ar in its atmosphere. If Titan outgassed very efficiently early in its history, and then stopped outgassing completely, how long would the outgassing have had to persist? [4]

d) Under what circumstances would early loss of a thick atmosphere on Mars affect your calculations for part b)? If atmospheric loss was important, is your estimate of the outgassing fraction in part b) too large or too small? [2]

e) At the present-day, about 9% of the ^{4}He being produced inside the Earth's interior is being outgassed. Suggest how you might reconcile this outgassing efficiency with that obtained from ^{40}Ar in part a). [2] [12 total]