Astronomy 1001/1005

Final Exam

(250 points)

Instructions:
Mark your answers on this test AND your bubble sheet
You will NOT get your bubble sheet back
One page of notes is allowed
Use a #2 pencil on the bubble sheet. Make your bubbles dark and neat.
There are 50 multiple choice problems and your choice of 5 short answer questions with point values given for each.
Useful Information:

\[ p^2 = \frac{4\pi^2}{G(M_1 + M_2)} a^3 \]

\[ F = \frac{GM_1M_2}{d^2} \]

\[ L = 4\pi r^2 \times \sigma T^4 \]

\[ B = \frac{L}{4\pi d^2} \]

\[ M = \frac{r \times v^2}{G} \]

\[ G = 6.67 \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2} \]

\[ 1 \text{ AU} = 1.5 \times 10^{11} \text{ m} \]

\[ 1 \text{ parsec} = 3.1 \times 10^{16} \text{ m} \]

\[ 1 \text{ parsec} = 3.26 \text{ light} – \text{ years} \]

\[ M_{Earth} = 6.0 \times 10^{24} \text{ kg} \]

\[ c = 300,000 \text{ km/s} \]

Scoring:

Multiple Choice: _____ / 150

Quantitative & Short Answer: _____ / 100

Total: _____ / 250
Multiple Choice (3 points each)

1) What is the current best estimate for the age of the Universe?  
   (a) 14 million years  
   (b) 10 billion years  
   (c) 14 billion years  
   (d) 10 trillion years  
   (e) 14 trillion years  

2) A brown dwarf is:  
   (a) a protostar  
   (b) a dead star  
   (c) an extra-solar planet larger than Jupiter  
   (d) a gaseous object without enough mass to achieve fusion  
   (e) a dwarf planet like Pluto

3) What is a red giant doing in its interior?  
   (a) Burning Hydrogen in its core  
   (b) Burning Hydrogen in a shell  
   (c) Burning Helium in its core and Hydrogen in a shell  
   (d) Burning Helium and Hydrogen in shells  
   (e) Burning Carbon in the core

4) What characteristic is most fundamental in determining how a star will evolve?  
   (a) Initial temperature  
   (b) Initial location  
   (c) Initial luminosity  
   (d) Initial color  
   (e) Initial mass

5) What is closest in size to a white dwarf?  
   (a) The Sun  
   (b) Jupiter  
   (c) Earth  
   (d) A small city (~10 km)  
   (e) A car (~10 m)
6) The order of stellar spectral types is:
   (a) OABFGKM  
   (b) ABFGKMO  
   (c) OBAFGMK  
   (d) OGBKFMA  
   (e) OBAFGKM

7) Hydrostatic equilibrium is the balance of gravity and:
   (a) temperature  
   (b) pressure  
   (c) density  
   (d) energy  
   (e) heat

8) What is the end product of a solar mass star?
   (a) A supernova  
   (b) Red giant  
   (c) White dwarf  
   (d) A black hole  
   (e) none of the above

9) You see a blue star and a red star. What can you say about these stars?
   (a) The red star is less massive than the blue star  
   (b) The red star is more massive than the blue star  
   (c) The red star is hotter than the blue star  
   (d) The red star is cooler than the blue star  
   (e) The red star is farther away than the blue star

10) Which is closest in size to a neutron star?
    (a) The Sun  
    (b) Jupiter  
    (c) Earth  
    (d) A small city (~10 km)  
    (e) A car (~10 m)
11) Clusters of stars are useful to study because they have the same:  

(a) distance  
(b) age  
(c) composition  
(d) all of the above  
(e) none of the above  

12) Elements heavier than Iron are formed in:  

(a) the Big Bang  
(b) low mass stars  
(c) high mass stars  
(d) supernovae  
(e) galaxy collisions  

13) When we observe very distant galaxies, we are also  

(a) observing the very beginning of the Universe  
(b) observing the very end of the Universe  
(c) observing the past  
(d) observing the future  
(e) none of the above  

14) What does the universe look like on very large scales?  

