

1. **DO NOT OPEN THIS EXAM UNTIL INSTRUCTED TO DO SO.**
2. Use a dark pencil such as a number 2 pencil
3. On your bubble sheet, mark form D.
4. Answer *ALL* of the questions. There is no penalty for guessing.
5. Don't get stalled on any one question.
6. Choose the **best** answer each for the problems.
7. For your reference there are formulas below.

DO NOT FORGET TO FILL IN "TEST FORM" D

Possibly Useful Formulae and Constants:

$$\text{Area of a circle} = \pi r^2$$

$$\text{Area of a sphere} = 4\pi r^2$$

$$\text{Volume of a sphere} = 4\pi/3 r^3$$

$$P^2 = a^3$$

$$d = vt$$

$$d = 1/p$$

$$F = ma$$

$$F = GM_1M_2/R^2$$

$$R = 2 GM/c^2$$

$$I \propto 1/r^2$$

Density = mass/volume

Astronomical Unit: 1AU = 1.5×10^8 km

Gravitational constant = 6.668×10^{-11} N m² kg⁻²

Mass of the Sun = 5.974×10^{24} kg

Sun's Radius = 6.96×10^8 m

Speed of light in a vacuum = 3.0×10^8 m/s

1 Parsec = 3.262 lyrs = 3.086×10^{16} m

NOTE: the above symbols may have different meanings in different equations!

1. To what do the words “hydrostatic equilibrium” in the Sun refer?
 - A) The balance of gravity inward and gas pressure outward.
 - B) The balance of gas pressure inward and heat outward.
 - C) The balance of gas pressure outward and magnetic forces inward.
 - D) The creation of one helium nucleus for the “destruction” of every four hydrogen nuclei.

2. Which of the following is NOT a consequence of core collapse at the end of the life of a massive star?
 - A) Electrons combine with protons to form neutrons.
 - B) The core density approaches the density of an atomic nucleus.
 - C) The silicon core is converted to iron by fusion reactions.
 - D) Great numbers of neutrinos are produced.

3. When visible light passes through a glass prism or a glass lens, which wavelengths of light are deflected the *least* by the glass?
 - A) All wavelengths have their directions changed by the same amount.
 - B) The light is not deflected by glass because glass is transparent.
 - C) The shorter wavelengths.
 - D) The longer wavelengths.

4. The explosion of a supernova appears to leave behind
 - A) a rapidly expanding shell of gas and a central neutron star.
 - B) a rapidly rotating shell of gas, dust, and radiation, but no central object.
 - C) a rapidly expanding shell of gas and a compact white dwarf star at its center.
 - D) nothing; the explosion changes all the matter completely into energy, which then radiates into space at the speed of light.

5. What would happen to the gravitational force upon the Earth if the Sun were to be replaced by a 1-solar-mass black hole?
 - A) It would remain as it is now.
 - B) It would become extremely high, sufficient to pull the Earth into it.
 - C) It would be much less, because the gravitational field of a black hole only exists very close to it.
 - D) It would double in strength.

6. The spectral class of the star Enif is K, while that of the Sun is G. Which of the following conclusions can be drawn about Enif from this information?
 - A) It is hotter than the Sun.
 - B) It is cooler than the Sun.
 - C) It is intrinsically fainter than the Sun.
 - D) It is intrinsically brighter than the Sun.

7. Which is the correct sequence for the following end points of stellar evolution, in order of increasing mass?
- A) White dwarf, neutron star, black hole.
 - B) Neutron star, black hole, white dwarf.
 - C) Black hole, neutron star, white dwarf.
 - D) White dwarf, black hole, neutron star.
8. Which of the following particles or types of radiation will provide the most direct information on the processes of nuclear fusion that are occurring at the present time in the solar core?
- A) Protons in the solar wind and from solar flares.
 - B) Neutrinos.
 - C) Visible light from the photosphere.
 - D) X rays from the solar corona.
9. A planetary nebula is
- A) a gas cloud surrounding a planet after its formation.
 - B) a shell of ejected gases, glowing because of ultraviolet light from a dying central star.
 - C) the spherical cloud of gas produced by a supernova explosion.
 - D) the formation stages of planets around stars other than the Sun dwarf star.
10. The main reason Leslie will fly with his far-infrared instrument FIFI LS on SOFIA is
- A) to avoid the absorption of the far-infrared radiation by water vapor.
 - B) to obtain longer observing times on specific sources by moving in the direction of the Earth's rotation.
 - C) to avoid stray infrared radiation from the warm Earth and its occupants.
 - D) to obtain photographs of resolution higher than can be obtained on the ground.
11. The neutrino is
- A) an elusive, subatomic particle, having very small mass, very difficult to detect.
 - B) a heavy nuclear particle, easily detected.
 - C) another name for an antielectron or positron.
 - D) another name for an antineutron, the antiparticle of the neutron, very difficult to detect.
12. A high-mass star near the end of its life undergoes successive cycles of energy generation within its core in which gravitational collapse increases the temperature to the point where a new nuclear fusion cycle generates sufficient energy to stop the collapse. This process does not work beyond the silicon fusion cycle that produces iron. Why is this?
- A) Electrostatic forces between the highly charged iron nuclei are sufficient to overcome the collapse and stabilize the stellar core.
 - B) Iron nuclei are so large that they occupy all remaining space and so the collapse cannot continue.
 - C) The pressure from high-energy photons and neutrinos at the very high core temperatures reached at this stage of development is finally sufficient to halt the collapse.
 - D) Fusion of iron nuclei into heavier nuclei requires energy rather than producing excess energy and therefore will not produce the additional gas pressure to halt the collapse.

