BROCK UNIVERSITY

Final Exam: July 2017
Course: ASTR 1P02
Examination date: 7 July 2017
Time of Examination: 9:00 – 11:00 am

Number of pages: 18
Number of students: 346
Time limit: 2 hours
Instructor: S. D'Agostino

Answer all questions on the scantron 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 scantron sheet when you leave the exam room.

DO NOT WRITE YOUR ANSWERS ON YOUR QUESTION PAGE. DOING SO WILL RESULT IN AN ASSIGNED GRADE OF ZERO.

1. Main sequence stars are in hydrostatic equilibrium, which is a balance between gravitational forces and
   (a) equilibrium forces.
   (b) forces due to neutrino pressure.
   (c) * forces due to gas pressure.
   (d) forces due to electron degeneracy pressure.
   (e) [None of the above.]

2. In the outer layers of the Sun, the primary way energy is transported outwards is
   (a) conduction.
   (b) nuclear fission.
   (c) nuclear fusion.
   (d) radio waves.
   (e) * [None of the above.]

3. In the inner layers of the Sun, the primary way energy is transported outwards is
   (a) conduction.
   (b) nuclear fission.
   (c) nuclear fusion.
   (d) radio waves.
   (e) * [None of the above.]

4. The lower-left corner of the H-R diagram contains
   (a) hot stars that are very luminous.
   (b) * hot stars that are NOT very luminous.
   (c) cool stars that are very luminous.
   (d) cool stars that are NOT very luminous.
5. The lower-right corner of the H-R diagram contains
   (a) hot stars that are very luminous.
   (b) hot stars that are NOT very luminous.
   (c) cool stars that are very luminous.
   (d) * cool stars that are NOT very luminous.
6. The upper-left corner of the H-R diagram contains
   (a) * hot stars that are very luminous.
   (b) hot stars that are NOT very luminous.
   (c) cool stars that are very luminous.
   (d) cool stars that are NOT very luminous.
7. The upper-right corner of the H-R diagram contains
   (a) hot stars that are very luminous.
   (b) hot stars that are NOT very luminous.
   (c) * cool stars that are very luminous.
   (d) cool stars that are NOT very luminous.
8. While a star is in its protostar phase, its main source of energy is
   (a) electric potential energy as the plasma spirals down along magnetic field lines.
   (b) * gravitational potential energy as the protostar contracts.
   (c) nuclear fission.
   (d) nuclear fusion.
9. While a star is in its main-sequence phase, its main source of energy is
   (a) electric potential energy as the plasma spirals down along magnetic field lines.
   (b) gravitational potential energy as the protostar contracts.
   (c) nuclear fission.
   (d) * nuclear fusion.

10. The net result of a proton-proton chain reaction is that

    (a) two protons combine to produce a neutron and a neutrino with the release of radiant energy.

    (b) * four hydrogen nuclei combine to produce a helium nucleus with the release of neutrinos and radiant energy.

    (c) four hydrogen nuclei combine to produce protons with the release of neutrinos and radiant energy.

    (d) four protons combine to produce a hydrogen nucleus with the release of neutrinos and radiant energy.

11. Fusion reactions in a star's core increase in probability as the _____ of the star's core increases.

    (a) electric charge

    (b) magnetic field

    (c) electron degeneracy pressure

    (d) neutron degeneracy pressure

    (e) * [None of the above.]

12. Main-sequence stars with masses much greater than the Sun's mass primarily use _____ for their fusion reactions.

    (a) the proton-proton chain

    (b) * the CNO cycle

    (c) the Krebs cycle

    (d) the recumbent cycle

    (e) the SNO cycle

13. Main-sequence stars with masses of about the Sun's mass or less primarily use _____ for their fusion reactions.

    (a) * the proton-proton chain

    (b) the CNO cycle

    (c) the Krebs cycle

    (d) the recumbent cycle

    (e) the SNO cycle

14. Stars like the Sun do not develop iron cores during their lifetimes because

    (a) their atmospheres are not dense enough.

    (b) their magnetic fields are too strong.

    (c) * their cores are not hot enough.

    (d) [The Sun does indeed have an iron core.]

15. Chemical elements heavier than iron are/were formed

    (a) within the first few seconds after the Big Bang, when there was enough energy density to fuse lighter elements into heavier elements.

    (b) by nuclear fusion in the cores of very massive stars while they are on the main-sequence phase of their evolution.

    (c) in the cores of neutron stars.

    (d) * during supernova explosions.

