

NAME: _____

Section Number: _____

Homework 12: Solar System Origin, Sun, Extrasolar Planets

Due: in your section on **the week of April 28th**. Be neat and concise, show your work, and remember units. An answer without the correct units is wrong.

Suggested reading: Chapters 8, 13, 14, and lecture notes 33-36.

1 Solar Nebula Theory

a. [1 point] What was the *frost line* in the solar nebula, and where was it located?

b. [2 points] How does the frost line explain the categorical differences in composition and mass between the terrestrial and jovian planets in our solar system?

c. [2 points] Given your answer to part (b), why was it surprising to find “hot Jupiter” extrasolar planets orbiting very close to their stars? How can we explain their small orbital semi-major axes?

d. [2 points] Aside from the differences between terrestrial and jovian planets, list two other observational constraints for solar system formation. **Explain** how each is accounted for by the solar nebula theory.

2 Fusion in the Sun

a. [2 points] When four protons fuse to form a helium atom in the Sun (with multiple intermediate steps), 0.7% of their mass is converted to energy according to Einstein's mass-energy equation. The mass of a proton is 1.67×10^{-27} kg. Calculate the energy released by a single fusion reaction.

b. [5 points] Your textbook (p. 501) says that the above reaction occurs roughly 10^{38} times each second. At this rate, given that the Sun's total mass is roughly 2×10^{30} kg, and 70% of this is hydrogen, how many years would it take to convert all of the Sun's hydrogen atoms into helium? Will the Sun have fused all of its hydrogen by the time it becomes a red giant in ~5 billion years?

3 Extrasolar Planets

a. [2 points] What technique has been used to discover most of the known extrasolar planets? What can this technique tell us about each planet it discovers?

b. [2 points] Search online for information about the transiting planet HD 189733b. What molecules have recently been discovered in its atmosphere? Do these molecules occur in the atmospheres of jovian planets in our solar system?

c. [2 points] Most known extrasolar planets are more massive than the most massive planet in our own solar system (Jupiter), and orbit closer to their stars than Jupiter does to the Sun. Does this mean our solar system is unusual? Why or why not?