13. What determines whether a particular region of an interstellar cloud can collapse and form a star?
- A) Only the amount of mass in the cloud, since this determines the strength of gravity.
 - B) The gas density, the ratio of the mass of the cloud over its volume, since this determines how gravity will act upon the cloud material.
 - C) Only the temperature, since higher temperatures act to prevent collapse
 - D) The amount of gravity pulling inward compared to gas pressure pushing outward.
14. The solar wind is
- A) a violent, explosive expansion of specific regions of the Sun's atmosphere at certain times.
 - B) a gentle outflow of solar material, mostly protons and electrons, that is always moving outward from the Sun.
 - C) ionized hydrogen gas and electrons orbiting the Sun between its surface and the planet Mercury.
 - D) the inflow of matter onto the Sun under gravitational attraction.
15. Which of the following objects is NOT an endpoint of a star's evolutionary life?
- A) Neutron star.
 - B) Black hole.
 - C) Red giant.
 - D) Supernova.
16. **BONUS:** Two stars are observed from another planet. Star A has a parallax of 1 arcseconds and star B has a parallax of 0.25 arcseconds. Star B has twice the intensity of Star A (i.e. $I_B = 2I_A$). Star B is really _____ times brighter than Star A intrinsically (i.e. if they were at the same distance).
- A) 4
 - B) 32
 - C) 1/2
 - D) 1/4
 - E) 1/32
17. In class, Leslie used liquid nitrogen and a balloon to demonstrate
- A) blackbody emission-- the cooled balloon emitted less blue light
 - B) electron degeneracy-- the balloon was held up by the liquid air
 - C) hydrostatic equilibrium-- the balloon collapsed when the pressure was reduced
 - D) atomic spectrum emission-- the balloon did not emit a continuous band of light
18. **BONUS:** The atomic spectrum (the barcode) of an atom is the direct consequence of
- A) the temperature of the atom
 - B) quantum leaps of electrons in the atom
 - C) combination of a rarefied hot gas and gravity
 - D) electrons orbiting the nucleus as described by Newton

19. Which of the following statements is NOT a property of neutron stars?
- A) They contain strong gravitational fields but weak magnetic fields.
 - B) They are composed almost entirely of neutrons.
 - C) They emit relatively narrow beams of light and other radiation.
 - D) They rotate from one to thirty times each second.
20. A white dwarf star, the surviving core of a low-mass star toward the end of its life, can be found on the Hertzsprung-Russell diagram
- A) above and to the right of the main sequence, since it evolved there after its hydrogen fusion phase.
 - B) below and to the left of the main sequence.
 - C) at the upper left end of the main sequence, since its surface temperature is extremely high.
 - D) at the bottom end of the main sequence, along which it has evolved throughout its life.
21. If you see an object moving past you at 90% of the speed of light, what will its length appear to be?
- A) It looks shorter than at rest while it is coming toward you and longer after it has passed you.
 - B) Its length will appear to be unchanged from when it is at rest since it is a solid object.
 - C) It will look shorter than if it were at rest.
 - D) It will look longer than if it were at rest.
22. Two rocket ships are traveling past the Earth at 90% of the speed of light, in opposite directions (i.e., they are approaching each other). One turns on a searchlight, which is seen by scientists aboard the other. What speed do the scientists measure for this light (c = speed of light in a vacuum)?
- A) c .
 - B) $0.9c$.
 - C) $1.8c$ (equal to $2 \times 0.9c$).
 - D) $1.9c$ (equal to $c + 0.9c$).
23. What is the likely final fate of a star whose mass is 25 solar masses after it has finished its nuclear burning phases?
- A) It will condense to the point where it is composed completely of neutrons, the degeneracy of which will prevent further shrinkage.
 - B) It will immediately split into two and become a binary star system.
 - C) It will collapse and become a black hole.
 - D) The degeneracy of the electrons within the star will prevent collapse below the diameter of a white dwarf.
24. The energy generation process inside a white dwarf star is
- A) nonexistent—a white dwarf star is simply cooling by radiating its original heat.
 - B) the combining of protons and electrons to form neutrons within its core.
 - C) the helium flash—very efficient and rapid helium fusion.
 - D) hydrogen fusion.

