

BROCK UNIVERSITY

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Time of Examination: 8:00 – 10:00 am

Instructor: S. D'Agostino

Answer all questions on the answer sheet provided. No aids permitted except for a non-programmable calculator (this regulation does not preclude special arrangements being made for students with disabilities). Translation dictionaries (e.g., English-French) or other dictionaries (thesaurus, definitions, technical) are not allowed. Use or possession of unauthorized materials or electronic devices will result in a charge of academic misconduct under the University's Academic Integrity Policy.

Each question is worth 1 mark. Total number of marks: 100.

Return both the exam script and your answer sheet when you leave the exam room.

1. The greater the mass of a main-sequence star, the _____ is its lifetime
 - (a) longer
 - (b) * shorter
 - (c) [The lifetime of a main-sequence star does not depend on its mass.]
2. The radius of Neptune's orbit around the Sun is _____ times larger than the radius of Earth's orbit around the Sun.
 - (a) 3
 - (b) * 30
 - (c) 300
 - (d) 3,000
3. Dark energy
 - (a) is emitted by certain political operatives.
 - (b) is the energy emitted by dark matter.
 - (c) causes black holes to retain any light inside.
 - (d) * causes the universe's expansion to accelerate.
 - (e) [None of the above.]
4. The Jovian planets are _____ the Sun than the terrestrial planets.
 - (a) closer to
 - (b) * farther away from
 - (c) [They are about equally distant.]

5. Reflection nebulae are typically
 - (a) * bluish.
 - (b) greenish.
 - (c) reddish.
 - (d) yellowish.
 - (e) [None of the above.]
6. The giant molecular clouds in which stars form are typically
 - (a) hot and dense.
 - (b) hot and not very dense.
 - (c) * cool and dense.
 - (d) cool and not very dense.
7. A shock wave passing through a giant molecular cloud can trigger the formation of
 - (a) black holes.
 - (b) gravitational waves.
 - (c) meteor showers.
 - (d) supernovae.
 - (e) * [None of the above.]
8. Astronomers typically detect protostars using
 - (a) * infrared light.
 - (b) radio waves.
 - (c) ultraviolet light.
 - (d) visible light.
 - (e) [None of the above.]
9. Radioactive dating is useful for determining the ages of
 - (a) celestial bodies on the dating site *Plenty of Planets*.
 - (b) stellar atmospheres.
 - (c) planetary atmospheres.
 - (d) the cosmic microwave background radiation.
 - (e) * [None of the above.]
10. The abundance of heavy elements is greater in the Milky Way's
 - (a) * disk.
 - (b) halo.
 - (c) [There are no heavy elements in the Milky Way.]

11. The ages of the oldest stars in the universe have been confirmed by studying the spectrum of _____ in the stars.
- (a) argon.
 - (b) hydrogen.
 - (c) neon.
 - (d) * uranium.
 - (e) [None of the above.]
12. The period of Jupiter in its orbit around the Sun is about
- (a) 12 days.
 - (b) 12 months.
 - (c) * 12 years.
 - (d) 12 centuries.
13. The cores of terrestrial planets are primarily composed of
- (a) hydrogen and helium.
 - (b) lithium.
 - (c) molten lava.
 - (d) rock.
 - (e) * [None of the above.]
14. Small rocks that land on Earth after coming from outer space are called
- (a) meteors.
 - (b) * meteorites.
 - (c) meteoroids.
 - (d) meteorinos.
15. Small rocks that leave a streak of light as they fly through our atmosphere are called
- (a) * meteors.
 - (b) meteorites.
 - (c) meteoroids.
 - (d) meteorinos.
16. Small rocks that fly through the solar system are called
- (a) meteors.
 - (b) meteorites.
 - (c) * meteoroids.
 - (d) meteorinos.

