C - Astronomy - Pearl City Invitational - 12-12-2020

46 questions, 125 points, 50 minutes.

There is a mix of easy questions and more challenging questions, in no particular order. Good luck!

General Knowledge and Optics

1. (1.00 pts)   From the point of view of a Calendar maker, almanac maker, or watcher of the skies, December 21 every year has a special name. It is called _____ _____

Winter Solstice

2. (1.00 pts)   If you lived in Antarctica, would the above name for December 21 seem reasonable to you? Explain.

Expected Answer: No, because December is in summer in the Southern hemisphere.

3. (2.00 pts)   On December 21 this year, stargazers are looking forward to a very special phenomenon. What is that?

Expected Answer: Jupiter and Saturn will appear very close to one another as seen from the Earth.

4. (2.00 pts)   Seen from the Earth, what is the approximate angular size of the full moon in degrees? How about in arc minutes?

Expected Answer: About 0.5 degrees; about 30 arc minutes.

5. (2.00 pts)   Total solar eclipses can sometimes be seen from the Earth. What can you deduce about the approximate angular size of the Sun as seen from the Earth?

Expected Answer: As seen from the Earth, the angular size of the Sun is approximately the same as that of the Moon.

6. (2.00 pts)   What is the approximate range of wavelengths of visible light in Angstroms?

Expected Answer: About 3800 to 7000 Angstrom

7. (5.00 pts)

The "aperture" of the dark-adjusted human eye is about 8 mm. What is the theoretical angular resolution of the human eye at a wavelength of 500 nm, in units of radians? How about in units of arc minutes?

Expected Answer: 0.000076 radians, about 0.26 arc minutes

8. (2.00 pts)   How many arc seconds is a radian?

Expected Answer: about 206265

9. (1.00 pts)   What is an Astronomical Unit (AU)?

Expected Answer: Average distance beween Earth and Sun (about 150 million km)

10. (2.00 pts)   How many AU is a parsec?

Expected Answer: About 206265

11. (2.00 pts)

Suppose two objects are so close in the sky that they are separated by 1/8 (one-eighth) the angular size of the full moon. By how many arc minutes are they separated?

Expected Answer: About 3.75 arc minutes

12. (3.00 pts)

Assume the actual angular resolution of the human eye is the same as what you calculated above for its theoretical angular resolution. Consider those two objects in the sky that are separated by only about 1/8 the angular size of the full moon. Would the human eye be easily able to distinguish them as two separate objects?

Expected Answer: Yes (because the separation of 3.75 arc minutes is much larger than the theoretical angular resolution of about 0.26 arc minutes. It is even greater than the realistic/actual angular resolution of the human eye, which is about 1 arc minute).

13. (2.00 pts)   On December 21 this year, will the two astronomical objects that stargazers are eagerly watching appear as a single object or as two separate objects?

Expected Answer: Two separate objects.

14. (2.00 pts)   Which of the following names is the "odd woman out"?

- ○ A) Vera Rubin
- ○ B) Henrietta Leavitt
- ○ C) Cecilia Payne
- ○ D) Annie Cannon
- ● E) Jennifer Doudna

Stars

15. (2.00 pts)   The Sun is "powered" by:

- ○ A) Chemical reactions
- ○ B) Nuclear fission
- ○ C) Release of gravitational potential energy by contraction
- ● D) Nuclear fusion
- ○ E) Abdominal contractions

16. (2.00 pts)

The Sun radiates about 4×10^{26} Joules per second. Nowadays, this large and long-term production of energy can be explained by nuclear physics, mass-energy equivalence, and quantum physics. These ideas emerged only in the first 3-4 decades of the 20th century. Before then, what was the best available scientific theory for the Sun's release of energy?

○ A) Chemical reactions

◉ B) Release of gravitational potential energy by contraction

○ C) Nuclear fission

○ D) Tidal forces

○ E) Magnetohydrodynamic effects

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17. (3.00 pts)
However, this explanation for the Sun's energy production was already realized to be inadequate, due to discoveries from geology and fossil evidence. In what way did the geological evidence conflict with the above theory for explaining how the Sun generates energy?

