Name:

1 pt Which is Newton's Second Law? (All are correct equations; use these equations for reference.)

1. **A**◯Ω=PE/KE
B◯F=ma
C◯v=HD
D◯KE=3/2kT, where T is temperature.
E◯$P^2=R^3$, where P is in years and R is in AU.
F◯KE=1/2 m v^2, where v is the speed
G◯$v^2>2GM_{planet}/R_{planet}$, where v is the speed.
H◯$R=2.5R_{planet}$.
I◯$M=R^3/P^2$, where where P is in years and R is in AU.
J◯$F=GMm/R^2$

---

1 pt Suppose it is full moon, as seen from Earth. How would Earth appear to someone on the Moon at this time?

2. **A**◯Half the side of Earth facing the Moon is bright, and half of it is dark.
B◯The illumination of Earth does not change, as viewed from the Moon.
C◯The side of Earth facing the Moon is completely dark.
D◯The side of Earth facing the moon is completely bright.

---

1 pt The mass of Jupiter can be calculated from observations by

3. **A**◯measuring the orbital period of a moon and the distance between it and Jupiter.
B◯measuring the orbital speed of one of Jupiter's moons.
C◯knowing the Sun's mass and measuring how Jupiter's speed changes during its elliptical orbit around the Sun.
D◯knowing the Sun's mass and measuring the average distance of Jupiter from the Sun.
E◯measuring the orbital period and distance of Jupiter's orbit around the Sun.

---

1 pt Suppose you drop a 10-pound weight and a 5-pound weight on the Moon, both from the same height at the same time. What will happen?

4. **A**◯The 5-pound weight will hit the ground before the 10-pound weight.
B◯Both weights will float freely, since everything is weightless on the Moon.
C◯Both will hit the ground at the same time.
D◯The 10-pound weight will hit the ground before the 5-pound weight.

---

1 pt Suppose the Sun were to suddenly shrink in size but its mass remained the same. According to the law of conservation of angular momentum, what would happen?

5. **A**◯The Sun would rotate faster than it does now.
B◯The Sun's angular size in our sky would stay the same.
C◯The Sun's rate of rotation would slow.
D◯This could never happen, because it is impossible for an object to shrink in size without an outside torque.

---

1 pt If the Sun were replaced by a black hole of the same mass,

6. **A**◯Earth will gradually spiral in toward the black hole.
B◯Earth will quickly get sucked into the black hole.
C◯Earth's orbit will remain the same.
D◯Earth will be thrown out into interstellar space.

---

1 pt How long does it take Earth to complete one orbit around the Sun?

7. **A**◯three months
B◯one year
C◯one week
D◯one day
E◯one month

---

1 pt The energy of levels 1-4 of hydrogen are 0, 10.2, 12.1, and 12.8 electron volts (eV), respectively. If the hydrogen is ionized, the electrons are

8. **A**◯in level 4.
B◯in level 3.
C◯in level 2.
D◯in level 1.
E◯not in levels 1-4.

$\boxed{1\ pt}$ The energy of levels 1-4 of hydrogen are 0, 10.2, 12.1, and 12.8 electron volts (eV), respectively. An electron absorbs 1.9 eV. The electron jumps from

9. **A**◯level 4 to 2.
B◯level 3 to 2.
C◯level 2 to 4.
D◯level 2 to 3.

$\boxed{1\ pt}$ X proposed the sun-centered solar system. Y made accurate observations of the planets. Z analyzed the observations of the planets. In order, X, Y, and Z are

10. **A**◯Tycho, Kepler, & Copernicus.
B◯Copernicus, Kepler, & Tycho.
C◯Copernicus, Tycho, & Kepler.
D◯Kepler, Tycho, & Copernicus.
E◯Kepler, Copernicus, & Tycho.
F◯Tycho, Copernicus, & Kepler.

$\boxed{1\ pt}$ Thermal radiation is

11. **A**◯radiation produced by a hot object.
B◯radiation that depends only on the temperature and emissivity of the emitting object.
C◯radiation that is felt as heat.
D◯radiation in the infrared part of the spectrum.

$\boxed{1\ pt}$ The Earth is accelerating primarily because

12. **A**◯it is slowing down.
B◯its direction is changing.
C◯The earth is not accelerating.
D◯it is speeding up.

$\boxed{1\ pt}$ S1: The speed of the Earth in its orbit is greater than the speed of Saturn. S2: The speed of the Earth in January is greater than in July. Kepler's Law of Equal Areas helps explain

13. **A**◯both S1 and S2.
B◯S2 only.
C◯S1 only.
D◯neither S1 nor S2.