17. Main-sequence stars with masses of about the Sun's mass or less primarily use _____ for their fusion reactions.
- (a) the CNO cycle
 - (b) the Krebs cycle
 - (c) * the proton-proton chain
 - (d) the recumbent cycle
 - (e) the SNO chain
18. Main-sequence stars with masses much greater than the Sun's mass primarily use _____ for their fusion reactions.
- (a) * the CNO cycle
 - (b) the Krebs cycle
 - (c) the proton-proton chain
 - (d) the recumbent cycle
 - (e) the SNO chain
19. Our location in the Milky Way was established in the 1900s by
- (a) Adorjan.
 - (b) Hubble.
 - (c) Kasparov.
 - (d) * Shapley.
 - (e) [None of the above.]
20. Comets are
- (a) balls of hot gas and dust that have erupted from the Sun.
 - (b) balls of hot gas and dust that have erupted from other stars.
 - (c) small protostars that have not grown large enough to join the main sequence.
 - (d) small quasars that have not yet left the solar system.
 - (e) * [None of the above.]
21. There is a relationship between the distance of a galaxy and its recession speed, first discovered by
- (a) Galileo Galilei.
 - (b) * Edwin Hubble.
 - (c) Vesto Slipher.
 - (d) Fritz Zwicky.
 - (e) [None of the above.]

22. The approximate composition of the universe is
- (a) 5% dark energy, 25% dark matter, and 70% ordinary matter
 - (b) 5% dark matter, 25% ordinary matter, and 70% dark energy
 - (c) 5% ordinary matter, 25% dark energy, and 70% dark matter
 - (d) * 5% ordinary matter, 25% dark matter, and 70% dark energy
 - (e) [None of the above.]
23. The atmosphere of _____ is extremely hot, about 90 times more dense than Earth's atmosphere, and is about 95% carbon dioxide.
- (a) Mercury
 - (b) * Venus
 - (c) Mars
 - (d) the Moon
 - (e) [None of the above.]
24. The Kirkwood gaps in the asteroid belt are caused by
- (a) the Cassini effect.
 - (b) density wave fluctuations in the galactic spiral arm that the solar system lies in.
 - (c) the late heavy bombardment.
 - (d) the Schadenfreude effect.
 - (e) * [None of the above.]
25. For a main-sequence star, as you move from its outer layers towards its core,
- (a) * the pressure increases and the temperature increases.
 - (b) the pressure increases and the temperature decreases.
 - (c) the pressure decreases and the temperature increases.
 - (d) the pressure decreases and the temperature decreases.
 - (e) [All of the above.]
26. The oldest stars in the universe are about
- (a) 12 million years old – 13 million years old.
 - (b) 120 million years old – 130 million years old.
 - (c) 1.2 billion years old – 1.3 billion years old.
 - (d) * 12 billion years old – 13 billion years old.
 - (e) [None of the above.]

27. It is expected that all liquid water on Earth will evaporate in about
- (a) 500 – 1 thousand years.
 - (b) 500 thousand – 1 million years.
 - (c) * 500 million – 1 billion years.
 - (d) 500 billion – 1 trillion years.
28. Vera Rubin did important work in the 1970s
- (a) * measuring rotation curves of stars in galaxies.
 - (b) determining the mass-luminosity relationship for irregular galaxies.
 - (c) tabulating redshifts of distant quasars.
 - (d) measuring absolute magnitudes of Type I supernovae.
 - (e) [None of the above.]
29. S-asteroids are composed primarily of
- (a) a mixture of sodium chloride and sodium hydroxide.
 - (b) sintered carbon.
 - (c) solidified gases.
 - (d) sulphur compounds.
 - (e) * [None of the others.]
30. Once the hydrogen fuel in the Sun's core is consumed, then the core of the sun will
- (a) * contract.
 - (b) expand.
 - (c) explode.
 - (d) solidify.
 - (e) [None of the above.]
31. In its first red giant phase, the Sun's core will begin fusing Helium into
- (a) Beryllium.
 - (b) Boron.
 - (c) * Carbon.
 - (d) Oxygen.
 - (e) [None of the above.]

