

NAME _____

Test 2

Astronomy 123

2013 May 29

There are 15 multiple choice questions each worth 2 points, and 5 short answer questions each worth 14 points. The exam is scored for a total of $15 \times 2 \text{ points} + 5 \times 14 \text{ points} = 100 \text{ points}$.

MULTIPLE CHOICE—Choose the best answer

1. A *Standard Candle* is _____.
 - a. an object which has the same brightness as the Sun
 - b. a bright object whose light can penetrate the dust in the Milky Way galaxy
 - c. an object of known power output (known luminosity)
 - d. an object which can be seen across the Universe, at redshifts $z > 5$
 - e. an object whose event horizon is greater than the radius of the Sun

2. A *black hole* is _____.
 - a. an object composed purely of Dark Matter
 - b. an object from which only the superbright Dark Energy can escape
 - c. an object from which things must be traveling faster than the speed of light to escape
 - d. the hypothetical object proposed by Einstein to account for dark energy
 - e. an object that can be seen only in the infrared portion of the spectrum

3. The first credible evidence that the expansion rate of the Universe was increasing with time came from _____.
 - a. observations of Type Ia Supernovas
 - b. observations of globular clusters
 - c. observations of the CMBR
 - d. the resolution of Olbers' Paradox
 - e. the verification of the Inflation Theory

4. The Heisenberg Uncertainty Principle asserts that _____.
 - a. no matter how long we wait, we will never be able to determine the ultimate fate of the Universe
 - b. the only material which can escape from a black hole is the mysterious stuff known as dark energy
 - c. we can never know precisely the position and momentum of an object at the same time
 - d. all events that occur beyond our horizon (the region of the Universe which we can see) are unknown
 - e. no scientific theory can ever be shown to be true

5. In terms of the Friedman models for the Universe, current data suggests that _____.
 - a. we will suffer a Big Crunch. We live in a closed Universe
 - b. we live in an oscillating Universe. We are in a closed Universe which, after collapse, will rebound and expand again.
 - c. we live in flat Universe
 - d. we live in an open Universe which will someday suffer a *Big Rip*

- e. we live in an open Universe which will eventually suffer a *Big Freeze*
6. The _____ contributes to the *Faint Young Sun Problem*.
- fact that the Sun was fainter when it was born 4.6 billion years ago than it is today
 - fact that the Earth was at least as warm 3 billion years ago as it is today
 - suggestion that the atmosphere of the Earth was dominated by free oxygen 3 billion years ago creating an ozone ten times thicker than today
 - Only a & b contribute to the *Faint Young Sun Problem*
 - a, b, & c all contribute to the *Faint Young Sun Problem*
7. The *Habitable Zone* is _____.
- the region in a planetary system where planets can have liquid oceans
 - the region in a planetary system where planets are shielded from the ultraviolet emission from the central star
 - the region in the Milky Way galaxy where planets are known to harbor life
 - the region in the Milky Way galaxy most extra-Solar planets have been discovered
 - the region in a planetary system where planets can have large amounts of free oxygen
8. In the *Gaia Hypothesis* _____.
- it is proposed that life can develop only on planets which have conditions similar to those found on the Earth
 - it is suggested that life and Earth-like planets are rare in the Milky Way galaxy
 - it is proposed that the Earth is special and the Principle of Mediocrity is not valid
 - it is suggested that all planets are capable of supporting life, not just planets like the Earth
 - it is proposed that life itself leads to conditions conducive to life on the Earth
9. As the Universe has aged, its evolution, in order of increasing time, was dominated by _____.
- radiation, then matter, and finally dark energy
 - dark matter, then radiation, and then normal matter
 - dark energy at all ages
 - radiation at all ages
 - normal matter, then dark matter, then dark energy, and finally by radiation
10. The design of searches for extra-Terrestrial life are usually _____.
- based on the Anthropic Principle
 - based on the Gaia Hypothesis
 - based on LAWKI
 - based on the Fermi Paradox
 - based on the Drake Equation
11. Of the following, which is **NOT** a correct statement about ALH84001? _____.