(a) Galaxies are uniformly distributed.  
(b) Galaxies are randomly distributed.  
(c) Galaxies all exist in clusters, superclusters, and hyperclusters  
(d) Galaxies appear to be distributed in chains and sheets that surround great voids.  
(e) Galaxies are distributed in a great shell expanding outward from the center of the universe.
15) What evidence supports the theory that there is a black hole at the center of our galaxy? 
   (a) We observe an extremely bright X-ray source at the center of our galaxy.  
   (b) We can see gas in an accretion disk at the center of our galaxy.  
   (c) The motions of the gas and stars at the center indicate that it contains a million solar masses within a region only about 1 parsec across.  
   (d) We see a large, dark object that absorbs all light at the center of our galaxy.  
   (e) All of the above

16) What is a quasar? 
   (a) a star-like object that actually represents a bright patch of gas in the Milky Way. 
   (b) a very large galaxy thought to be formed by the merger of several smaller galaxies, typically found in the center of a galaxy cluster. 
   (c) a specialized astronomical instrument for observing distant stars. 
   (d) the extremely bright center of a distant galaxy, thought to be powered by a massive black hole. 
   (e) another name for very bright stars of spectral type O

17) When was the Cosmic Microwave Background formed? 
   (a) The Planck Era. 
   (b) During matter and anti-matter annihilation. 
   (c) During the recombination of nuclei and electrons. 
   (d) After the formation of the first stars. 
   (e) During the final stages of galaxy formation.

18) What is the current temperature of the Universe? 
   (a) 3,000 K. 
   (b) 300 K. 
   (c) 30 K. 
   (d) 3 K. 
   (e) Absolute zero.
19) The force of the Sun’s gravity on the Earth is: __e__

(a) the cause of earthquakes  
(b) greater than the force of the Earth’s gravity on the Sun  
(c) negligible during Spring Equinoxes  
(d) decreasing over time, causing Earth’s rotation to slow  
(e) equal to the force of the Earth’s gravity on the Sun

20) What causes the radio pulses of a pulsar? __b__

(a) The star vibrates.  
(b) The star spins and beams of radio waves periodically sweep across Earth.  
(c) The star accretes matter causing periodic runaway fusion that we observe as pulses.  
(d) The star’s binary companion periodically blocks the pulsar’s constant radio emission.  
(e) A black hole near the star absorbs the pulsar’s energy and reemits it as radio waves.

21) Which of these stars has the coolest surface temperature? __a__

(a) a K star  
(b) an A star  
(c) an F star  
(d) a G star  
(e) an O star

22) What prevents gravity from crushing a white dwarf any further? __b__

(a) Thermal pressure  
(b) Electron degeneracy pressure  
(c) Neutron degeneracy pressure  
(d) Gas pressure  
(e) Nothing

23) Stars most easily form in clouds that are: __a__

(a) cold and dense.  
(b) hot and dense.  
(c) cold and low density.  
(d) hot and low density.  
(e) awesome looking.
24) Where are most of the Milky Way’s globular clusters found?  
   (a) In the disk  
   (b) In the bulge  
   (c) In the halo  
   (d) In the solar neighborhood  
   (e) There are no globular clusters in the Milky Way.  

25) Which of these galaxies would you most likely find at the center of a large cluster of galaxies?  
   (a) An average spiral galaxy  
   (b) A large spiral galaxy  
   (c) A dwarf elliptical galaxy  
   (d) A giant elliptical galaxy  
   (e) An irregular galaxy  

26) If all the main-sequence stars of a star cluster are typically only one-hundredth as bright as their counterparts in the Hyades Cluster, then that cluster’s distance from us is  
   (a) 100 times farther than Hyades  
   (b) 30 times farther than Hyades  
   (c) 10 times farther than Hyades  
   (d) 1/10 as far as Hyades  
   (e) 1/100 as far as Hyades  

27) Why are type Ia supernovae such good standard candles?  
   (a) Their mass is always the same.  
   (b) Their luminosity is always the same.  
   (c) The physics behind the explosion is always the same.  
   (d) All of the above  
   (e) None of the above
28) Which of these possible types of universes would not expand forever? [b]
(a) An accelerating universe
(b) A recollapsing universe
(c) A coasting universe
(d) They will all expand forever
(e) None will expand forever

29) A photograph of a cluster of galaxies shows distorted images of galaxies that lie behind the cluster at greater distances. This is an example of: [b]
(a) dark energy
(b) gravitational lensing
(c) density waves
(d) a bad camera
(e) magic

30) Which of the following does inflation help to explain? [d]
(a) The near critical density of the Universe
(b) The uniformity of the Universe
(c) The large scale structure of the Universe
(d) All of the above
(e) None of the above