16. Data collected over many years by the SNO in Sudbury, Ontario provided strong evidence for the standard theory of

    (a) the origin of the universe.

    (b) the evolution of the solar system.

    (c) * energy production in the Sun.

    (d) stellar nucleosynthesis.

    (e) giant supernovae explosions.

17. Astronomers distinguish between Type Ia supernovae and Type II supernovae by

    (a) measuring their brightnesses.

    (b) measuring their densities.

    (c) measuring their durations.

    (d) * detecting the absence or presence of hydrogen lines in their spectra.

18. The atomic nuclei of oxygen that we breathe were synthesized

    (a) by plants.

    (b) by UV radiation.

    (c) * by a star fusing lighter nuclei in its interior.

    (d) during the Era of Nuclei after the Big Bang.

19. As the mass of the iron core of a star increases, its diameter

    (a) increases.

    (b) * decreases.

    (c) [It might increase or decrease, depending on other factors.]

20. Astronomers determine the mass of a black hole by measuring

    (a) its Doppler shift.

    (b) its Schwarzschild radius.

    (c) the rate at which surrounding material falls into it.

    (d) * the orbital period and radius of a star or material orbiting the black hole.

21. The more massive a black hole is, the _____ is its Schwarzschild radius.

    (a) * larger.
    (b) smaller.
    (c) [It could be larger or smaller, depending on other factors.]

22. You observe a clock dropped towards a black hole from a high orbit, and notice that

    (a) * time on the clock runs slower as it approaches the black hole, and light emitted from the clock is increasingly redshifted.
    (b) time on the clock runs faster as it approaches the black hole, and light emitted from the clock is increasingly blueshifted.
    (c) [Either could occur, depending on factors not mentioned.]

23. When the core of a star begins to run out of hydrogen, the next stage in the star's evolution is that

    (a) the star's core expands and its outer layers contract.
    (b) * the star's core contracts and its outer layers expand.
    (c) the star explodes into a giant supernova.
    (d) the star fades away into a brown dwarf.

24. Helium fusion in the core of a red giant star produces

    (a) hydrogen and lithium.
    (b) iron and nickel.
    (c) sodium and potassium.
    (d) uranium and plutonium.
    (e) * [None of the above.]

25. A planetary nebula is a remnant of

    (a) a Type I supernova explosion.
    (b) a Type II supernova explosion.
    (c) the end-stage evolution of a high-mass star.
    (d) * the end-stage evolution of a medium-mass star.

26. When a star that has a mass of more than twenty solar masses leaves the main-sequence phase of its life, it will eventually become a

    (a) black hole.
    (b) neutron star.
    (c) * either a black hole or neutron star.
    (d) pulsar
    (e) white dwarf.

27. As a contracting protostar heats up, if the core temperature reaches 10 million degrees K, then

    (a) a planetary nebula is formed.
    (b) * hydrogen fusion begins and the protostar becomes a main-sequence star.
    (c) an event horizon is formed.
    (d) a naked singularity is formed.

28. Reflection nebulae are

    (a) * blue.
    (b) red.
    (c) white.
    (d) yellow.

29. Emission nebulae are

    (a) blue.
    (b) * red.
    (c) white.
    (d) yellow.

30. When the Sun leaves the main-sequence phase of its life, it will eventually become a

    (a) black hole.
    (b) neutron star.
    (c) either a black hole or neutron star.
    (d) pulsar
    (e) * white dwarf.

31. A binary pulsar

    (a) has two rotation axes.
    (b) emits pulses of radiation at two different frequencies.
    (c) has two distinct Reissner-Nordström ratios.
    (d) * closely orbits at least one other star.

32. If a collapsing star has a mass less than the Chandrasekhar limit, then it

    (a) fails to leave the main sequence.
    (b) eventually becomes a quasar.
    (c) * eventually becomes a white dwarf.
    (d) eventually becomes a neutron star or black hole.

33. White dwarfs typically have sizes that are approximately the size of

    (a) the Moon.
    (b) * the Earth.
    (c) Jupiter.
    (d) the Sun.

34. The surface temperature of a white dwarf is approximately

    (a) * tens of thousands of degrees.
    (b) hundreds of thousands of degrees.
    (c) millions of degrees.
    (d) tens of millions of degrees.

35. The remnant of a type II supernova is

    (a) * either a black hole or a neutron star.
    (b) either a brown dwarf or a red dwarf.
    (c) either a quasar or a T-Tauri star.
    (d) either a Herbig-Haro object or an Oort cloud.

36. 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.

