

## ASTRO 250 -- EXAM 2 (sample)

This exam has two parts. In **Part I**, indicate the best answer to the question directly on the question sheet. In **Part II**, write your answer in the space provided. Partial credit will be given if it looks like you are on the right track, or if you have the basic idea but do not give sufficient detail. Note that the sum of total possible points is 102.

GOOD LUCK --- and RTFQ

### USEFUL FORMULAE

$$V = H_0 d \quad \Omega = \rho / \rho_{\text{crit}} \quad t \approx 2 / (3H_0) \quad \Delta\lambda / \lambda = v / c \quad Z = \lambda_{\text{observed}} / \lambda_{\text{emitted}} - 1$$

$$E = mc^2$$

$$c = 3 \times 10^{10} \text{ cm/s} \quad 1 \text{ Mpc} = 10^6 \text{ pc}$$

$$= 3 \times 10^5 \text{ km/s}$$

**PART I: MULTIPLE CHOICE:** 22 questions, 3 points each. Select the *best* answer to each of the questions below. Indicate your answer on this sheet.

1. The giant galaxy M87 is 3 times farther away than the spiral galaxy M51. The velocity of M87 will be \_\_\_\_\_ times \_\_\_\_\_ than the velocity of Galaxy B with respect to the Milky Way.
  - a) 3 ; smaller
  - b) 3 ; bigger
  - c) 9 ; smaller
  - d) 9 ; bigger
  - e) none of the above
2. Most of the matter of the universe is
  - a) undetected by any means.
  - b) in the form of energy.
  - c) matter that exerts gravitational force, but is otherwise completely hidden.
  - d) composed of stars and gas.
  - e) is visible in some region of the electromagnetic spectrum.
3. The diameter of the disk of our galaxy is closest to \_\_\_\_\_ parsec(s), or about \_\_\_\_\_ light years.
  - a) 1 ; 3.26
  - b) 100 ; 326
  - c) 1,000 ; 3260
  - d) 18,000 ; 53,000
  - e) 30,000 ; 100,000
4. If the density of the universe is less than the critical density the universe will
  - a) stop expanding only after an infinite amount of time has passed.
  - b) eventually stop expanding and begin contracting.
  - c) eventually stop contracting and begin expanding.
  - d) continue to contract forever.
  - e) continue to expand forever.

5. What percentage of the mass of the universe was formed into helium during the Big Bang?
  - a) much less than 1%
  - b) 10%
  - c) 25%
  - d) 75%
  - e) 90%
6. Spectra of distant galaxies show
  - a) a large red shift.
  - b) a large blue shift.
  - c) no spectral shift.
  - d) a small red shift.
  - e) a small blue shift.
7. Our current best direct measurements of the density of visible matter in the universe indicates that the universe is
  - a) open.
  - b) closed.
  - c) flat.
  - d) static.
  - e) fictional.
8. The 3° K microwave background radiation has a spectrum most similar to that of
  - a) synchrotron radiation from a hot body.
  - b) thermal radiation from a very cool body.
  - c) an approaching galaxy
  - d) heated mercury gas.
  - e) synchrotron radiation from a nuclear reactor.
9. The general shape of our galaxy is nearest to that of a(n)
  - a) pear.
  - b) egg.
  - c) ear of corn.
  - d) baseball.
  - e) fried egg (sunny side up).
10. The 3K background radiation observed by COBE is not smooth in all directions. Why not?
  - a) There must have been a mistake in the calibration of the instrument.
  - b) The universe must have been lumpy at the time of the Big Bang.
  - c) It is seeing radiation from different distances in different directions.
  - d) This statement is incorrect. The cosmic background *is* perfectly smooth in all directions.
  - e) The universe must have been slightly lumpy at the time of recombination.
11. Which of the following pieces of evidence places a strong upper limit on the *baryonic* density of the universe?
  - a) the rotation curve of the Milky Way beyond the sun
  - b) the rotation curve of the Milky Way between the sun and the center of the galaxy
  - c) the age and velocities of galaxies in clusters
  - d) fluctuations in the cosmic microwave background
  - e) the cosmic abundance of helium, deuterium, and lithium

