

ASTRONOMY 143
The History of the Universe
Professor Barbara Ryden

Problem Set # 8: The Last Problem Set
Due Wednesday, December 2
at class time

NAME (please print clearly): _____

SCORE (instructor use only): _____

1) [20 points] The dim little star Proxima Centauri, the Sun's nearest neighbor among the stars, has a mass $M = 0.12M_{\text{sun}}$, where M_{sun} is the Sun's mass. It has a luminosity $L = 0.00014L_{\text{sun}}$, where L_{sun} is the Sun's luminosity. Like the Sun, Proxima Centauri is powered by the fusion of hydrogen into helium. If the Sun's lifespan is $t = 10$ billion years, what is the lifespan of Proxima Centauri? Is this longer than or shorter than the Hubble time?

2) [20 points] Exponential growth (as we saw when discussing inflation on Wednesday, November 25) can be very effective at making small things into large things. Suppose that you invest \$1000 in an investment that will double in value 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 100 years?

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

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

3) [20 points] The temperature of the cosmic background light today is $T \approx 2.7\text{K}$. At the time of Big Bang Nucleosynthesis, the temperature of the cosmic background light was $T \approx 5 \times 10^8\text{K}$. What was the scale factor a at the time of Big Bang Nucleosynthesis? If the density of ordinary matter today is $\rho = 4 \times 10^{-28}\text{kg/m}^3$, what was the density of ordinary matter at the time of Big Bang Nucleosynthesis? Is this greater than or less than the density of the air around you?

4) [40 points] Consider an ordinary carbon atom in your body, containing 6 protons and 6 neutrons in its nucleus. Write a brief essay describing the history of this carbon atom. Some questions your essay should answer include: When did the individual protons and neutrons first fuse? When and where did the final carbon nucleus form? How did the carbon atom make its way to Earth? How did it come to inhabit your body?

Feel free to indulge your imagination – as long as you don't violate any known scientific principles!