31) Which is oldest? [a]
(a) M15, a globular cluster
(b) The Solar System
(c) Betelgeuse—a red supergiant
(d) The Sun
(e) You

32) The wavelength at which a blackbody (e.g. a star) emits the most energy depends on: [a]
(a) Temperature.
(b) Composition
(c) Density
(d) Size (radius)
(e) Mass
33) What is the approximate composition of the Universe?  
(a) 25% H and He, 75% other stuff  
(b) 25% H, 75% He, a little bit of other stuff  
(c) 75% H, 25% He, a little bit of other stuff  
(d) 97% H, 3% He, a little bit of other stuff  
(e) 75% H and He, 25% other stuff

34) If Star A’s absolute magnitude is higher than Star B’s absolute magnitude…
(a) Star A is closer than Star B.  
(b) Star A is farther away than Star B.  
(c) Star A is brighter than Star B.  
(d) Star A is dimmer than Star B.  
(e) Star A is hotter than Star B.

35) The nightly motion of stars across the sky is due to:
(a) Revolution of Earth around the Sun  
(b) Rotation of the celestial sphere around Earth  
(c) Precession  
(d) Rotation of the Earth on its axis  
(e) Gravitational pull of the Moon and stars

36) Accretion of hot gas onto a black hole could yield which type of observational phenomenon?
(a) AGN  
(b) Radio galaxy  
(c) Quasar  
(d) Any of the above  
(e) None of the above

37) If the star Alpha Centauri were moved to a distance 10 times farther from Earth than it is now, its parallax angle would:
(a) Get bigger  
(b) Stay the same  
(c) Get smaller  
(d) Be exactly zero  
(e) Be about 5 degrees
38) What kind of star is most likely to be found in the Milky Way’s bulge?  d
   (a) An O star
   (b) An M star
   (c) An A star
   (d) Any of the above
   (e) None of the above

39) Who discovered that the orbits of planets are ellipses?  e
   (a) Copernicus
   (b) Ptolemy
   (c) Galileo
   (d) Tycho Brahe
   (e) Kepler

40) Meteor showers are caused by:  b
   (a) The earth passing through the asteroid belt
   (b) The earth moving through the debris field of a comet
   (c) The solar wind
   (d) Unstable conditions in the ionosphere
   (e) They occur randomly

41) What is a planetary nebula?  b
   (a) What is left of the planets around a star when that star dies
   (b) The expanding shell of gas that is no longer gravitationally held to the
        remnant of a low-mass star
   (c) The expanding shell of gas that is left when a white dwarf explodes as a
        supernova
   (d) A disk of gas surrounding a protostar that may fall into planets
   (e) The molecular cloud from which protostars form

42) The main sequence lifetime of the Sun is about:  d
   (a) 4.5 million years
   (b) 10 million years
   (c) 4.5 billion years
   (d) 10 billion years
   (e) Forever
43) The Milky Way is: ___c___
   (a) A giant elliptical galaxy
   (b) An irregular galaxy
   (c) A spiral galaxy
   (d) A quasar
   (e) A dwarf elliptical galaxy

44) Compared to Terrestrial planets, Jovian planets are typically: ___d___
   (a) More massive
   (b) Less dense
   (c) Closer to the Sun
   (d) A and B
   (e) All of the above

45) The most important property of a telescope is: ___b___
   (a) Magnification
   (b) Collecting area
   (c) Angular resolution
   (d) Focal length
   (e) Reflector vs. refractor

46) Star A has a surface temperature of 20,000 K. Star B has a surface temperature of 10,000 K. If they are the same distance from Earth, which star is brighter and by how much? ___c___
   (a) Star A is 2x brighter than Star B
   (b) Star A is 4x brighter than Star B
   (c) Star A is 16x brighter than Star B
   (d) Star B is 2x brighter than Star A
   (e) Star B is 4x brighter than Star A

47) Where are you most likely to see star formation? ___d___
   (a) The core of an elliptical galaxy
   (b) The edges of an elliptical galaxy
   (c) The bulge of a spiral galaxy
   (d) The disk of a spiral galaxy
   (e) The halo of a spiral galaxy
48) What is the process by which high mass stars generate most of their energy?  
(a) The p-p chain  
(b) The CO2 cycle  
(c) The CNO cycle  
(d) Nuclear fission  
(e) Burning coal