37. In a type II supernova, most of the energy produced in the explosion is carried away by

    (a) conduction.
    (b) convection.
    (c) * neutrinos.
    (d) visible light photons.
    (e) X-rays.

38. A pulsar is a rotating

    (a) black hole.
    (b) * neutron star.
    (c) quasar.
    (d) white dwarf.
    (e) [None of the above.]

39. Precision measurements on binary pulsars have provided strong evidence for

    (a) * Einstein's theory of gravity.
    (b) Kepler's laws.
    (c) Newton's theory of gravity.
    (d) the Stefan-Boltzmann law.
    (e) Wien's law.

40. If the Sun were suddenly and magically replaced by a black hole of the same mass, then the planets in our solar system would

    (a) immediately be "vacuumed" into the black hole.
    (b) gradually spiral in and be consumed by the black hole.
    (c) escape the solar system by "flying off on tangents" to their orbits.
    (d) begin moving chaotically, much like the atoms in a cloud of gas.
    (e) * [No change in planetary motions would occur.]

41. The escape velocity from within the event horizon of a black hole is

    (a) less than the speed of light.
    (b) equal to the speed of light.
    (c) * greater than the speed of light.

42. It was first confirmed that separate galaxies existed outside our own Milky Way galaxy

    (a) by ancient Greek astronomers.
    (b) by medieval European astronomers.
    (c) in the 1700s.
    (d) * in the 1900s.
    (e) in the year 2005, using the Hubble Space Telescope.

43. With the aid of modern telescopes, the number of galaxies currently visible is in the

    (a) hundreds.
    (b) thousands.
    (c) millions.
    (d) * billions.

44. Spiral galaxies contain mostly

    (a) Population I stars and tend to be red.
    (b) * Population I stars and tend to be blue.
    (c) Population II stars and tend to be red.
    (d) Population II stars and tend to be blue.

45. Spiral 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.

46. The expansion of the space between galaxies has an effect on light travelling through space,

    (a) increasing its density.
    (b) decreasing its mass.
    (c) flattening its curvature.
    (d) * shifting its wavelength towards the red end of the spectrum.

47. Collisions between galaxies are much more common than collisions between individual stars because

    (a) galaxies move much faster than stars.
    (b) galaxies move much slower than stars.
    (c) * the distances between galaxies in a cluster are comparable to their sizes, but the distances between stars in a galaxy are much greater than their sizes.
    (d) [Collisions between stars are actually more common than collisions between galaxies.]

48. A quasar is

    (a) a super-giant star with an extremely blue-shifted spectrum.
    (b) * a powerful source of energy in the active core of a distant galaxy.
    (c) a very energetic anti-particle of a neutrino.
    (d) a very bright object that results when two stars collide.

49. Seyfert galaxies are _____ that have small, highly luminous nuclei.

    (a) irregular galaxies
    (b) elliptical galaxies
    (c) * spiral galaxies
    (d) [None of the others.]

50. The Higgs boson was first detected

    (a) by the WMAP satellite in 2005.
    (b) by the Planck satellite in 2007.
    (c) by the COBE satellite in 2009.
    (d) * by the LHC in 2012.

51. One of the predictions of Einstein's theory of general relativity is that light from distant stars should have its path bent by

    (a) refraction through interstellar glasses, ices, and crystals.
    (b) scattering from interstellar gas and dust.
    (c) destructive interference due to the Doppler effect from giant black holes.
    (d) * the gravitational effect of matter between us and the source of the light.

52. Data from the WMAP and Planck satellite observatories suggest that the the universe

    (a) is flat (overall).
    (b) has accelerating expansion.
    (c) will probably expand forever.
    (d) * [All of the above.]
    (e) [None of the above.]

53. In the first minute or so after the Big Bang, _____ could not exist because it was too hot.

    (a) * atomic nuclei beyond hydrogen.
    (b) protons.
    (c) neutrons.
    (d) electrons.

54. We know that the Milky Way galaxy has spiral arms by observing the distribution of

    (a) Type Ia supernovae.
    (b) Type II supernovae.
    (c) Population II stars.
    (d) * associations of hot and luminous young stars.

55. The amount of ordinary matter in the universe is currently thought to be _____ the amount of dark matter.

    (a) much greater than
    (b) about the same as
    (c) * much less than
    (d) [We currently have no idea about this.]

