

ASTRO 250 SAMPLE FINAL EXAM

NAME _____

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.

GOOD LUCK --- and RTFQ

USEFUL FORMULAE

$$V = H_0 d \quad \Omega = \frac{\rho}{\rho_{\text{crit}}} \quad t = \frac{2}{3H_0} \quad \frac{\Delta\lambda}{\lambda} = \frac{v}{c} \quad Z = \frac{\lambda_{\text{observed}}}{\lambda_{\text{emitted}}} - 1 \quad E = mc^2$$

$$M_{\text{sun}} = 2 \times 10^{33} \text{g} \quad \frac{t_{\text{moving}}}{t_{\text{rest}}} = \sqrt{1 - \frac{v^2}{c^2}} \quad \frac{t_{\text{rest}}}{t_{\text{moving}}} = \sqrt{1 - \frac{v^2}{c^2}}$$

$$E = mc^2 \quad R_{\text{Sch}} = 3\text{km} \times \left(\frac{M}{M_{\text{sun}}} \right)$$

$$\frac{\text{stretch}}{\text{weight}} = \text{height}[\text{cm}] \times 10^7 \times \left[\frac{d}{R_{\text{Sch}}} \right]^3 \times \left[\frac{M}{M_{\text{sun}}} \right]^{-2}$$

$$c = 3 \times 10^{10} \text{cm/s} \quad t_{\text{evap}} = 10^{10} \text{yr} \times \left(\frac{M}{4 \times 10^{14} \text{g}} \right)^3 \quad T_{\text{H,R}} = 2 \times 10^{11} \text{K} \times \left(\frac{M}{4 \times 10^{14} \text{g}} \right)^{-1}$$

$$N = R_* \times M_{\text{sun}} f_p \times n_e \times f_i \times f_c \times L$$

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

$$1 \text{pc} = 3.26 \text{light years}$$

$$1 \text{Mpc} = 10^6 \text{pc}$$

$$1 M_{\text{sun}} = 2 \times 10^{33} \text{g}$$

PART I: MULTIPLE CHOICE: 27 questions, 2 points each. Select the *best* answer to each of the questions below. Indicate your answer on this sheet.

- 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.
 - 3 ; smaller
 - 3 ; bigger
 - 9 ; smaller
 - 9 ; bigger
 - none of the above
- The current best estimate of the Hubble constant is
 - 25 km/s/Mpc
 - 50 km/s/Mpc
 - 70 km/s/Mpc
 - 100 km/s/Mpc
 - 125 km/s/Mpc
- The observatory that has produced the best data on the cosmic background radiation is
 - the Hubble Space Telescope (HST)
 - the Wilkinson Microwave Anisotropy Probe (WMAP)
 - the Roentgen X-Ray Satellite (ROSAT)
 - the COsmic Background Explorer (COBE)
 - the Compton Gamma Ray Observatory (C-GRO)
- On what basis does Hawking connect the thermodynamic and psychological arrows of time?
 - 'Time flies like an arrow' has several interpretations.
 - The structuring of memory by the brain creates disorder in the universe because it consumes energy and generates heat.
 - Hawking asserts that the human mind *controls* time.
 - He doesn't connect them, and calls the relationship random.
 - Huh?
- Which of the following is not an *essential* ingredient for the time machine we discussed in class?
 - a movable black hole
 - a mechanism for preventing the collapse of a wormhole
 - a way to accelerate to faster than the speed of light
 - use of the principles of general relativity
 - space travel
- The rotation rate of observable neutron stars is about
 - once per month
 - once per minute
 - once per second
 - 10,000,000 times per second
 - none of the above
- Approximately how many years will it take a black hole of 1 solar mass to evaporate by emission of Hawking radiation?
 - 10 years
 - 10^{10} years
 - 10^{26} years
 - 10^{66} years
 - 10^{99} years