49) The evolution of a solar mass star is:  
(a) Main Sequence, RGB, HB, AGB, Planetary Nebula, White Dwarf  
(b) Main Sequence, RGB, AGB, HB, Planetary Nebula, White Dwarf  
(c) Main Sequence, AGB, HB, RGB, Planetary Nebula, White Dwarf  
(d) Main Sequence, HB, AGB, RGB, Planetary Nebula, White Dwarf  
(e) Main Sequence, AGB, HB, RGB, Planetary Nebula, Supernova

50) What is meant by the “critical density” of the Universe?  
(a) the density separating a collapsing and infinitely expanding Universe  
(b) the minimum density that the Universe needs to form stars  
(c) the average density of space between galaxies  
(d) the average density of space between stars  
(e) the minimum density that the Universe needs to form galaxies
**Short Answer Questions (pick 5, 20 points each)**

Use pictures and words to describe the three types of spectra and how they are produced.

<table>
<thead>
<tr>
<th>Continuous</th>
<th><img src="image" alt="Continuous Spectrum" /></th>
<th>Created by pure thermal emission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absorption</td>
<td><img src="image" alt="Absorption Spectrum" /></td>
<td>Created when specific wavelengths from thermal emission is absorbed by an intervening gas cloud as electrons jump from the ground state to excited states</td>
</tr>
<tr>
<td>Emission</td>
<td><img src="image" alt="Emission Spectrum" /></td>
<td>Created when electrons in excited states jump back down to lower energy levels</td>
</tr>
</tbody>
</table>

Draw and label an HR diagram. Be sure to label the axes (indicate where larger and smaller values are), the main sequence, the giants, supergiants white dwarfs, and the location of the Sun.
Draw and label the 3 main parts of the Milky Way. Indicate where the following objects are most likely to be found: young stars, old stars, globular clusters, gas and dust, metals, and the supermassive black hole.

Young stars, gas and dust, and metals would be found in the disk/spiral arms. The supermassive black hole would be found right at the center of the galaxy, in the center of the bulge.
Old stars and globular clusters are in the halo, but there are also some older stars in the bulge and scattered through the disk.

Use words and a diagram to explain why we observe the phases of the moon.

Just like Earth, half of the surface of the moon is always lit; there is a day side and a night side. We only ever see the side that is lit. Based on the position of the moon in its orbit around Earth (the angle it makes with the Earth and Sun a.k.a. elongation), our perspective from Earth allows us to see a portion of the Moon’s surface (the lit portion). We observe the Moon’s phases as it progresses through its monthly orbit.
Describe two observations that hint at the existence of dark matter. Specifically what is seen, and why is dark matter the best explanation?

We can look at the rotation curves of spiral galaxies or the width of absorption lines in elliptical galaxies, and both tell us that objects in the outer regions of galaxies orbit much faster than we expected, which implies there is a lot more mass inside their orbits than we expected. Dark matter is the best solution.

The temperature of gas in galaxy clusters tells us how strongly the gas is being compressed, which is due to gravity from the mass in the cluster. Again, the temperatures are higher than we expect, implying there is more mass than we can see.

Gravitational lensing occurs when mass warps spacetime, forcing light to bend around massive objects like galaxy clusters. The more light bends, the more mass there is. Again, light bends more than we expect, so there is more mass than we expect.

(a) Describe each step in the Star-Gas-Star cycle with 1-2 sentences. Use a diagram if you like.
(b) How does the SGS cycle affect future generations of stars?

Each generation of stars makes more metals and heavier elements, so when they return their material to the universe to make more stars, those newer stars will contain more of those heavier elements.
Describe the difference between nuclear fusion and nuclear fission. Which one is being used by the Sun?

Nuclear fusion is when two light nuclei come together to form a heavier nucleus. Nuclear fission is when a heavy nucleus splits into two lighter nuclei.

The Sun (and all stars) generates energy via nuclear fusion.

What are the three different types of galaxies, and how do they look different from each other?

**Spiral Galaxies** are easily identified by their flat disk, usually containing well-defined spiral arms as well as gas and dust. They also have a central spheroidal bulge and are surrounded by a spheroidal halo containing globular clusters.

**Elliptical Galaxies** are simple spheroidal collections of stars. The stars are usually very old as ellipticals are devoid of gas and dust, preventing ongoing star formation.

**Irregular Galaxies** are galaxies that do not fall into either of the previous two categories. They come in all shapes and sizes and are often the result of recent gravitational interactions between two or more galaxies.