56. About _____ of the mass of the solar system is contained in the Sun.

    (a) 50%
    (b) 65%
    (c) 80%
    (d) * 99.9%

57. The diameter of the Sun is about _____ times the diameter of the Earth.

    (a) 10
    (b) * 100
    (c) 1,000
    (d) 10,000
    (e) 100,000

58. The solar nebula theory proposes that

    (a) * planets form in rotating disks of gas and dust around young stars.
    (b) the Sun will become a nebula after its red giant stage.
    (c) sunspots occur because the Sun sweeps up magnetic material from a cloud of gas and dust.
    (d) the solar wind interacts with the Oort cloud to produce the Kuiper belt.

59. The terrestrial planets are _____ the Jovian planets.

    (a) * less massive than
    (b) about as massive as
    (c) more massive than

60. The terrestrial planets are _____ the Jovian planets.

    (a) less dense than
    (b) about as dense as
    (c) * more dense than

61. The terrestrial planets are typically _____ than the Jovian planets.

    (a) * warmer
    (b) colder

62. The planet Venus has _____ moon(s).

    (a) * 0
    (b) 1
    (c) 2
    (d) 3
    (e) [None of the above.]

63. The planet _____ has dozens of moons.

    (a) Mercury
    (b) Mars
    (c) * Jupiter
    (d) Ceres
    (e) [None of the above.]

64. The ages of rocks found in the solar system are often determined by using the properties of

    (a) transversal bifurcations.
    (b) magnetic susceptibility.
    (c) nuclear magnetic resonance.
    (d) * radioactive elements.
    (e) [None of the above.]

65. The inner planets have a much higher concentration of _____ than the outer planets.

    (a) ammonia.
    (b) hydrogen.
    (c) * iron.
    (d) methane.

66. There is strong evidence that Venus was once geologically/volcanically active.

    (a) * True.
    (b) False.

67. The age of the planets is about

    (a) 50 million years.
    (b) 500 million years.
    (c) * 5 billion years.
    (d) 50 billion years.

68. Asteroids are

    (a) cars that were driven on the planet Mercury in the 1960s.
    (b) snowballs ejected from the underworld.
    (c) chunks of frozen gases with solid particles mixed in.
    (d) rocks that have broken off from planets.
    (e) * [None of the others.]

69. The process by which planetary material separates inside a planet is known as

    (a) accretion.
    (b) * differentiation.
    (c) integration.
    (d) sublimation.

70. Most of the craters in the solar system appear to have been formed about

    (a) 4 million years ago.
    (b) * 4 billion years ago.
    (c) 4 trillion years ago.
    (d) [None of the above.]

71. Small chunks of rock that leave a streak of light as they fly through Earth's atmosphere are called

    (a) meteorinos.
    (b) meteorites.
    (c) meteoroids.
    (d) * meteors.

72. Small chunks of rock that fly through the solar system are called

    (a) meteorinos.
    (b) meteorites.
    (c) * meteoroids.
    (d) meteors.

73. Small chunks of rock that have landed on Earth after coming from outer space are called

    (a) meteorinos.
    (b) * meteorites.
    (c) meteoroids.
    (d) meteors.

74. The Chicxulub crater is

    (a) one of the hottest new clubs in the Sector 8 Void.
    (b) one of the most prominent craters on the Moon.
    (c) one of the largest craters on Mars.
    (d) * a large crater on Earth that is associated with the extinction of the dinosaurs.
    (e) [None of the above.]

75. Mars has a higher albedo than Venus.

    (a) True.
    (b) * False.
    (c) [Neither Mars nor Venus have an albedo.]

76. The magnetic field of _____ is about 10 times stronger than Earth's magnetic field.

    (a) Mercury
    (b) Venus
    (c) Mars
    (d) * Jupiter
    (e) [None of the above.]

77. Jupiter's atmosphere is _____ Saturn's atmosphere.

    (a) * warmer than
    (b) about the same temperature as
    (c) cooler than

78. The largest mountain in the solar system is on the surface of

    (a) Mercury.
    (b) Venus.
    (c) Earth.
    (d) * Mars.
    (e) [None of the above.]

79. Gaps in the rings of Saturn are caused by

    (a) over-zealous interplanetary vacuum cleaners.
    (b) bombardment by meteors in the early days of the solar system.
    (c) * orbital resonances with some of Saturn's moons.
    (d) temperature variations above Saturn's magnetic field zone.
    (e) [None of the above.]

80. The mass of the Milky Way galaxy is determined by carefully measuring

    (a) * motions of the stars within the galaxy.
    (b) stellar spectra of stars in nearby galaxies.
    (c) parallaxes of stars in binary clusters.
    (d) entropies of nebulae in the Milky Way's disk.
    (e) [None of the above.]