8. In this space, place the following events in the correct chronological order: _____
- Star formation ends when all the available hydrogen in the Universe is used up
 - The Earth rotation period and the moon's orbit become synchronized at 45 days
 - The sun becomes a white dwarf star
 - The lowest-mass main sequence stars become white dwarf stars
 - AGN central black holes evaporate
9. Which of the following fates await the Earth in the distant future?
- it will be gobbled up by the Sun when it first becomes a red giant
 - it will survive until the Sun becomes a white dwarf, when the planetary nebula destroys it
 - it will forever orbit the Sun, escaping destruction because of its relatively large orbit
 - the Earth will spiral into the Sun when the Sun becomes a black hole
 - it will eventually be destroyed when the moon's orbit decays and the moon crashes down
10. Identify the condition that is *not* thought to be necessary for intelligent life to develop on a planet:
- correct distance from the star for liquid water to exist
 - star orbited is an F, G, or K-type star
 - ample silicon present on the planetary surface
 - ample carbon available on the planetary surface
 - ample oxygen available on the planetary surface
11. Which of the following factors in the Drake equation are directly addressed by astronomy?
- R^*, f_p, n_e
 - f_i, f_l, f_c
 - f_c, L
 - f_p, n_e, f_l
 - L
12. The 3K background radiation observed by COBE is not smooth in all directions. Why not?
- There must have been a mistake in the calibration of the instrument.
 - The universe must have been lumpy at the time of the Big Bang.
 - It is seeing radiation from different distances in different directions.
 - This statement is incorrect. The cosmic background *is* perfectly smooth in all directions.
 - The universe must have been slightly lumpy at the time of recombination.
13. What is the approximate best guess we came up with in class for the value of N for our galaxy?
- 0.001
 - 100
 - 100,000
 - 10,000,000
 - billions and billions
14. Which of the following phenomena can be associate with interacting galaxies?
- starburst nuclei
 - distorted spiral structure
 - long, thin streams of stars and gas called "antennae"
 - rings of star formation
 - all of the above

15. Which of the following reasons is most compelling for why we will not travel directly to the stars any time soon?
- It is impossible to travel faster than the speed of light.
 - The energy required is too large to ever accumulate
 - Travel at near-light speed requires very extensive shielding from gamma rays
 - all of the above are important
 - none of the above; interstellar travel is only a generation away
16. The 3° K microwave background radiation has a spectrum most similar to that of
- synchrotron radiation from a hot body.
 - thermal radiation from a very cool body.
 - an approaching galaxy
 - heated mercury gas.
 - synchrotron radiation from a nuclear reactor
17. Over what distances is the Earth detectable by a radio telescope such as Arecibo?
- 5 light years
 - 10 light years
 - 20 light years
 - 50 light years
 - 100 light years
18. The condensed remnants of stars with masses less than 15 solar masses are
- O and B stars
 - black holes or neutron stars
 - white dwarfs only
 - neutron stars
 - white dwarfs or neutron stars
19. How many radio frequencies need to be searched when looking for alien transmissions?
- 10
 - 10,000
 - 100,000
 - 10,000,000
 - more than 10 million
20. If the density of the universe is less than the critical density the universe will
- stop expanding only after an infinite amount of time has passed.
 - eventually stop expanding and begin contracting.
 - eventually stop contracting and begin expanding.
 - continue to contract forever.
 - continue to expand forever.
21. The current search for extraterrestrial radio signals is known as
- Project Ozma
 - Project Meta
 - Project Phoenix
 - HRMS
 - Project Mercury

22. What would be the most obvious signature of life on Earth when viewed by the Galileo spacecraft from the distance of the Moon?

- a) The spectral signatures of oxygen and methane
- b) The Great Wall of China
- c) The gray patches of cities
- d) Christmas lights in the Midwest at night
- e) the wakes of oil-tankers in the oceans

23. 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

24. 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

25. 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%

26. 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.

27. Our current best measurements of the density of matter in the universe indicates that the universe is

- a) open.
- b) closed.
- c) flat.
- d) static.
- e) fictional.

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

28. (7 points) Why is it that we cannot expect contact with extraterrestrial beings to be a two-way dialog? What can we gain from the search for such signals?

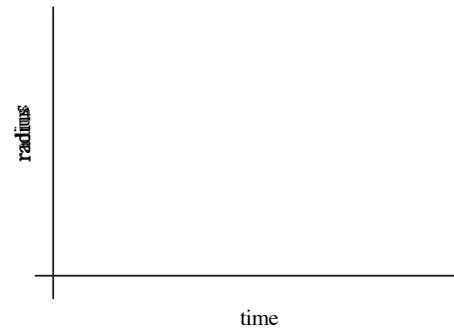
29. (8 pts) a) What is the age of the universe today?

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.



30. (2 points) With this edition of Astro 250 finished, is there any topic that you have learned about that was the most interesting? Is there some topic that we didn't discuss that you would like to know more about? Is there anything that should be skipped next time this course is taught?

31. (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.

32. (8 points) Describe the role that cosmic "accidents" play in the evolution of the Universe, both on an intergalactic scale and on a more local scale. Be specific, with at least two examples.

33. (6 pts.)

a) The Hubble Law is written $v = H_0 d$. Explain what each variable means, and how it is observed or determined.

b) What does the variation of H_0 with distance or 'look-back' time tell us?

34. (7 points) Trace the history of the calcium in your teeth throughout the history of the Universe. Follow it from the initial formation of matter after the Big Bang, through the formation and evolution of galaxies and stars, the eventual formation of the Earth, and the events that led to beings like you with teeth. Follow the future of the calcium in your teeth through the end of time. Speculate on how frequently this historical path has been followed in our Universe.... but please limit your response to this sheet of paper.