Name:_____ Section:_____

Earth 110 – Exploration of the Solar System

Assignment 3: Planetary Atmospheres Due in class Tuesday, Feb. 16, 2016

An atmosphere is a thin layer of gas surrounding a planet. The amount and type of gas an atmosphere contains depends largely on the size of the planet it surrounds. In other words, it depends on *gravity*. What is so important about this gas layer? First, it provides a surface pressure, which pushes in all directions and holds up the atmosphere. Second, it can warm a surface through the *greenhouse effect*. The combination of pressure and temperature governs what molecules are stable as solids, liquids, and gases. Third, atmospheres scatter and absorb light. Scattering is why we have a beautiful blue sky in the daytime and absorbing keeps harmful radiation from hitting the surface (thank you ozone!). Fourth, atmospheres create weather at the surface and play a huge role in climate change. Lastly, gases in the atmosphere interact with a planetary magnetic field to form a magnetosphere, which protects the planet from harmful solar wind particles. An atmosphere is one of the main reasons why life happily exists on Earth and studying atmospheres of other planets helps us learn about our own (discovering the cause of Earth's ozone hole relied on studies of Venus' atmosphere).

This homework is based off of Chapter 10 in the textbook. While completing this assignment, it's best to keep in mind how important an atmosphere is to our existence, what positive effects it has for us, and what Earth might be like if the atmosphere changed (by comparing to other planet atmospheres). Also think about the fundamental links between atmospheres and planet properties (size, distance, rotation), interior heat (gain/loss), and surface processes. If Earth's atmospheric composition changes, it has ways of regulating surface temperature but the main question is: How fast can it respond? As humans wrestle with climate change, this is one of the uncertainties we have to keep in mind.

Earth's atmosphere from space (Credit: NASA)

Planets gain atmospheres through three processes: outgassing, evaporation/sublimation, and surface ejection. Explain, **in your own words**, how these processes release gas.

Outgassing:

Evaporation/Sublimation (make sure to describe the difference between the two):

Surface Ejection:

Which process(es) is (are) most important for Venus' atmosphere? Earth's? Mars'? Mercury's? The Moon's?

Planets lose atmospheres by condensation, chemical reactions, solar wind stripping, and thermal escape.
Compare condensation and chemical reactions.

What are the differences between solar wind stripping and thermal escape?

What is (are) the main process(es) that have contributed to atmospheric loss for Mercury? Venus? Earth? The Moon? Mars?

A planet's global average surface temperature, in the absence of the greenhouse effect, depends on two things: (1) distance from the Sun and (2) overall reflectivity (albedo):

$$T_{no\ greenhouse} = 280 \times \left(\frac{1 - reflectivity}{d^2}\right)^{\frac{1}{4}}$$

where T is in Kelvin.

If planetary distance is kept constant (d = 1 AU), calculate the "no greenhouse" temperature for a planet with 25% reflectivity and a planet with 50% reflectivity.

Now let's keep reflectivity constant at 35% and vary planet distance. Calculate the "no greenhouse" temperature for a planet at 0.25 AU and 0.5 AU.

What variable is more important, reflectivity or distance? Explain using your above answers.

Now let's focus on the greenhouse effect.
Explain, **in your own words**, how the greenhouse effect affects planet surface temperature. What are some important greenhouse gases?

Explain the idea behind a "runaway" greenhouse effect (positive feedback loop).

Venus' atmosphere contains 96% carbon dioxide (CO_2), resulting a large greenhouse effect which results in surface warming of 510ºC. Mars also has an atmosphere composed mainly of CO_2 (95%), but its greenhouse effect only results in a surface warming of 6ºC. Why this difference?

Without the greenhouse effect, Earth's average surface temperature would be -16ºC. What would this mean for life?

How could adding more CO_2 and methane (CH_4) into Earth's atmosphere trigger a runaway greenhouse effect?