AST 301
Test #4
Friday Dec. 3 Name:_________________________________

1. a) Astronomers use the parallax method to measure the distance to nearby stars, but we can't use it to measure the distance to stars in other galaxies. Why not? Why isn't the parallax method useful for measuring the distances to stars in other galaxies?
They are so distant that the parallax is too small to be measured since parallax varies inversely with distance.
b) Instead of the parallax method, we use the standard candle method to measure the distance to stars in other galaxies. In particular, we use the standard candle method to measure the distances to Cepheid variable stars in other galaxies. What is special about Cepheid variable stars that makes them useful for this purpose?
We can figure out their luminosities from their periods of variation. Then if we measure their fluxes we can calculate their distances.

2. a) From what were the protons and electrons in your body made, and roughly when were they made?
They were made from energy (or gamma rays) very soon after the big bang (in the first second). 400,000 years later they got together to make hydrogen atoms.
b) From what were the carbon atoms in your body made, and where were they made?
They were not made in the big bang. They were made much later inside of stars or in supernovae. They were made by fusion from lighter atoms.

3. Make two sketches of the Milky Way Galaxy, one an edge-on view and one a face-on view, labeling the various parts of the galaxy.
You should have labeled the disk, nucleus, bulge, halo, and perhaps spiral arms in the disk or star clusters in the halo.

4. Fritz Zwicky measured the masses of clusters of galaxies. How did he do that (or in general how would an astronomer measure the mass of a cluster of galaxies)? Hint: we use almost the same method anytime we measure the masses of astronomical objects. What quantities would an astronomer have to measure to determine the mass of a cluster of galaxies? (Your method should include all of the mass, not just the mass of the luminous matter.)

We measure masses by seeing how fast things orbit each other. In this case the galaxies in the clusters are orbiting around each other. We have to measure their orbital speeds and distances from the center. (We could calculate their orbital periods from their speeds.)

5. Astronomers think that the Universe was filled with gas with a temperature of 3000 K 400,000 years after the big bang. The gas emitted light like that from a 3000 K star.

a) Using the facts that the surface temperature of the Sun is 6000 K and the light it emits is brightest at a wavelength of 500 nm (0.0005 mm), at what wavelength was the radiation from the 3000 K gas that filled the Universe brightest when it was emitted?

It was at half the temperature of the surface of the Sun, so the light it emitted was at twice the wavelength. That is 1000 nm, or 1 μm, or 0.001 mm.

b) The radiation we see now from the early Universe is brightest at a wavelength of 1 mm. What caused the wavelength of the radiation to change since it was emitted?

The light waves were stretched by the expansion of the Universe (or by the Doppler shift because the gas that emitted the radiation we see is moving away from us).

The light waves have been stretched by a factor of 1000 because the Universe is now 1000 times bigger.

6. I measured the speed of a galaxy 100 million parsecs (100 Mpc) from here to be 7000 km/sec.

a) What sort of a measurement did I make to determine that speed?

I measured the Doppler shift. That is, I measured the shift in the spectrum to longer wavelengths from what was emitted. With our balloons we measured the change in distance with time, but we can't do that with the real Universe.

b) What value of Hubble's constant do I calculate from my measurements?

$H = v / d = 7000$ km/s / 100 Mpc = 70 km/s/Mpc

c) Imagine that a record of my measurements is found by an astronomer 5 billion years from now, and she measures the distance and speed of the same galaxy. Assume she measures the same speed as I did, but a different distance. Would you expect her to calculate a larger or a smaller value of Hubble's constant than I calculated? Why?

The distance will increase since the galaxy is moving away from us (or actually space is stretching between us), so $H = v/d$ will decrease.

d) If instead she measures the galaxy's speed to be 8000 km/sec, what might have caused the galaxy's speed to have changed?

That's a bigger speed. Dark energy (or vacuum energy) is what we think causes an increased rate of expansion of the Universe.