- a. ALH84001 contains what appear to be fossilized primitive bacteria.
 - b. ALH84001 contains carbonate globules perhaps microfossils of primitive Martian bacteria.
 - c. ALH84001 contains magnetite perhaps formed by primitive Martian bacteria.
 - d. ALH84001 was discovered in the Allan Hills of Antarctica.
 - e. All of the above are correct statements about ALH84001.
12. The current consensus on the results of the analysis ALH84001 is _____.
- a. that life existed on Mars 3.6 billion years ago
 - b. that Martian life traveled to Earth 3.6 billion years ago, seeding life on Earth
 - c. although the evidence is strong that life existed on Mars 3-4 billion years ago, the appearance of the magnetite makes this result uncertain
 - d. that ALH84001 is actually from the asteroid belt, the meteorite was misidentified
 - e. the results that life existed on Mars are suggestive, but not strong
13. An example (or examples) that water exists or has existed on Mars _____.
- a. are the large, dried-up seabeds similar in appearance to those found on Earth, that are found in the Martian lowlands
 - b. are the outflow channels and *islands* seen on Mars' surface
 - c. are the great canyons carved by erosion seen Mars' surface, features similar to the Grand Canyon on the Earth
 - d. are the observed seasonal variations in the ground vegetation of Mars
 - e. is the seasonal variation of the thick ozone layer of Mars
14. In the Greenhouse Effect _____.
- a. high-energy radiation from the Sun passes freely through our atmosphere while infrared radiation from the surface of the Earth is trapped within the atmosphere
 - b. the ozone layer allows sunlight to pass freely through the atmosphere of the Earth but traps ultraviolet radiation in the atmosphere of the Earth
 - c. a thick layer of dust at the top of our atmosphere traps infrared radiation in our atmosphere while allowing ultraviolet radiation from the Sun to reach the surface of the Earth
 - d. carbon dioxide absorbs and traps ultraviolet radiation in our atmosphere but allows sunlight to pass freely to the surface of the Earth
 - e. All of the above contribute to the Greenhouse Effect on the Earth
15. The known extra-Solar planets _____.
- a. now number over 700
 - b. have been discovered primarily over the last 20 years
 - c. now includes several examples which exhibit free oxygen and so likely harbor life
 - d. only a & b are correct
 - e. a, b, & c are all correct

SHORT ANSWERS

Question 1: Dark Energy, Dark Matter, and Normal Matter

a. State what is meant by Dark Energy, Dark Matter, and Normal Matter.

b. What are *virtual pairs*? Describe how *virtual pairs* offer a possible explanation for Dark Energy.

Question 2: Cosmic Microwave Background Radiation

a. The Cosmic Microwave Background (CMBR) was formed when the Universe was _____ years old. At the time of the formation of the Cosmic Microwave Background (CMBR), what change in the properties of the material in the Universe led to the formation of the CMBR?

b. How did the Wilkinson Microwave Anisotropy Probe (WMAP) use the observed small fluctuations in the CMBR to estimate the dark matter content of the Universe?

Question 3: The Ultimate Fate of the Universe

- a. Briefly outline the evolution of the Universe starting from today to ages beyond 10^{100} years. Be sure to describe how the appearance and make-up of the Universe changes as it evolves.

- b. If in the distant future life somehow redevelops on Earth, what kind of cosmological model would the observer likely develop to describe the Universe? In particular, would the observer propose a version of the currently accepted Big Bang Theory? Why or why not?

Question 4: Life in the Universe

- a. Complete the Drake Equation,

$$N = R \times$$

Here, N is the number of intelligent civilizations in Milky Way galaxy who wish to communicate with us, and R is the rate of star formation in the Milky Way galaxy. Define each term in the Drake Equation and state which terms are well-determined and which terms are not well-determined at the present time.

- b. Based on our best current information, give estimates for the terms in the Drake Equation. Roughly, what is N for the Milky Way galaxy? Comment on the reliability of the estimated N . Support your answer citing relevant evidence.