Expected Answer: Geological evidence indicated that the Earth was at least hundreds (or thousands) of millions of years old. But the release of gravitational potential energy would be capable of powering the Sun for only tens of millions of years.

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18. (2.00 pts)   However, the energy released by a certain category of stars is in fact due to this phenomenon, rather than nuclear fusion. What is that category of stars?

◉ A) Pre-Main Sequence stars

○ B) Main Sequence stars

○ C) Red Supergiants

○ D) Red Giants

○ E) White dwarfs

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19. (1.00 pts)
The temperature at the core of the Sun is believed to be about 16 million degrees Kelvin. What is the dominant process by which nuclear fusion occurs in the Sun's core?

○ A) CNO cycle

○ B) Triple alpha process

◉ C) Proton-proton chain reaction

○ D) Proton-neutron chain reaction

○ E) Deuterium fusion

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20. (2.00 pts)   In a star like the Sun, the heaviest element produced in the core by nuclear fusion is

○ A) Iron

○ B) Nickel

○ C) Helium

○ D) Uranium

◉ E) None of the above

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21. (2.00 pts)   After leaving the main sequence, the Sun is expected to eventually undergo a "helium flash."

◉ True   ○ False

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22. (3.00 pts)   Asteroseismology is the study of the oscillations (vibrations, pulsations) of stars. Data from asteroseismology can give us information about:

○ A) The approximate age of the star

○ B) The internal structure of the star

○ C) The distance to the star

○ D) All of the above

◉ E) Only A and B

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23. (3.00 pts)   Which of the following types of star has the lowest maximum mass?

○ A) White dwarf

◉ B) Brown dwarf

○ C) Red dwarf

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24. (3.00 pts)   Which of the following is true about the so-called "Lithium test"?

○ A) Lithium is generally present in brown dwarfs, but not in low-mass main sequence stars

○ B) Lithium is generally present in low-mass main sequence stars, but not in brown dwarfs

○ C) Lithium can be fused in the more massive brown dwarfs

○ D) Both A and B

◉ E) Both A and C

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25. (3.00 pts)   Which of the following statements is true?

○ A) Wolf-Rayet stars have broad emission lines in their spectrum

○ B) Wolf-Rayet stars are very hot and luminous

○ C) A Wolf-Rayet galaxy has many Wolf-Rayet stars

○ D) Wolf-Rayet stars are unlikely to be found in globular clusters

◉ E) All of the above

Galaxies

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26. (1.00 pts)   There are about as many galaxies as there are stars

○ True   ◉ False

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27. (3.00 pts)   Which of the following statements are true about spiral galaxies?

○ A) Some spiral galaxies are reddish

○ B) Some spiral galaxies have very little star formation going on

○ C) Most galaxies in the Local Group are spiral galaxies

○ D) The gaps between spiral arms have very few stars and almost no gas and dust

◉ E) A and B

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28. (3.00 pts) Which of the following statements is true?

◉ A) None of the following options is true

○ B) Core collapse supernovae are often observed in elliptical galaxies

○ C) Elliptical galaxies are rich in gas but not in dust

○ D) Due to mergers and interactions between galaxies, elliptical galaxies tend to evolve into spirals

○ E) Elliptical galaxies rarely have globular clusters

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29. (1.00 pts) In general, collisions or close interactions are thought to be more common for stars than for galaxies

○ True   ◉ False

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30. (3.00 pts) Which of the following statements is true about the Tully-Fisher relation?

○ A) It gives an empirical relationship between rotational speed and luminosity for spiral galaxies

○ B) It can be used to estimate the distance to many spiral galaxies

○ C) One of the astronomers for which it is named works at the University of Hawaii

○ D) An analogous relationship called the Faber-Jackson relation has been found for elliptical galaxies

◉ E) All of the above

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31. (3.00 pts) Which of the following is the largest type of gravitationally bound structure?

○ A) Superclusters

○ B) Galaxy groups

○ C) Globular clusters

◉ D) Galaxy clusters

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32. (3.00 pts) What is the Galaxy Zoo project? Name at least one interesting discovery that came out of this project.

Expected Answer: A series of "crowdsourced" or "citizen science" galaxy-related astronomy projects. Some discoveries: red spiral galaxies; blue elliptical galaxies; spiral galaxies that are near each other tend to rotate in the same direction; ...etc...