81. The cosmological flatness problem is that

    (a) the Earth appears flat to observers on its surface.
    (b) the *Flat Earth Society* is propagating pseudo-scientific nonsense that the Earth is actually flat.
    (c) * the early universe must have contained a very precise amount of matter in order that space-time be very nearly flat.
    (d) the space-time in the vicinity of a Kerr black hole is much flatter than expected based on Einstein's theory of gravity.

82. In the Milky Way galaxy, star formation is most common

    (a) in the halo.
    (b) * in the spiral arms.
    (c) in the central bulge.
    (d) in the spaces of the disk between the spiral arms.
    (e) [None of the above.]

83. The fact that galaxies are generally moving away from each other is expressed by

    (a) * Hubble's law.
    (b) Kepler's second law.
    (c) Galileo's law.
    (d) Wien's law.

84. The following observed properties of cosmic microwave background radiation provide strong evidence for the Big Bang theory of the formation of the universe.

    (a) its mass and density
    (b) its pressure and volume
    (c) * its temperature and similarity in all directions
    (d) its tension and diameter

85. The cosmic microwave background radiation was first observed using

    (a) a gamma-ray telescope.
    (b) an optical telescope.
    (c) * a microwave antenna.
    (d) an X-ray observatory.
    (e) [None of the above.]

86. By the first few minutes after the Big Bang, the number of hydrogen atoms in the universe was greater than the number of helium atoms by a factor of about

    (a) * 3.
    (b) 30.
    (c) 300.
    (d) 3000.

87. The protons, neutrons, and electrons that make up the ordinary matter in our universe were formed _____ after the Big Bang.

    (a) * within the first few seconds
    (b) within the first few hours
    (c) within the first few days
    (d) within the first few years

88. 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.

89. If the average density of the universe is small enough, then the universe

    (a) will be able to take up gymnastics as a hobby.
    (b) will slow its expansion.
    (c) * will expand indefinitely.
    (d) will eventually stop expanding and re-collapse into a highly compact state.

90. Which mechanism is most responsible for generating the internal heat of Io that drives its volcanic activity?

    (a) bombardment by solar system debris.
    (b) * tidal heating.
    (c) radioactive decay.
    (d) [None of the above.]

91. Most asteroids are

    (a) nearly spherical conglomerations of rock, ice, gas, and dust.
    (b) * irregular in shape, and battered by impact cratering.
    (c) nearly spherical and battered by impact cratering.
    (d) irregular in shape, and are conglomerates of rock, ice, gas, and dust.

92. Asteroids and comets in our solar system

    (a) * have been studied extensively by numerous unmanned spacecraft that have flown close by them.

    (b) have never been studied by any spacecraft that have flown close by them, but have been studied by ground-based observatories.

93. Meteor showers on Earth occur when

    (a) meteor storm clouds loom.

    (b) the Earth is closest to the Kuiper belt.

    (c) the Earth is closest to the Oort cloud.

    (d) * the Earth passes near the orbit of a comet.

    (e) [None of the others.]

94. Greenhouse gases

    (a) transmit infrared light.

    (b) transmit visible light.

    (c) * reflect infrared light.

    (d) reflect visible light.

95. Which of these planets has the lowest atmospheric pressure at its surface?

    (a) Venus

    (b) Earth

    (c) * Mars

    (d) Jupiter

96. Which of the following is not a greenhouse gas?

    (a) carbon dioxide (CO_2)

    (b) methane (CH_4)

    (c) * nitrogen (N_2)

    (d) water vapour (H_2O)

    (e) [None of the above are greenhouse gases.]

97. A carbonaceous chondrite is a type of

    (a) nebula.

    (b) supernova.

    (c) * stony meteorite.

    (d) variable star.

98. The nucleus of a comet resembles

    (a) a harbinger of doom.
    (b) a muddy baseball.
    (c) a sticky tarball.
    (d) * a dirty snowball.

99. Most comets originate

    (a) in Ford factories of the 1960s if they have long periods and in used car lots if they have short periods.
    (b) * in the Kuiper belt if they have short periods and in the Oort cloud if they have long periods.
    (c) in the Kuiper belt if they have long periods and in the Oort cloud if they have short periods.
    (d) in the Bermuda triangle if they have short periods and in the Costa del Sol if they have long periods.

100. Concerning planets orbiting other stars besides our Sun,

    (a) none have ever been observed, and there is no evidence for them yet.
    (b) * many have been observed, and research is ongoing.
    (c) there is indirect evidence for them, but there have been no definitive discoveries yet.