32. Astronomers often speak informally about hydrogen fuel “burning” in the core of a star, but what really happens to the hydrogen is that it undergoes
- (a) nuclear fission.
 - (b) * nuclear fusion.
 - (c) nuclear pair-production.
 - (d) nuclear annihilation chain reactions.
33. About 90% of all stars that generate energy by nuclear fusion are
- (a) * main-sequence stars.
 - (b) blue super-giants.
 - (c) red giants.
 - (d) white dwarfs.
 - (e) [None of the above.]
34. Type Ia supernovae form in
- (a) * binary star systems that include a white dwarf.
 - (b) binary star systems that include a neutron star.
 - (c) giant open-pit mines.
 - (d) giant interstellar supernovae regions.
35. Helium nuclei began to form about _____ after the Big Bang.
- (a) * 3 minutes
 - (b) 3 years
 - (c) 3 thousand years
 - (d) 3 million years
 - (e) [None of the above.]
36. Stars with masses between about 0.1 solar masses and about 0.5 solar masses are called
- (a) white dwarfs.
 - (b) * red dwarfs.
 - (c) brown dwarfs.
 - (d) black dwarfs.
37. A collapsing star will become a white dwarf provided that its mass is less than about
- (a) 1.4 Earth masses.
 - (b) 1,400 Earth masses.
 - (c) * 1.4 solar masses.
 - (d) 1,400 solar masses.

38. Eventually, a white dwarf will stop emitting light, but this is expected to take
- (a) until next Thursday at the latest.
 - (b) several million years.
 - (c) several billion years.
 - (d) * longer than the currently-accepted lifetime of the universe.
39. A teaspoonful of material from a white dwarf has a mass of about
- (a) 1 tonne.
 - (b) * 10 tonnes.
 - (c) 100 tonnes.
 - (d) 1,000 tonnes.
 - (e) [None of the others.]
40. Globular clusters typically contain about 100 thousand to 1 million
- (a) constellations.
 - (b) galaxies.
 - (c) pulsars.
 - (d) * stars.
 - (e) [None of the above.]
41. A black hole is a remnant of a
- (a) type Ia supernova.
 - (b) * type II supernova.
 - (c) planetary nebula.
 - (d) giant molecular cloud.
42. As the fusion of progressively heavier nuclei takes place in the later stages in the lifetime of a very massive star, each stage of fusion takes
- (a) * progressively less time.
 - (b) about the same amount of time.
 - (c) progressively more time.
43. The first astronomers to conclude that the Milky Way is roughly disk-shaped were William and Caroline Herschel in
- (a) 410 BC.
 - (b) * 1785.
 - (c) 1964.
 - (d) 2011.

44. Cepheid variables have periods that are about
- (a) * a week or two.
 - (b) a year or two.
 - (c) a century or two.
 - (d) a million years or two.
 - (e) [None of the above.]
45. For a very massive star, energy production declines when the core contains primarily
- (a) carbon.
 - (b) hydrogen.
 - (c) plutonium.
 - (d) uranium.
 - (e) * [None of the above.]
46. Elliptical galaxies typically contain
- (a) a lot of gas and dust.
 - (b) a lot of dust, but very little gas.
 - (c) an unusually large amount of gas, but very little dust.
 - (d) * very little gas and dust.
47. Cosmological redshift is a result of
- (a) light moving away from massive stars.
 - (b) * space between galaxies expanding.
 - (c) the source of light moving rapidly towards us.
 - (d) the gravitational lensing effect.
48. Quasar spectra have
- (a) very small blueshifts.
 - (b) very large blueshifts.
 - (c) very small redshifts.
 - (d) * very large redshifts.
49. Near the Sun's location, the Milky Way galaxy experiences differential rotation, which means that
- (a) the entire galaxy rotates like a solid disk.
 - (b) objects closer to the centre generally take longer to go once around.
 - (c) * objects farther from the centre generally take longer to go once around.
 - (d) [None of the above.]