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33. (4.00 pts) What is meant by the "flattened rotation curve" of spiral galaxies?

Expected Answer: Based on Kepler's third law, orbital speeds of stars in the disk of spiral galaxies should go down as distance from the center of the galaxy goes up. Instead, for many spiral galaxies, the orbital speed of stars in the disk is fairly constant for a range of distances from the center.

34. (4.00 pts)
What is a starburst galaxy? Be specific: compare (specific:compare) with the Milky Way. What kind of event may trigger a starburst? What phenomena may eventually "quench" a starburst?

Expected Answer: A galaxy that has an unusually high rate of star formation. For example, the rate of star formation in the MW is a few (about 1) solar masses per year, but in a starburst galaxy it can be tens or even hundreds of times larger.

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35. (4.00 pts)   What is the Lyman alpha forest? How is it thought to be formed? What kind of information can it give us?

Expected Answer: Absorption lines in the spectrum of distant AGNs and galaxies, due to Lyman alpha absorption by gas clouds between the source and the observer. Since different gas clouds are at different distances (redshifts), the absorption lines are shifted accordingly. Gives a variety of information about the intergalactic medium on a very large distance scale.

Cosmology

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36. (2.00 pts)   About how many percent of the total mass-energy content of the Universe is thought to be electromagnetic radiation?

○ A) About 68%

○ B) Less than 5%

◉ C) Less than 0.1%

○ D) About 27%

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37. (1.00 pts)   About how many percent of the mass-energy content of the Universe is thought to be dark matter?

◉ A) About 27%

○ B) Less than 0.1%

○ C) About 68%

○ D) Less than 5%

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38. (1.00 pts)   About how many percent of the mass-energy content of the Universe is thought to be baryonic (ordinary) matter?

○ A) About 68%

○ B) About 27%

◉ C) Less than 5%

○ D) Less than 0.1%

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39. (4.00 pts) Four fundamental forces are known to physics. List them in order of weakest to strongest.

Expected Answer: Gravity, weak nuclear force, electromagnetism, strong nuclear force.

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40. (3.00 pts) Dark matter is thought to interact by means of which of the four fundamental forces?

Expected Answer: Gravity only; possibly some other force not stronger than the weak nuclear force.

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41. (5.00 pts)
Although the "Big Bang" theory of the origin of the Universe is dominant today, up to the 1950s or 1960s there was an influential alternative theory. What is that theory called? Explain it briefly. What specific prediction does it make about the Universe of the distant past?

Expected Answer: Steady state theory. The Universe is eternal and statistically similar at different times and distances. As the Universe expands, in each volume of space a small amount of Hydrogen spontaneously comes into existence and keeps the overall density constant. Prediction: the Universe of the distant past was similar to the Universe of today.

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42. (3.00 pts)
Astronomers generally subscribe to the so-called "Cosmological Principle", which postulates that the Universe is homogenous and isotropic. What is meant by homogenous? What is meant by isotropic?

Expected Answer: Homogeneous = similar at all locations. Isotropic = similar in all directions.

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43. (5.00 pts) What is Olbers' Paradox? If the Universe is indeed homogeneous and isotropic, what prediction does it make?

Expected Answer: If the Universe is infinite, homogeneous, and isotropic, no matter in which direction you look there must be a star, and so the night sky should be uniformly very bright.

44. (4.00 pts) How does Big Bang cosmology resolve Olbers' Paradox?

Expected Answer: The observable Universe is not infinite; furthermore, light from distant sources is redshifted to low energies.

45. (10.00 pts) Describe and characterize the Cosmic Microwave Background in up to 10 sentences (1 point per meaningful fact, up to 10 points).

Expected Answer: Many different interesting points can be listed about the CMB.

46. (3.00 pts)
This question is just for fun and creativity. Three points extra credit. There is a star called Zubenelgenubi (also called Alpha Librae). Like many star names, it is Arabic. To me, "Zubenelgenubi" almost sounds like a line from a song.   :-)   Write something fun (song, poem, joke, riddle...) using the word Zubenelgenubi. Keep it non-offensive.

Expected Answer: Give full points for trying.

I hope that you found the test questions interesting. Good luck with your other events.

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