Name _____

Astronomy H161 – An Introduction to Solar System Astronomy
Winter Quarter 2009 – Prof. Gaudi
Homework #6

Due Monday, March 2 in class

No late homework will be accepted.

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1. Astronomers surveying the outer solar system discover a new planet, which they name Fred. Astronomers estimate that Fred has an orbital period around the Sun of 64 years and is on a circular orbit. They come to you asking for your help to figure out more about Fred.
    a. What is Fred's semi-major axis?
    b. What is the apparent brightness of the Sun on Fred relative to the apparent brightness on the Earth?
    c. First you assume that Fred is a perfect absorber (zero albedo), and has no atmosphere. What is Fred's equilibrium temperature?
    d. The astronomers tell you that new observations have shown that Fred's surface is actually covered with a substantial amount of snow. Given what you've calculated for the equilibrium temperature, is this a surprising result?
    e. The astronomers next tell you that Fred's average albedo is 0.3, exactly the same as the Earth. Is his equilibrium temperature higher or lower than what you calculated in part c? What is his

equilibrium temperature in this case (still assuming no atmosphere)?

f. Now you assume that Fred has the same average albedo as the Earth, and a similar atmosphere as the Earth's. What is the equilibrium temperature of Fred relative to the equilibrium temperature of the Earth?

g. In class I said that the velocity needed to escape the gravitational pull of a planet of mass M and radius R is,

$$v_E = \sqrt{\frac{2GM}{R}}$$

Where G is the gravitational constant.

h. Assuming that all planets have the same uniform density, how does the escape velocity depend on mass? (*Hint: if all planets have the same density, then you can write the radius of the planet in terms of its mass*).

i. Astronomers estimate that Fred has a mass that is only one eighth of the mass of the Earth. Assume he has the same density as the Earth. What is his escape velocity relative to that of the Earth?

j. In class I said that the thermal velocity of a gas of temperature T composed of molecules or atoms of mass m is given by:

$$v = \sqrt{\frac{2kT}{m}}$$

Where k is a constant.

k. For fixed particle mass *m*, how does the thermal velocity depend on distance from the Sun?

l. If the atmosphere of Fred is composed of gas particles of the same mass as the atmosphere of the Earth, what is the thermal velocity of the gas particles in Fred's atmosphere relative to those in the Earth's atmosphere?

m. Given what you know about his mass, radius, and temperature, is Fred capable of maintaining an atmosphere like the Earth's? Why or why not?