25. Pulsars, emitting very regular radio and sometimes visible light pulses, are what type of object?
- A) Rapidly rotating neutron stars.
 - B) Rapidly rotating binary star systems in which the stars undergo regular eclipses as seen from Earth.
 - C) Pulsating variable stars.
 - D) Black holes, with material falling regularly into them.
26. What is it that keeps a white dwarf star from collapsing inward upon itself?
- A) Convection currents or updrafts from the nuclear furnace.
 - B) Electron degeneracy or “quantum crowding.”
 - C) Normal gas pressure.
 - D) The physical size of the neutrons of which this star is composed.
27. The stars that eventually become white dwarfs are those that start life with masses less than
- A) 1.4 solar masses.
 - B) 3 solar masses.
 - C) 8 solar masses.
 - D) 25 solar masses.
28. The BIMA observatory, partially owned by UIUC, is
- A) a single 12 inch refracting telescope on the Quad.
 - B) an optical telescope in Hawaii.
 - C) an array of radio antennas in New Mexico.
 - D) an array of microwave antennas in California.
29. Where on the Hertzsprung-Russell diagram do most local stars in our universe congregate?
- A) On the main sequence, where stars are generating energy by fusion reactions.
 - B) In the giants area, where most stars spend the longest time of their lives.
 - C) In the white dwarf area, the “graveyard” of stars.
 - D) In the supergiant area, where the most massive stars spend a significant time.
30. In the atomic nucleus there are often numerous positively charged protons. What keeps the nucleus from flying apart?
- A) Neutrinos.
 - B) The force of gravity.
 - C) The nuclear strong force.
 - D) The electromagnetic force.
31. The main reason for building large optical telescopes on the Earth's surface is
- A) to collect more light from faint objects.
 - B) to magnify images of objects and produce higher resolution photographs.
 - C) to bring astronomical objects closer for more detailed examination by scientists.
 - D) for national prestige, with no scientific reason.

32. The light from a small amount of a particular chemical element, when heated in a lamp (like in class), is found to consist of
- A) a continuous spectrum of light whose peak wavelength is specific to the particular element.
 - B) a pattern of narrow, bright emissions at wavelengths that are specific to the element and different for each element.
 - C) a continuous spectrum of light from which certain colors are missing or absorbed, the absorbed colors being different for different elements.
 - D) a pattern of narrow, bright emissions at specific wavelengths that are the same for all elements, only the relative intensities of each line differing for different elements.
33. The major feature that distinguishes a sunspot from other regions on the Sun is
- A) a coronal hole existing above it.
 - B) its very powerful magnetic field.
 - C) faster rotation around the Sun's axis than neighboring regions.
 - D) its greater light emission compared to the photosphere.
34. What is the source of most of the heavy elements on the Earth and in our own bodies?
- A) Cosmic ray interactions with hydrogen and helium nuclei in interstellar clouds.
 - B) Nuclear reactions during the formation of the universe (the Big Bang).
 - C) Explosive nucleosynthesis during supernova explosions of massive stars.
 - D) Thermonuclear fusion reactions in the cores of massive stars.
35. In the process of helium shell fusion in low-mass stars near the end of their lives, the star moves upward and to the right as a red giant in the Hertzsprung-Russell diagram. In this process, the star is
- A) expanding, heating up, and becoming more luminous.
 - B) contracting, becoming hotter, and becoming much less luminous.
 - C) expanding, cooling, and becoming more luminous.
 - D) contracting, cooling, and hence becoming less luminous.
36. Our Sun will end its life by becoming
- A) a black hole.
 - B) a pulsar.
 - C) a molecular cloud.
 - D) a white dwarf.
37. Stars that have ejected a planetary nebula go on to become
- A) supernovae.
 - B) white dwarfs.
 - C) red giants.
 - D) protostars.

38. In terms of its total lifetime, the Sun is
- A) about 1/4 of the way through its life.
 - B) about half-way through its life.
 - C) about 1/10 of the way through its life.
 - D) about 3/4 of the way through its life.
39. Granulation on the surface of the Sun is caused by
- A) magnetic field disturbances above the solar surface.
 - B) convective currents carrying heat from beneath the surface.
 - C) nuclear fusion processes occurring just below the surface.
 - D) differential rotation of the Sun.
40. Microwaves travel through space at what speed?
- A) At the speed of light, 3×10^8 m/s.
 - B) Slightly faster than the speed of light, because their wavelength is longer.
 - C) Much faster than the speed of light
 - D) Much slower than the speed of light.
41. The center of the disk of the visible Sun appears brighter than the edges because we see
- A) into deeper and cooler layers at the center of the solar disk.
 - B) less radiation from the cooler chromosphere near the edges of the Sun.
 - C) a greater contribution from the corona of the Sun at the center of the disk.
 - D) into deeper and hotter layers at the center of the disk.
42. In which of the following parameters does a photon of blue light NOT differ from a photon of yellow light, in a vacuum?
- A) Color.
 - B) Speed.
 - C) Energy.
 - D) Wavelength.

Answer Key

1. A
2. C
3. D
4. A
5. A
6. B
7. A
8. B
9. B
10. A
11. A
12. D
13. D
14. B
15. C
16. B
17. C
18. B
19. A
20. B
21. C
22. A
23. C
24. A
25. A
26. B
27. C
28. D
29. A
30. C
31. A
32. B
33. B
34. C
35. C
36. D
37. B
38. B
39. B
40. A
41. D
42. B