Name _____

Astronomy 141 – Life in the Universe
Autumn Quarter 2008 – Prof. Gaudi
Homework #2

Due Monday, October 27 in class

Instructions

Answer the following six questions by circling the correct answer. Each question is worth the number of points given in parentheses (out of a total of 100). I may award partial credit if you show your work. In addition, there are five extra credit questions. These are a bit more challenging, but I encourage you to attempt them.

No late homework will be accepted.

Astronomers surveying the outer solar system discover a new planet that they name Rocky. Astronomers estimate that Rocky has an orbital period around the Sun of 64 years and is on a circular orbit.

Question 1 (20 points)

What is Rocky's semi-major axis?

a) 64 AU
b) 16 AU
c) 4,096 AU
d) 512 AU
e) 8 AU

Question 2 (20 points)

What is the apparent brightness of the Sun on Rocky relative to the apparent brightness on the Earth?

a) 16 times fainter
b) 262,144 times brighter
c) 256 times fainter
d) 64 times fainter
e) 4096 times fainter

Question 3 (20 points)

Assuming that Rocky has the same average albedo as the Earth, what is the equilibrium temperature of Rocky relative to the equilibrium temperature of the Earth?

a) Rocky is 16 times warmer
b) Rocky is 4096 times cooler
c) Rocky is 64 times cooler
d) Rocky is 4 times cooler
e) Rocky is the same temperature

Question 4 (20 points)

Now assume that Rocky is a perfect absorber (zero albedo) and absorbs the Sun's energy on one hemisphere but emits energy over his entire surface. What is Rocky's equilibrium temperature? (*Hint: You can find the relevant formula in my lecture notes on the class webpage).*

a) 69.5 K
b) 17.4 K
c) 1.1 K
d) 4.3 K
e) 278 K

Question 5 (10 points)

Scientists discover that Rocky's surface is actually covered with snow (water ice). Given what you've calculated for the equilibrium temperature, is this a surprising result?

a) Yes
b) No

Question 6 (10 points)

If Rocky is indeed covered with snow, is his equilibrium temperature higher or lower than what you calculated in Question 4?

a) Higher
b) Lower
c) Rocky's equilibrium temperature is the same.

Extra Credit Questions:

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.

Question 7 (10 points)

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

a) v_E scales as $M^{1/2}$
b) v_E scales as $M^{1/3}$
c) v_E scales as M^3
d) v_E scales as $M^{3/2}$
e) v_E scales as M

Question 8 (10 points)

Astronomers estimate that Rocky 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?

a) half of the escape velocity of the Earth
b) one eighth of the escape velocity of the Earth
c) one fourth of the escape velocity of the Earth
d) the same as the escape velocity of Earth

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

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

Where k is a constant.

Question 9 (10 points)

For fixed particle mass m, how does the thermal velocity scale with distance from the Sun?

a) the thermal velocity scales as $d^{-1/2}$.
c) the thermal velocity scales as $d^{1/2}$.
d) the thermal velocity scales as $d^{-1/4}$.
e) the thermal velocity scales as $d^{-3/2}$.

Question 10 (10 points)

If the atmosphere of Rocky 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 Rocky's atmosphere relative to those in the Earth's atmosphere?

a) the thermal velocity is the same as the Earth's.
b) the thermal velocity is half of the Earth's.
c) the thermal velocity is about a fourth of the Earth's.
d) the thermal velocity is about twice the Earth's.

Question 11 (5 points)

Given what you know about his mass, radius, and temperature, is Rocky capable of maintaining an atmosphere like the Earth's?

a) Yes
b) No