50. The chemical element that has the greatest nuclear binding energy per nucleon is
- (a) carbon.
 - (b) hydrogen.
 - (c) * iron.
 - (d) uranium.
 - (e) [None of the above.]
51. Astronomers search for black holes by examining binary systems in which an invisible component has mass greater than 3 solar masses and is a strong emitter of
- (a) infrared radiation.
 - (b) quasars.
 - (c) radio waves.
 - (d) ultraviolet radiation.
 - (e) * X-rays.
52. A rotating neutron star that emits regular bursts of electromagnetic radiation is called a
- (a) * pulsar.
 - (b) quasar.
 - (c) regular star.
 - (d) variable star.
 - (e) [None of the above.]
53. The centre of the Milky Way galaxy can be observed from Earth using
- (a) * radio waves.
 - (b) neutrinos.
 - (c) visible light.
 - (d) [All of the above.]
 - (e) [None of the above.]
54. There is strong evidence that quasars are located
- (a) * at the centres of galaxies.
 - (b) in the voids between galactic superclusters.
 - (c) near the edges of galaxies.
 - (d) within black holes.
 - (e) [None of the above.]

55. A common result of a galaxy collision is
- (a) many star collisions.
 - (b) stars from each galaxy forming binary systems.
 - (c) the dark matter in one galaxy absorbing dark energy from the other galaxy.
 - (d) * gravitational distortion of one or both of the galaxies.
56. The idea of dark matter was first introduced by
- (a) Aristotle in ancient times.
 - (b) Kant in the 1600s.
 - (c) Bessel in the 1700s.
 - (d) Zarathustra in the 1800s.
 - (e) * [None of the above.]
57. Elliptical galaxies
- (a) have a number of spiral arms.
 - (b) have prominent disks.
 - (c) have a number of spokes radiating from their nuclei.
 - (d) [All of the above.]
 - (e) * [None of the above.]
58. The vast majority of meteorites are
- (a) carbonaceous.
 - (b) ceramics.
 - (c) irons.
 - (d) stony-irons.
 - (e) * [None of the above.]
59. The centres of many galaxies appear to contain
- (a) land-fill sites containing an enormous number of broken kitchen appliances.
 - (b) super computers busy calculating the meaning of life.
 - (c) enormous clouds of gravitinos and neutralinos.
 - (d) * extremely massive black holes.
60. The method of Cepheid variables is used to measure the distances to
- (a) * only the closest galaxies.
 - (b) only spiral galaxies.
 - (c) only elliptical galaxies.
 - (d) only the most distant galaxies.

61. In the Milky Way, disk stars tend to move in orbits that are
- (a) * approximately circular, slightly undulating, and in the same direction.
 - (b) approximately circular, extremely undulating, and in the same direction.
 - (c) highly elliptical and in random directions.
 - (d) highly elliptical and in the same direction.
 - (e) [None of the above.]
62. Calculations showing that white dwarfs are the likely end-state for low-mass stars were first carried out by
- (a) Tycho Brahe.
 - (b) * Subrahmanyan Chandrasekhar.
 - (c) Johannes Kepler.
 - (d) Hikaru Nakamura.
 - (e) [None of the above.]
63. In the Milky Way, halo stars tend to move in orbits that are
- (a) approximately circular, slightly undulating, and in the same direction.
 - (b) approximately circular, extremely undulating, and in the same direction.
 - (c) * highly elliptical and in random directions.
 - (d) highly elliptical and in the same direction.
 - (e) [None of the above.]
64. A catastrophic event wiped out much of life on Earth, including dinosaurs, about
- (a) 65 thousand years ago.
 - (b) 650 thousand years ago.
 - (c) * 65 million years ago.
 - (d) 650 million years ago.
 - (e) [None of the above.]
65. According to the Big Bang theory, neutral hydrogen atoms formed about _____ after the Big Bang.
- (a) 380 years
 - (b) 380 million years
 - (c) 380 billion years
 - (d) * [None of the others.]

