Name: **Section:**

ID #:

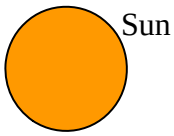
AOS 1 Homework # 1 (30 points, Understanding of Greenhouse Effect)

Put your answers in the boxes. Show work to receive partial credit.

A. Suppose we are on Venus located about 0.7 times closer to the Sun as compared to the Earth (the Earth from the Sun is scaled to 1). What is the solar flux, S, coming in at the top of the Venus' atmosphere? Assume the solar flux coming in at the top of the Earth's atmosphere, S_0, is 342 W/m^2. (Hint: use the inverse square law) (4 points)

S =

B. For the moment, suppose Venus has no atmosphere. Assume also that its surface, like that of Earth, is reflective of incoming solar radiation resulting in a planetary albedo of about 80%. The Venus itself also emits radiation according to its temperature. Fill in the schematic diagram that illustrates these flows of radiation, using arrows and labels to indicate radiation fluxes. (You'll need one arrow for incoming solar radiation, one for reflected solar radiation, and one for radiation emitted by Venus.) (3 points)



Venus's Surface

C. With no atmosphere, the surface energy balance is simply:

Energy absorbed at surface from the sun = Energy emitted by the surface.

Using this equation and the Stefan-Boltzmann law, calculate the Venus' surface temperature.

(The Stefan-Boltzmann constant $\sigma = 5.67 \text{ X } 10^{-8} \text{ J K}^{-4} \text{ m}^{-2} \text{ s}^{-1}$) (4 points)

Temperature =

D. What is the wavelength at which most of the energy is radiated from Venus and what form of radiation is this? (4 points)

Wavelength =

Radiation type:

E. How does this compare to the wavelength and form of radiation emitted by the planet Earth? (4 points)

Earth's wavelength =

Radiation type:

F. Is the surface temperature of Venus hotter or cooler than that of Earth? (2 points)

G. The surface temperature in part **C** was calculated assuming NO atmosphere. Suppose we now introduce an atmosphere to this planet, and the planet's albedo remains 80%. The equilibrium energy balance equation at the top of the atmosphere is

Solar energy absorbed by planet (including its atmosphere) =
Infrared Energy emitted by the planet (including its atmosphere)

Use this equation to calculate the radiation flux emitted by the atmosphere. (2 points)

Flux =

H. Like Earth's atmosphere, this Venus' atmosphere contains greenhouse gases that absorb all

radiation emitted by the surface. The flux you calculated in part **G** is therefore directed both upwards to space and downwards to the surface. Using this radiation flux and the surface equilibrium energy balance, calculate the new surface temperature when the planet has an atmosphere containing greenhouse gases. Hint: The surface equilibrium energy balance equation is: (5 points)

Energy absorbed at surface from sun + Energy absorbed at surface from atmosphere = Energy emitted by the surface

Temperature =

I. How much warmer is the planet with an atmosphere containing greenhouse gases compared to when the atmosphere is absent? (2 points)

Temperature difference =

(Note: The exercises here are intended for understanding of the greenhouse effect and the values that you calculate in them do not reflect the present day Venus' temperature and radiation field.)