$\boxed{1\ pt}$ Moons of Jupiter, the rings of Saturn, and the phases of Venus: which of these did Galileo not discover?

14. **A**◯Rings of Saturn
B◯Galileo discovered all of them.
C◯Phases of Venus
D◯Moons of Jupiter

$\boxed{1\ pt}$ Which is one of the large moons of Jupiter?

15. **A**◯Charon
B◯Deimos
C◯Ganymede
D◯Titan
E◯Phobos

$\boxed{1\ pt}$ The planet that is fifth closest to the sun is

16. **A**◯Earth.
B◯Jupiter.
C◯Saturn.
D◯Mars
E◯Venus.

$\boxed{1\ pt}$ Why does the tail of a comet point away from the sun?

17. **A**◯Gas from the comet, heated by the sun, pushes the tail away from the sun.
B◯The solar wind blows gas and dust away from the sun.
C◯Conservation of angular momentum keeps the tail pointing away.
D◯The magnetic field of the sun keeps the tail pointing away.

$\boxed{1\ pt}$ Why can the material in the rings of Saturn not collect to form moons?

18. **A**◯The gravity of Saturn tears moons apart.
B◯The rings are not made of sticky material.
C◯There is not enough material.
D◯The rings are too thin.

$\boxed{1\ pt}$ Astronomers believe that Mars had liquid water in the past because

19. **A**◯photographs show dry riverbeds.
B◯the space probe Odyssey found water ice.
C◯photographs show smooth rocks.
D◯microscopic fossils were found.

1 pt What is the source of the energy that heats Io, a moon of Jupiter?

20. **A**◯Radioactivity.
B◯Solar energy.
C◯Motion of the moons.
D◯Infrared radiation from Jupiter.

---

1 pt The space probe Odyssey found that the in regions north and south of 60 degrees latitude the surface is 50% water ice by volume. How is it that Odyssey was able to detect this water?

21. **A**◯The density of the surface was greater where there is no water.
B◯The Odyssey sent a surface probe down to collect samples.
C◯The temperature of the surface is cooler where there was so much ice.
D◯The energy of the neutrons coming off the surface of the planet is lower where there is water.
E◯The color of the surface is different where there is water.

---

1 pt The planets near the sun have a high density because

22. **A**◯the sun evaporated the lighter materials.
B◯the lighter materials escaped the planets gravity.
C◯the lighter materials could not condense because the proto planet fell too far and became too hot.
D◯the sun prevented the lighter materials from condensing.

---

1 pt Consider this hypothetical discovery of a new planet beyond the orbit of Pluto. S1: Its density is 5 times the density of water. S2: It has many craters. __ would require revising theories about planet formation.

23. **A**◯S2
B◯Neither S1 nor S2
C◯S1
D◯Both S1 & S2

---

1 pt The carbon in my hand was made in

24. **A**◯a comet.
B◯the center of the sun.
C◯some other star.
D◯the photosphere of the sun.

---

1 pt In addition to the losses in the solar wind, the sun loses 5 million tons of mass every second. How can you capture some of that mass?

25. **A**◯Get some hydrogen from the sun.
B◯That mass cannot be captured.
C◯Absorb some sun light.
D◯Get some helium from the sun.

---

1 pt Compared to a main sequence star of spectral class A, a main sequence star of spectral class F is

26. **A**◯cooler and more massive.
B◯hotter and less massive.
C◯cooler and less massive.
D◯hotter and more massive.

---

1 pt In which of these stages does the sun spend the longest time?

27. **A**◯Main sequence.
B◯Giant.
C◯White dwarf.
D◯Planetary nebula.

---

1 pt Has the sun ever been or will be a star like Vega, an A main-sequence star? Same question for Aldebaran, a K giant?

28. **A**◯Yes for Vega. Yes for Aldebaran.
B◯No for Vega. Yes for Aldebaran.
C◯Yes for Vega. No for Aldebaran.
D◯No for Vega. No for Aldebaran.

---

1 pt If a giant hand moved Vega twice as far as it is, it moves (1) down and (2) right on the HR diagram. True or false?

29. **A**◯TF
B◯FF
C◯TT
D◯FT

1 pt A star cluster has A, M, F, G, and K main-sequence stars and K and M giants. After a few billion years, a single type of star will be gone. What type will be gone?

30. **A**◯M giants
B◯M dwarfs
C◯G dwarfs
D◯F dwarfs
E◯K giants
F◯A dwarfs

1 pt In a degenerate gas, the pressure increases if (1) the temperature increases, (2) if the space for the gas decreases. Clauses (1) and (2) are

31. **A**◯TT
B◯FF
C◯TF
D◯FT

1 pt At some time after the main-sequence phase, 1) the sun burns helium, 2) it burns hydrogen, and 3) it burns carbon. Clauses 1, 2, and 3 are

32. **A**◯FFT
B◯TFF
C◯FFF
D◯FTF
E◯TFT
F◯TTT
G◯TTF
H◯FTT

1 pt Suppose the temperature of star A and star B are the same. The flux of Star A is 100 times less than that of star B. Which answer is always true?