66. There is evidence that quasars are powered by
- (a) powerful magnetic fields produced by neutral currents.
 - (b) intermediate vector bosons.
 - (c) Milanković cycles.
 - (d) * supermassive black holes.
 - (e) [None of the above.]
67. Data from the WMAP and Planck satellite observatories suggest that the the universe
- (a) is spherical (overall).
 - (b) has decelerating expansion.
 - (c) * will probably expand forever.
 - (d) [All of the above.]
 - (e) [None of the above.]
68. We can observe the centre of the Milky Way galaxy using
- (a) visible light.
 - (b) * radio waves.
 - (c) satellite exploration.
 - (d) [None of the above.]
 - (e) [Both (a) and (b).]
69. The reciprocal of the Hubble constant gives us an estimate for
- (a) the average galactic density.
 - (b) the average power output of quasars.
 - (c) the degree of gravitational lensing from distant galaxies.
 - (d) * the age of the universe.
 - (e) [None of the above.]
70. When nuclei lighter than iron fuse to produce nuclei that are also lighter than iron, _____ in the process.
- (a) energy is absorbed
 - (b) * energy is released
 - (c) axions are absorbed
 - (d) axions are released
 - (e) [None of the above.]
71. The surfaces of terrestrial planets are _____ than the surfaces of Jovian planets.
- (a) colder
 - (b) * warmer

72. The universe is homogeneous on average, which means that it has
- (a) * approximately the same properties in all its sufficiently large regions.
 - (b) quite different properties in different regions.
 - (c) approximately the same properties in all directions.
 - (d) quite different properties in different directions.
 - (e) [None of the above.]
73. Isolated galaxies
- (a) * can change their structure over time.
 - (b) never change their structure.
74. The terrestrial planets are _____ the Jovian planets.
- (a) less dense than
 - (b) about as dense as
 - (c) * more dense than
75. The orbits of the planets around the Sun lie
- (a) approximately on the celestial sphere.
 - (b) approximately in a spiral.
 - (c) approximately in an egg-shaped surface.
 - (d) in chaotic directions.
 - (e) * [None of the above.]
76. When a photon of light moves away from a star, its energy _____ and its wavelength _____.
- (a) decreases / decreases
 - (b) * decreases / increases
 - (c) increases / decreases
 - (d) increases / increases
 - (e) [There is no change in energy or wavelength.]
77. The rapid orbital motions of stars very close to the centre of the Milky Way provide evidence for
- (a) dark energy.
 - (b) dark matter.
 - (c) Einstein's theory of stellar orbits.
 - (d) * a very massive object at the centre of the Milky Way.
 - (e) [None of the above.]

78. Most of the energy released in a Type II supernova is carried away by

- (a) gravitational waves.
- (b) * neutrinos.
- (c) visible light.
- (d) X-rays and gamma rays.
- (e) [None of the above.]

79. In planet formation, the process of differentiation causes

- (a) * denser substances to move towards the core of a planet and less dense substances to move towards the surface.
- (b) larger planets to move towards the outer region of the solar system and smaller planets to move towards the inner region of the solar system.
- (c) planetary orbits to nearly align along a plane.
- (d) the overall angular momentum of the solar system to move into the Oort cloud.
- (e) [None of the above.]

80. The _____ planets all have extensive systems of satellites.

- (a) * Jovian
- (b) terrestrial
- (c) exo-
- (d) asteroidal
- (e) [None of the above.]

81. The interiors of the Jovian planets contain small cores of

- (a) caramel.
- (b) carbon.
- (c) radioactive substances.
- (d) rubber.
- (e) * [None of the above.]

