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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:

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

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

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

$$P^2 = a^3$$

$$d = vt$$

$$F = ma$$

$$F = GM_1M_2/R^2$$

density = mass/volume

Astronomical Unit: 1AU = 1.5×10^8 km

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

Mass of the Earth = 5.974×10^{24} kg

Earth's Radius = 6.378×10^6 m

Acceleration of gravity on Earth is approximately equal to 10 m/s²

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

1. Which of the following objects rotates the most quickly around its own axis?
 - A) Earth.
 - B) Venus.
 - C) Jupiter.
 - D) The Earth's Moon.

2. A person orbiting the Earth in the Space Shuttle feels weightless because
 - A) her mass is zero in space, and weight requires mass.
 - B) no forces act on her.
 - C) only one force (gravity) acts on her, but gravity also accelerates the Shuttle so the Shuttle does not push up on her to create the feeling of weight.
 - D) two forces are acting on her in opposite directions, so they cancel and produce the same effect as if no force at all were acting.

3. If the line joining a planet to the Sun sweeps out a particular area in one day, then in two days it will sweep out
 - A) exactly twice the area.
 - B) less than twice the area if the planet is approaching perihelion and more than twice the area if it is leaving perihelion.
 - C) half the area.
 - D) more than twice the area if the planet is approaching perihelion and less than twice the area if it is leaving perihelion.

4. Most surface rocks on the Earth are younger than a few million years old, whereas ages of lunar rocks have been measured in billions of years. Why is this?
 - A) Most early surface rocks on Earth have been washed into the sea by weathering and rainwater; this does not happen on the Moon.
 - B) The ages of Earth and Moon are fundamentally different, the Moon being an old object captured from space by a younger Earth.
 - C) Much of the Earth's surface is continually recycled (created and subducted) by the underlying mantle because of plate tectonic activity; this does not occur on the Moon.
 - D) The complete surface of the Earth has been covered periodically by younger material from intense volcanic eruptions in the last few million years; no such activity occurred on the Moon.

5. Tomorrow's weather report for Venus would be
 - A) cold and clear.
 - B) hot and humid, with clear skies.
 - C) overcast and very hot.
 - D) snow.

6. What was the declination (angle from the celestial equator) of the Sun on March 21 this year?
 - A) 180° .
 - B) It would have no unique value but could be any angle between $+23.5^\circ$ and -23.5° .
 - C) 23.5° .
 - D) 0° .

7. The acceleration of a body is defined as its rate of change of
- A) velocity.
 - B) mass.
 - C) weight.
 - D) position.
8. The average density of the large, outer planets is
- A) very much less than the density of water, because of the amount of hydrogen that they contain.
 - B) close to the density of basaltic rocks on Earth.
 - C) much higher than the density of Earth rocks, due to the great gravitational compression of their interiors.
 - D) close to the density of water.
9. If an astronaut landed on a planet of half the radius as the Earth but four times the mass, then the astronaut's weight on the planet would be
- A) half of her weight on the Earth.
 - B) twice her weight on the Earth
 - C) eight times her weight on the Earth.
 - D) sixteen times her weight on the Earth.
10. A meteoroid is the name used to describe a solid particle that
- A) originated on the Moon, but was knocked onto the Earth by a massive impact.
 - B) is drifting around in space.
 - C) has fallen to Earth from space.
 - D) burns up as it falls through the Earth's atmosphere.
11. To what does "planetary differentiation" refer?
- A) The sinking of heavier elements toward the center of a planet and the floating of lighter elements toward the surface.
 - B) The circulation of iron in the core of a planet, resulting in the generation of a magnetic field.
 - C) The formation of rocky planets in the hotter, inner solar system and gas giants in the colder, outer regions.
 - D) The large-scale convection of molten rock in the mantle of a planet, which on the Earth causes continental drift.
12. In searches for planets orbiting stars other than the Sun, what is the astrometric method?
- A) Searching for tiny wobbles in the positions of absorption lines in the star's spectrum, caused by radial velocity variations of the star due to a planet orbiting around it.
 - B) Searching for tiny "bumps" on images of the star, due to the light from a planet located close to the star.
 - C) Searching for tiny displacements of the infrared image of a star compared to its optical image, caused by the presence of planets that are cool and emit primarily in the infrared.
 - D) Searching for tiny wobbles in the position of the star due to the gravitational pull of a planet orbiting around it.
13. **BONUS:** The asteroid Ceres has $1/8100$ th the mass of the Earth and $1/14$ th the radius. If a rock, with mass of 1000 kg on the Earth, was placed on Ceres, which of the following would be closest to the rock's weight on Ceres?
- A) 240 N
 - B) 2400 N
 - C) 1000 N, since the mass doesn't change
 - D) 24 N