33. **A**◯Star A is smaller.
B◯Star A is closer.
C◯Star A is bigger.
D◯Star A is farther away.
E◯None of the other answers is always true.

1 pt S1: The sun has been burning hydrogen for about 5 billion years. S2: It will use up its hydrogen in about 5 billion years. Statements S1 and S2 are

34. **A**◯FF
B◯TF
C◯FT
D◯TT

1 pt The disk of the Milky Way appears in the sky as

35. **A**◯The disk is invisible to the naked eye.
B◯a fuzzy cloud in the constellation Orion.
C◯a fuzzy cloud in the constellation Virgo.
D◯a band of light that goes all of the way across the sky.

1 pt Most of the stars in the halo of the Milky Way are

36. **A**◯very young.
B◯found inside molecular clouds.
C◯blue in color.
D◯very old.

1 pt Consider this hypothetical discovery: A new star is found. It is an O star, and its orbit is highly elliptical. This star is part of

37. **A**◯the globular star system.
B◯the bulge.
C◯the disk.
D◯Unable to answer. The evidence is contradictory.
E◯the halo.

1 pt Which type of galaxies has no young stars?

38. **A**◯Spiral
B◯Barred spiral
C◯Elliptical
D◯Irregular

1 pt Why do we believe that most of the mass of galaxies is in the form of dark matter?

39. **A**◯The high orbital speed of stars means the stars feel the gravity of something besides the stars and gas.
B◯We can see dark blotches in galaxies.
C◯We can see the dark matter at radio wavelengths.
D◯Theoretical models suggest that galaxies cannot form unless they have dark matter.

1 pt Penzias & Wilson observed radiation that was isotropic. S1: As viewed from Earth, the radiation from the Milky Way Galaxy is isotropic. S2: As viewed from Earth, the radiation from the Big Bang is isotropic. Statements 1 and 2 are

40. **A**◯FT.
B◯TF.
C◯FF.
D◯TT.

---

1 pt A 2-liter bottle of the universe has 0.8 million photons. How many photons were in a 1/4-liter bottle back when the universe was half the present size (when distance between two galaxies was half of the present distances)?

41. **A**◯0.8 Million
B◯3 Million
C◯6 Million
D◯1.6 Million

---

1 pt A 2-liter bottle of the universe has 3x10^{-34} kg of photons. How much mass in the form of light was there in a 1/4-liter bottle back when the universe was half the present size?

42. **A**◯6x10^{-34} kg
B◯18x10^{-34} kg
C◯3x10^{-34} kg
D◯12x10^{-34} kg
E◯24x10^{-34} kg

---

1 pt The mass of the black hole in M87 is ___ times the mass of the sun.

43. **A**◯3 billion
B◯15
C◯3 million
D◯3,000

---

1 pt A star orbits the black hole in the center of the Milky Way. Its period is 10 years and the distance between it and the black hole is 1,000 AU. The mass of the black hole is ___ times the mass of the sun. (The numbers are chosen to make the calculation easier; they do not represent the actual case.)

44. **A**◯10,000,000
B◯1,000,000
C◯10,000
D◯100

---

1 pt Simplicio says, "Material falling toward a black hole cannot be seen." An example that contradicts Simplicio's statement is

45. **A**◯the radio source Cygnus A.
B◯the Orion nebula.
C◯Sirius B.
D◯supernova 1987A.

---

1 pt In an average 200,000-km sphere (same size as moon's orbit), there is

46. **A**◯3 lb of dark energy, 1 lb of dark matter, and 3 oz of ordinary matter.
B◯3 lb of ordinary matter, 1 lb of dark matter, and 3 oz of dark energy.
C◯3 lb of dark matter, 1 lb of dark energy, and 3 oz of ordinary matter.
D◯3 lb of radiation.
E◯3 lb of ordinary matter, 1 lb of dark energy, and 3 oz of dark matter.

---

1 pt You and I are made of

47. **A**◯dark matter.
B◯dark energy/ cosmological constant.
C◯light.
D◯ordinary matter.

---

1 pt Decoupling occurs at a temperature of 3000 K. At that time, what was the distance between the two blobs that eventually became the Milky Way and a galaxy now 100 Mly away?

