ASTRONOMY 294Z
The History of the Universe
Professor Barbara Ryden

Problem Set # 6
Due Tuesday, February 26
at class time

NAME (please print clearly): _____

SCORE (instructor use only): _____

Only four questions on this problem set! However, the final question is an essay question which counts double, so give it some careful thought.

1) [20 points] Potassium-40 is an unstable atomic nucleus; it decays to argon-40 with a half-life of 1.3 billion years. Suppose that a rock contains 1,000,000 potassium-40 atoms at the time it forms. How many potassium-40 atoms will be left after 1.3 billion years? How many will be left after 2.6 billion years? How many will be left after 3.9 billion years?

2) [20 points] The "life span" of the Sun is 10 billion years; that is, at the time it formed, it contained enough hydrogen to power nuclear fusion for 10 billion years. The star Altair, like the Sun, is powered by the fusion of hydrogen to helium. The mass of Altair is $M_{\rm altair} = 1.7 M_{\rm sun}$. The luminosity of Altair is $L_{\rm altair} = 10.7 L_{\rm sun}$. Is the lifespan of Altair *shorter* or *longer* than that of the Sun? What is the approximate lifespan of Altair, in billions of years? [Hint: use the arguments presented in the lecture for Thursday, February 14.]

3) [20 points] Exponential growth (as we saw while discussing inflation during the early universe) can be very effective at making small things into big things. Suppose that you invest $1000 in an investment that doubles every 10 years. That is, after 10 years, your investment will be worth $2000, after 20 years, it will be worth $4000, and so forth.

What will be the value of your investment after 50 years?

What will be its value of your investment after 100 years?

What will be the value of your investment after 200 years?

What will be the value of your investment after 300 years?

4) [40 points] The star Phi Orionis, like the Sun, is powered by the fusion of hydrogen to helium. The mass of Phi Orionis is $M_{\rm phi} = 18 M_{\rm sun}$. The luminosity of Phi Orionis is $L_{\rm phi} = 20{,}000 L_{\rm sun}$. Discuss the likelihood of intelligent life existing on a planet orbiting the star Phi Orionis. [Questions you might want to consider: What is the lifespan of Phi Orionis? How long did it take intelligent life to develop on Earth? How far would you have to be from Phi Orionis to receive the same flux of light that we receive here on Earth from the Sun?]