12. Which of the following are in the correct order of formation following the Big Bang?  
 a) protons, electrons, helium, deuterium  
 b) deuterium, protons, electrons, helium  
 c) neutrinos, electrons, protons, deuterium  
 d) protons, electrons, deuterium, helium  
 e) Newton, Copernicus, Kepler, Abian
13. The current best estimate of the Hubble constant is closest to  
 a) 25 km/s/Mpc  
 b) 50 km/s/Mpc  
 c) 70 km/s/Mpc  
 d) 100 km/s/Mpc  
 e) 125 km/s/Mpc
14. Which of the following is true about "cold dark matter" ("CDM")  
 a) planet-sized black holes can be considered as CDM  
 b) neutrinos can be CDM  
 c) it exerts no gravitational force but affects light  
 d) it is required to understand formation of large structures in the universe  
 e) all of the above
15. Which of the following is true about "hot dark matter" (or "HDM")  
 a) planet-sized black holes can be considered HDM  
 b) neutrinos can be HDM  
 c) it exerts no gravitational force but affects light  
 d) it is required to understand the formation of large structures in the universe  
 e) all of the above
16. The current best observational estimate of the value of the fraction of the closure density of the universe that is made of ordinary matter (i.e.  $\Omega_{\text{baryon}}$ ) is  
 a)  $1-10^{-32}$   
 b)  $1+10^{-32}$   
 c) 1.0000000000000000...  
 d)  $< 0.1$   
 e) 0
17. Frank Drake was/is :  
 a) The next-door neighbor of Huey, Dewey, and Louie (Duck).  
 b) The first man to walk on the Moon  
 c) The first person to search for evidence of technological civilizations around nearby star systems using radio waves  
 d) The first scientist to suggest that Martian meteorites may contain biological material  
 e) One of the scientists that showed that passing sparks and UV radiation through a glass jar containing a mixture of various gases (ammonia, water vapor, carbon dioxide, methane etc) could create long polymer chains including some simple amino acids needed for life to begin on Earth
18. The most successfully technique (so far) to find planets around other stars has been  
 a) photometry of stars to look for variations caused by planets blocking some starlight  
 b) gravitational microlensing  
 c) precision spectroscopy to detect orbital motion of the star caused by orbiting planets  
 d) direct infrared imaging of planets around nearby stars  
 e) interviews with people who have been abducted by aliens

19. The 3K microwave background that we see on Earth  
 a) has a redshift (Z) of 1000.  
 b) has a redshift (Z) of 1,000,000.  
 c) is radiation left over from the time of freeze-out of electrons and positrons  
 d) a) and c)  
 e) b) and c).
20. Among the following, the best estimate of the age of the Universe is \_\_\_ years, and its **overall** size is \_\_\_ light years in radius.  
 a) 5,000; 50,000  
 b) 13 billion; less than 13 billion  
 c) 100 million; 100 million  
 d) 13 billion; much greater than 13 billion  
 e) 13 billion; 13 billion
21. Which of the follow substances is believed to have been crucial in the ability for organisms to thrive and grow on Earth?  
 a) Petroleum  
 b) Ammonia gas  
 c) Nitrogen  
 d) Sulphuric acid vapor  
 e) Liquid water
22. Why is it unlikely that we will find Earth-like life on the planet found orbiting 51 Peg? This planet was the first extrasolar planet found by Mayor and Queloz in 1995.  
 a) The planet orbits too close to the primary  
 b) The planet has been spectroscopically proven not to contain evidence of life forms in its atmosphere  
 c) The planet lies inside the "habitable zone" but shows evidence for the runaway greenhouse effect  
 d) The planet has a period of 400 Earth years and so all life on the planet will be frozen  
 e) images taken with the Hubble Space Telescope have been unable to confirm the existence of the planet

**PART II: SHORT ANSWER:** Answer all questions in this part in the spaces provided

23. (8 points) a) What is non-baryonic dark matter? What kind of stuff could be considered non-baryonic dark matter?

b) Describe one piece of evidence that a large fraction of the mass of the universe is non-baryonic dark matter.

24. (8 points) In our discussion of the values of  $\Omega$  and  $H_0$ , a number of perplexing questions emerged. State and discuss a current mystery about various measurements of these and related quantities, and how they lead to contradictory conclusions.

25 (8 points) Describe two characteristics of extrasolar planetary systems which were not expected before their discovery?

a)

b)

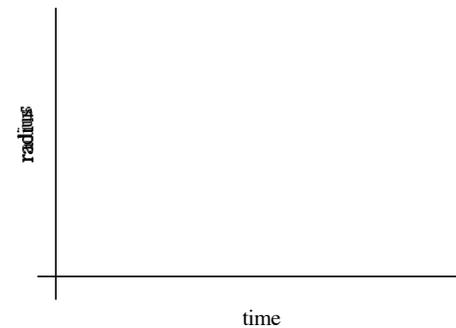
26. (8 pts) a) What is the age of the universe today?

b) What is the size of the observable universe today, in light-years?

c) On the graph below, draw (and label) lines showing how the size of the universe changes with time when

- i)  $\Omega < 1$
- ii)  $\Omega = 1$
- iii)  $\Omega > 1$

from the Big Bang until well into the future. Indicate the position of the present time on each of the three lines.



27. (2 points) With 2/3 of Astro 250 finished, is there any topic that you have learned about that is particularly interesting? Is there some topic that you would like to know more about? Is there anything that should be skipped next time this course is taught? Use the back of this sheet if needed.