Homework 5: Due April 28, 2006, in class. (or turn it in before then to your TA's mailbox, 5th floor, Sterling Hall). If you run out of room, please use the back of this sheet for your answers.

1. (30%) One of the Balmer lines of hydrogen, H-Beta, is normally seen at a wavelength of 486 nm. In a distant galaxy, the line is seen instead at 489 nm.
   a) Why is this?
   b) How fast is it moving (in km/sec) (use the normal Doppler formula)?
   c) Assuming that Hubble's constant \( H = 65 \text{ km/sec/Mpc} \), how far away is this galaxy?

2. (10%) (Sample Exam Question) The surprising observational fact about quasars is that they appear
   A. to be associated with ancient supernova explosions
   B. to produce the luminosity of 100 galaxies in a volume similar to the solar system
   C. to be the largest known structures in our Universe, while producing modest amounts of energy
   D. to be moving rapidly towards us, while emitting large amounts of energy

3. (30%) a) What is meant by "critical density"?
   b) If the Hubble constant is as large as 100 km/sec/Mpc, what is the maximum age of anything in the Universe?
   c) If the Universe continues to expand forever, what will happen to the redshift of quasars? (ie, imagine you came back 100 billion years from now and looked for some quasars- would they have the same redshifts?)

4. (30%) a) What is "Olber's Paradox" in an unbounded universe (one with no edge)?
   b) Explain how an evolving, expanding universe can help explain the paradox