82. The mass of the Sun accounts for _____ of the mass of the entire solar system.

- (a) less than 1%
- (b) between 1% and 10%
- (c) between 10% and 50%
- (d) between 50% and 90%
- (e) * over 90%

83. The mass of Jupiter accounts for _____ of the mass of all of the planets in the solar system.
- (a) less than 25%
 - (b) between 25% and 50%
 - (c) between 50% and 70%
 - (d) * over 70%
84. Mercury has an atmosphere that is
- (a) thicker and denser than Earth's atmosphere.
 - (b) about as thick and dense as Earth's atmosphere.
 - (c) somewhat less thick and less dense than Earth's atmosphere.
 - (d) * practically non-existent.
85. Among terrestrial planets, the one with the highest surface temperature is
- (a) Earth.
 - (b) Mars.
 - (c) Mercury.
 - (d) * Venus.
86. The deepest interior of the Earth is probed by
- (a) core sampling.
 - (b) exploring very deep mines.
 - (c) * detecting seismic waves.
 - (d) using X-rays, CT scans, and MRI scans.
 - (e) [None of the above.]
87. The cosmic microwave background radiation was first observed by
- (a) ancient astronomers.
 - (b) Tycho Brahe.
 - (c) Nicolas Copernicus.
 - (d) Isaac Newton.
 - (e) * [None of the above.]
88. The historical significance of Hubble's law is that it helped to establish the fact that
- (a) black holes have event horizons.
 - (b) Kepler's laws of planetary motion are also valid elsewhere in the Milky Way galaxy.
 - (c) both red shifts and blue shifts are possible in stellar spectra.
 - (d) * galaxies are generally moving away from each other.

89. If the average density of the universe is large enough, then the universe
- (a) will be able to kick sand in the faces of those other universes that have been bullying it in the past.
 - (b) will experience accelerated expansion.
 - (c) will expand indefinitely.
 - (d) * will eventually stop expanding and re-collapse into a highly compact state.
90. An observer on Earth will see more stars by looking
- (a) * within the plane of the Milky Way's disk.
 - (b) perpendicular to the plane of the Milky Way's disk.
 - (c) [The results are about the same for each direction.]
91. Short-period comets typically originate
- (a) in Ford factories of the 1960s.
 - (b) * in the Kuiper belt.
 - (c) in the Oort cloud.
 - (d) in the asteroid belt.
 - (e) in the large Magellanic cloud.
92. Long-period comets typically originate
- (a) in Ford factories of the 1960s.
 - (b) in the Kuiper belt.
 - (c) * in the Oort cloud.
 - (d) in the asteroid belt.
 - (e) in the large Magellanic cloud.
93. The atmosphere of Earth consists primarily of
- (a) carbon dioxide.
 - (b) * nitrogen.
 - (c) oxygen.
 - (d) sulphuric acid.
 - (e) [None of the above.]
94. When a star explodes into a supernova, its brightness
- (a) temporarily decreases dramatically.
 - (b) temporarily decreases slightly.
 - (c) temporarily increases slightly.
 - (d) * temporarily increases dramatically.

95. Two planets in the solar system were unknown to the ancients, and were discovered after the telescope was invented. These two planets are
- (a) Mercury and Pluto.
 - (b) Jupiter and Mercury.
 - (c) Saturn and Venus.
 - (d) * Neptune and Uranus.
 - (e) [None of the above.]
96. The greenhouse effect is a significant effect
- (a) only on the Earth.
 - (b) on all terrestrial planets.
 - (c) * on planets that have atmospheres.
 - (d) only on exoplanets.
97. A “shooting star” is
- (a) a Hollywood celebrity fired from a circus cannon.
 - (b) a corona discharge high in the atmosphere.
 - (c) * a meteor.
 - (d) a comet.
 - (e) [None of the above.]
98. Open clusters often consist of
- (a) * young, hot, luminous stars.
 - (b) young, cool, not very luminous stars.
 - (c) old, hot, luminous stars.
 - (d) old, cool, not very luminous stars.
 - (e) [None of the above.]
99. The source of the light emitted by a stable white dwarf is
- (a) nuclear fusion.
 - (b) nuclear fission.
 - (c) chemical reactions in its core.
 - (d) corona discharges.
 - (e) * [None of the above.]
100. More than _____ Earths could fit inside Jupiter.
- (a) * 1400
 - (b) 14 million
 - (c) 14 billion
 - (d) 14 trillion