14. Why did the Soviet spacecraft only survive for a few minutes on the Venus surface?
- A) They were attacked and destroyed by native inhabitants, but the space agency is not telling the world of this.
 - B) The conditions of extreme pressure, corrosive atmosphere, and high temperatures severely damaged it.
 - C) They landed very fast because there was insufficient atmosphere to slow down their descent.
 - D) They landed in very rugged terrain and were not able to land upright, and became damaged when they toppled over.
15. A trampoline jumper weighing 158 pounds has just jumped up and is doing a back flip before starting to descend back toward the trampoline. How much force does the jumper exert on the Earth at the highest point of the jump?
- A) Much less than 158 pounds (but more than zero), because the jumper has so much less mass than the Earth.
 - B) 158 pounds.
 - C) Zero.
 - D) Much more than 158 pounds, because the Earth is so much more massive than the jumper.
16. Why is the surface of Venus hotter than that of Mercury, even though Mercury is much closer to the Sun?
- A) Because the thick CO₂ atmosphere has prevented re-emission into space of the heat absorbed from sunlight.
 - B) Because Venus rotates rapidly and this ensures that all of its surface is being heated regularly and uniformly.
 - C) Because of continuous volcanic activity and the release of hot lava onto the surface.
 - D) Because chemical reactions within the thick clouds and dense atmosphere are continuously supplying heat to the surface.
17. The reason why Ptolemy's geocentric theory was preferred to Copernicus' heliocentric theory before Kepler and Galileo is that
- A) the heliocentric theory was obviously incorrect from watching the Sun move.
 - B) the geocentric theory accounted for the same observed motions of the planets as the heliocentric theory, but better fit into the philosophy of the time.
 - C) the heliocentric theory used complex constructions called epicycles and deferents to account for the observed motions of the planets, and so was considered more reliable than the geocentric theory.
 - D) the geocentric theory accounted for retrograde motion, which the heliocentric theory was unable to explain.
18. Most asteroids
- A) have irregular shape and are covered with very light-colored dust, reflecting sunlight well.
 - B) are spherical and ice-coated, and hence are light-colored and shiny.
 - C) are dark, irregular in shape, and heavily cratered.
 - D) are dark and spherical in shape, with many craters on their surfaces.
19. In class, Leslie used a water balloon to illustrate
- A) The conservation of momentum-- spinning made it faster
 - B) The Earth's tides-- it went from spherical to stretched-out
 - C) The effect of gravity-- they both fell at the same rate.
 - D) The escape velocity of the Earth-- it fell back to the ground

20. What characteristic of Jupiter's satellite, Io, makes it different from any other known satellite in the solar system?
- A) It has geyser-like plumes of nitrogen gas.
 - B) It has a permanent, dense atmosphere.
 - C) Its surface is broken into heavily cratered and lightly cratered regions in a pattern similar to plate tectonics.
 - D) It is volcanically active, with gas plumes and lava flows.
21. Evidence of lava flow, either recent or ancient, is NOT found on
- A) Earth.
 - B) Earth's Moon.
 - C) Mars.
 - D) Jupiter.
22. On the Moon, where gravity is 1/6 of that upon Earth, which of the following activities would an astronaut NOT find easier to carry out?
- A) Running.
 - B) Long jumping.
 - C) Slowing down and stopping.
 - D) High jumping.
23. Which of the planets fits the following description: "Cool, solid surface with an atmosphere of N₂ and O₂, and H₂O clouds"?
- A) Mercury.
 - B) Venus.
 - C) Earth.
 - D) Mars.
24. How is water ice able to remain on the surface of Mercury, despite the planet's close proximity to the Sun?
- A) It exists as permafrost below the thermally insulating surface, being exposed only by occasional impacts.
 - B) It is continuously replenished by condensation of water vapor from volcanoes.
 - C) It is permanently shielded from the Sun by crater walls at the north and south poles.
 - D) It is continuously replenished by fresh impacts from comets.
25. The expected seasonal changes on Uranus because of its orbital and spin-axis alignments, compared to those on Earth, will be
- A) absent, because of the alignment of the spin axis.
 - B) much less.
 - C) the same.
 - D) very much exaggerated.
26. The physical structure of Saturn's rings is
- A) hot, ionized gas from the planet's magnetosphere.
 - B) a thin solid ring, structured from ice and rock.
 - C) a thin but extensive gas cloud over the equator.
 - D) a sequence of many hundred separate ringlets, consisting of ice blocks and ice-coated rock.

