Feel free to discuss these problems with classmates, but write up your work independently. Put your name and discussion section on this and any additional sheets of paper and staple them together. Show your work for full credit. Use scientific notation when appropriate.

1. **(6 pts) Your Eye and the Keck Telescope**

   a) The diameter of the Keck Telescope (on Mauna Kea, Hawaii) is 10 m. The diameter of your fully dilated pupil is 5 mm. How many times fainter can we see with the Keck Telescope than with your naked eye?

   b) What is the diffraction limit of your eye in arcseconds? What is the diffraction limit of the Keck telescope? Use a wavelength of 500 nm. Are these the actual resolution limits of each? Why or why not? Typical atmospheric “seeing” (i.e., blurring due to turbulence) is 1 arcsecond.

   c) What is the largest diameter telescope whose resolution at 500 nm is limited by its diffraction limit rather than by the atmosphere?

   d) Give two distinct reasons why the Hubble Space Telescope was put in space? The diameter of the HST mirror is 2.4 m, not especially large. In real, every-day operation, does the Hubble Space Telescope produce better or worse resolution than the Keck Telescope?

   e) What is the diffraction limit of a 10m radio telescope? A typical radio telescope might observe at a wavelength of 20 cm. How does this compare to the resolution limit of your eye at 500 nm (see part a).

2. **(8 pts) Trends in the Solar System**

   Do Problem 11 a-f in BDSV. Note that 2 pts will be given specifically for your answer to the question in 11a, “Explain why this trend exists.” It is not enough to simply say, “Pluto is colder because it is further from the Sun”. I am looking for your understanding into WHY being further from the Sun leads to cooler temperatures. A sketch will likely make your explanation clearer.

3. **(4 pts) Formation of the Earth**

   a) Suppose that the Earth grew to its present size in 1 million years through accumulation of planetesimals of mass 1 kg = 1000 gms. How many planetesimals collided with the Earth during this time? (Take the mass of the Earth to be $6 \times 10^{27}$ gm.)

   b) On average, how many planetesimals did the Earth capture per second?

   c) If you stood on the first football field on Earth during its formation, how many planetesimal impacts would expect to see in a second? (Take a football field to be 100m x 100m, the radius of the Earth to be $6.4 \times 10^6$ m, and remember that the surface of a sphere is $4\pi r^2$.)
4. (2 pts) Sample Exam Question:

An atom has energy levels with energies as shown below. Consider the two transitions shown. If transition X emits a photon of 500 nm, then transition Y emits a photon having a wavelength of

a. 100 nm  
b. 250 nm  
c. 500 nm  
d. 1000 nm  
e. 2500 nm

5. (3 pts)

Explain fully the reasoning behind your answer to question 4?.