48. **A**◯100 Mly
B◯1000 Mly
C◯10 Mly
D◯1 Mly
E◯0.1 Mly

---

1 pt A supernova emitted some light when the scale of the universe was 0.6. Temperature fluctuations are imprinted on the cosmic background radiation. In a universe with more mass, the supernova is ___, and the fluctuations appear at ___ angles in the sky.

49. **A**◯fainter & larger
B◯brighter & larger
C◯brighter & smaller
D◯fainter & smaller

1 pt Newton and Einstein disagreed on the source of gravity. Einstein said that in addition to mass, ___ causes gravity.

50. **A**◯gas
B◯pressure
C◯dark matter
D◯radiation

1 pt The WMAP satellite measured

51. **A**◯flares on the sun.
B◯the temperature and polarization of the cosmic background radiation over the entire sky.
C◯the distribution of galaxies.
D◯the distribution of ice on Mars.

1 pt The first stars and galaxies formed ___ after the Big Bang.

52. **A**◯4.5 Byr
B◯300 Myr
C◯3 min
D◯0.001 s
E◯13.7 Byr

1 pt What evidence is from the formation of the first stars and galaxies?

53. **A**◯The distribution of galaxies.
B◯Polarization of the cosmic background radiation.
C◯The abundance of helium.
D◯The abundance of lithium.

1 pt What is evidence that the sun was not one of the first stars to form?

54. **A**◯Presence of helium in the sun.
B◯Presence of iron in the sun.
C◯Jovian planets.
D◯The solar wind.
E◯Presence of hydrogen in the sun.

1 pt D1 is the distance between Jupiter and the sun. D2 is the distance between the center of the Milky Way and the Large Magellanic Cloud, a satellite galaxy. D3 is the distance between the Milky Way and Hoag's Galaxy, a distant galaxy. Do distances D1, D2, and D3 expand in step with the expansion of the universe?

55. **A**◯NYN
B◯NNY
C◯YNN
D◯NYY
E◯YYN
F◯NNN
G◯YNY
H◯YYY

1 pt What is the source of energy in a quasar?

56. **A**◯Conversion of potential energy into kinetic energy when material falls towards the black hole.
B◯Burning hydrogen
C◯Burning helium
D◯Burning carbon

1 pt A quasar is

57. **A**◯the extremely bright center of a distant galaxy.
B◯a starlike object that is actually a gas cloud in the Milky Way Galaxy.
C◯a specialized instrument for observing stars
D◯a very large galaxy thought to be formed by the merger of two galaxies.

1 pt If Hubble's constant (H in v=HD) has the same sign but a different value,

58. **A**◯the universe would not be expanding.
B◯the age of the sun would be different.
C◯galaxies at the same distance would be moving faster or slower.
D◯there would not be a Big Bang.

1 pt The sun's location in the Milky Way Galaxy is

59. **A**◯in the halo.
B◯very near the center.
C◯in the disk, roughly halfway between the center and outer edge of the disk.
D◯in the globular star system.

1 pt For a black hole having the same mass as the sun, the Schwarzschild radius (the radius within which nothing can escape) is the size of

60. **A**◯the Earth
B◯East Lansing
C◯a large shopping mall
D◯Michigan

---

1 pt Astronomers showed that there is a massive black hole in the center of the galaxy M87 by

61. **A**◯measuring the distance to M87.
B◯measuring the speed of ejected material.
C◯measuring the speed and location of stars in orbit.
D◯observing the luminosity of the nucleus.

---

1 pt Hoag's Galaxy is 3 times as far as the Coma Cluster of galxies. Will this still be true in the future? Was this true in the past?

62. **A**◯NN
B◯YY
C◯NY
D◯YN

---

1 pt The Coma Cluster of galaxies is moving away from us at 6000 km/s. When the universe was half as old, Coma was moving from us with about

63. **A**◯4 times the speed.
B◯the same speed.
C◯half the speed.
D◯twice the speed.

---

1 pt A time machine takes you to 200,000 years after the Big Bang. This is before decoupling. You cannot see very far (only a light year) because

64. **A**◯light has not had time to travel far, since the universe is not very old.
B◯light travels a short distance and scatters off of electrons.
C◯radio waves are very blurred.
D◯there are many free neutrons.

---

1 pt A time machine takes you back in time, and you collect many samples of the universe. The samples contains hydrogen, helium, and no other elements. The time machine took you to ___ after the Big Bang.

65. **A**◯1 minute
B◯1 billion years
C◯1 thousand years
D◯1 second
E◯More than one answer is possible.

---

1 pt Why is there much more helium than oxygen in the sun?

66. **A**◯The sun makes helium.
B◯Lots of helium was made in the Big Bang.
C◯Generations of stars all make helium.
D◯The oxygen collected in the planets.