27. The appearance of the entire surface of the Moon could be described as
- A) mostly craters on the near side, extensive maria with few craters on the far side.
 - B) uniform distribution of surface features, including maria and craters.
 - C) maria only on the near side, no major maria on the far side.
 - D) dry, waterless terrain in the near side, ice sheets on the dark side.
28. According to modern theories, the most significant difference between the formation of the terrestrial and the large, outer planets is that
- A) both formed by accretion of rocky and icy planetesimals, but the terrestrial planets were close enough to the Sun that almost all of the ices escaped back to space after the planets formed.
 - B) the terrestrial planets formed by accretion of planetesimals, whereas the outer planets formed by direct condensation of gas from the solar nebula.
 - C) both formed by accretion of planetesimals but the outer planets became massive enough to also pull gas onto them directly from the solar nebula.
 - D) the terrestrial planets formed close to the Sun where there was an abundance of rock but no ice, whereas the outer planets formed far from the Sun where there was an abundance of hydrogen and ice but no rocky material.
29. I have a massive purple object in my laboratory. If I were to take it to the Moon, which of its characteristics will be guaranteed to change?
- A) Density (mass per unit volume).
 - B) Mass.
 - C) Color.
 - D) Weight.
30. The birthplace of the Sun and planets (and of other stars and maybe their planets) is thought to have been
- A) at the centers of supernova explosions.
 - B) in black holes dotted about the universe.
 - C) in the centers of galaxies.
 - D) in cool gas and dust clouds.
31. **BONUS:** The near side and far side of the Moon receive equal amounts of sunlight when the moon has which phase?
- A) new
 - B) 1st or 3rd quarter
 - C) waxing or waning crescent
 - D) full
 - E) the far side of the Moon is never illuminated
32. The earth's atmosphere contains carbon dioxide (CO₂), which is not lost to space at the Earth's present orbit. If in a future industrial accident, the Earth were moved closer to the Sun, but retained the same mass and radius of rocky material, would the CO₂ be lost to space?
- A) depends on how close to the Sun the Earth was moved.
 - B) depends on how many meteors hit the Earth.
 - C) no
 - D) yes

33. Which spacecraft was the most recent to reach Jupiter?
- A) Galileo.
 - B) Cassini.
 - C) Voyager 2.
 - D) Hubble Space telescope.
34. The Moon is setting at 2:00 am. What is the phase of the Moon?
- A) Waning crescent
 - B) Waxing gibbous
 - C) Waxing crescent
 - D) Waning gibbous
35. In a single photograph of a comet and its tail, the only direction that one can determine with certainty is
- A) the direction away from the Sun, because the tail is pushed in this direction by the solar wind.
 - B) the direction in which the comet is moving, from the trailing tail.
 - C) the direction toward Jupiter, because the gravity of this giant planet pulls the tail material toward it.
 - D) the direction toward the Sun indicated by the tail direction, because gas and dust in the tail are attracted toward the Sun by its gravity.
36. Which of the following signs of water is NOT seen on Mars?
- A) Water ice (as opposed to CO₂ ice) in the polar caps.
 - B) Occasional clouds around the large volcanoes.
 - C) Meltwater pools at the edges of the polar caps.
 - D) Evidence of permafrost under the Martian surface.
37. The overall interior structure of the Jovian planets is expected to be
- A) four-layered: a rocky core, a semi-fluid ice layer, a liquid mantle of hydrogen, and a gaseous hydrogen and helium atmosphere.
 - B) four-layered: a solid inner core, a liquid iron outer core, a semi-fluid rocky mantle, and a solid crust.
 - C) three-layered: a rocky core covered by liquid metallic hydrogen and a thin gaseous hydrogen/helium atmosphere.
 - D) two-layered: a large, solid, rocky core surrounded by an extensive gaseous atmosphere.
38. When Neil Armstrong walked on the Moon, he did not float away. Why?
- A) The Moon does have gravity, and Neil's weight there was the same as on Earth.
 - B) The Moon does have gravity, though Neil's weight there was less than on Earth.
 - C) The Moon has no gravity, but Neil wore magnetic boots.
 - D) The Moon has no gravity, but Neil wore heavy boots.
39. Over the duration of a given night in Urbana, some stars will be observed to NOT pass through (from one side to the other of)
- A) the zenith
 - B) the celestial equator
 - C) the horizon
 - D) a point exactly South and up by 40 degrees (the Latitude of Urbana)

- 40.** If the mass of the Sun were doubled, the gravitational force on Jupiter due to the Sun would
- A)** be twice its present value.
 - B)** be 16 times its present value.
 - C)** stay the same.
 - D)** be 4 times its present value.
- 41.** If the Earth's spin axis were to be perpendicular to the plane of its orbit (the ecliptic), seasonal variations on the Earth would
- A)** be much more severe.
 - B)** be nonexistent.
 - C)** remain the same as they are at present.
 - D)** have the same severity but each season would last twice as long.
- 42.** As an observer moves toward increasing latitude, the number of circumpolar stars
- A)** increases.
 - B)** decreases.
 - C)** increases if the location of the observer is east of the Greenwich Meridian but decreases if the location is west of this meridian.
 - D)** remains approximately constant.

Answer Key—Test D

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