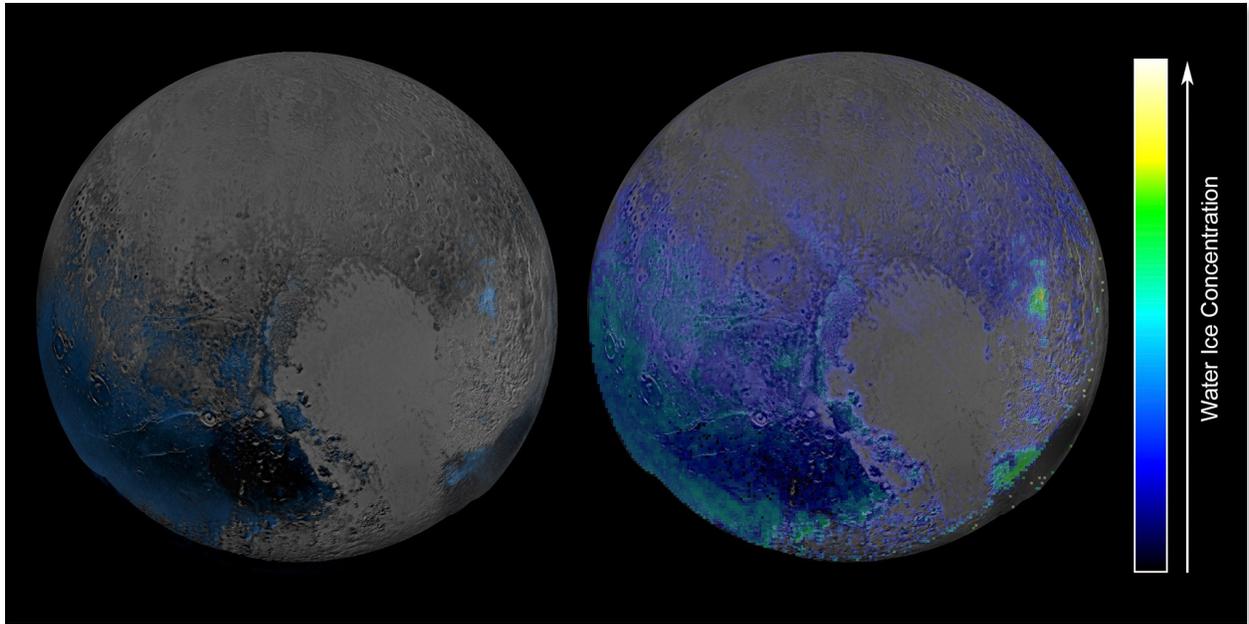


SOLAR SYSTEM 2019

SAMPLE EXAM



Team Name: _____

Team #: _____

- No calculators are allowed.
- All questions are of equal weight unless otherwise noted.
- Turn in all materials when you have completed the test!
- Make sure to write your **team name** and **team number** at the top of both answer sheets.

Good Luck!

For questions #1 – 42, refer to Image Sheet A.

1. Images J and M show craters on which object?
2. The crater in image M is a "double crater". What does this indicate happened to the incident meteor before impact?
3. What is the name of the geologic feature of this object shown in image G?
4. Which other images on Image Sheet A show the same object?

5. Which image shows Mimas?
6. Mimas is a satellite of which solar system planet?
7. Mimas is the smallest object in the solar system that is rounded by what force?
8. What is the name of the large crater on Mimas (shown in the image)?
9. What is the name for the gap in the rings of its host planet that Mimas is responsible for creating?

10. Which image shows an artist's conception of 2007 OR₁₀?
11. Which image shows a telescopic image of 2007 OR₁₀?
12. What kind of solar system object (as determined by distance) is 2007 OR₁₀?
13. What kind of solar system object (as determined by mass) is 2007 OR₁₀ suspected to be?
14. 2007 OR₁₀ is in orbital resonance with which planet?

15. Which dwarf planet is shown in Image C?
16. What are the bright spots shown in Image C thought to be composed of?
17. What kind of subsurface structure are these bright spots thought to indicate the existence of (in the past or present)?

18. Which dwarf planets have no moons?
19. Which dwarf planet has the greatest number of moons?
20. Which image shows the dwarf planet with the greatest number of moons?

21. What is the most massive dwarf planet in the solar system?
22. Which image shows the most massive dwarf planet in the solar system?
23. What is the largest (by volume) dwarf planet in the solar system?
24. Which image shows the largest (by volume) dwarf planet in the solar system?

25. The image on the cover of this exam shows the concentration of water ice on Pluto's surface. What is the name for the heart-shaped region containing relatively little water ice?
26. What is the name of Pluto's largest moon?
27. Which image shows Pluto's largest moon?
28. Pluto and its largest moon are sometimes considered a binary system because the central point that both objects orbit lies outside the volume of either object. What is the name of this central point of orbit?

29. Which dwarf planet has the smallest semi-major axis?
30. Which two solar system planets does this dwarf planet orbit between?

31. Which image shows Haumea?
32. Observations of what kind of plot of Haumea's brightness over time have revealed that it has a highly elliptical shape?
33. The variations in this plot (those indicating Haumea's highly elliptical shape) occur every 4 hours. What does this indicate about Haumea that distinguishes it from other dwarf planets?

34. Which image shows "extraterrestrial interloper" 'Oumuamua?
35. The official designation of 'Oumuamua according to the International Astronomical Union is "1I", and it is the first object to be given a letter "I" label. What does the "I" stand for?

Research published in November 2018 suggests that 'Oumuamua's trajectory is not determined by the sun's gravitational influence alone.

36. The deviation from expected trajectory could be explained if part of 'Oumuamua evaporated when passing the sun. What feature would need to be present (which has not been observed) if this were the case?
37. What other characteristic could result in 'Oumuamua's unexpected trajectory?

38. Which of Saturn's satellites orbits in the opposite direction that Saturn rotates?
39. What is the name for this kind of satellite orbit?
40. Which image shows this satellite?
41. This satellite has an extremely low albedo. Does this mean it appears less or more reflective than an object with higher albedo?
42. The presence of what substance on this object's surface suggests that it is not a captured asteroid but instead a captured Kuiper belt object?

For questions #43 – 75 , refer to Image Sheet B.

Consider the diagram of a planet orbiting the Sun shown in Image Q.

43. Is the area swept out by the planet labelled 1 or 2 larger?
44. Which of Kepler's laws is shown in this diagram?
45. If the semimajor axis of this planet were quadrupled, how many times longer would a year on this planet last?
46. If the semimajor axis of this planet were quadrupled, how many times longer would a day on this planet last?

This planet's orbit has a semimajor axis of 5 Astronomical Units and an eccentricity of 0.2.

47. How many times further is this planet from the Sun than Earth?
48. At aphelion, how far is this planet from the Sun?
49. Is the orbit of this planet more or less elliptical than the orbit of the Earth?

50. Which kind of eclipse is shown in Image S?
51. Which kind of eclipse is shown in Image T?
52. When the **moon is at perigee** in its orbit around **Earth**, is the eclipse shown in Image T or Image S more likely to occur?
53. When the **moon is at apogee** in its orbit around **Earth**, is the eclipse shown in Image T or Image S more likely to occur?
54. When the **Earth is at perihelion** in its orbit around **the Sun**, is the eclipse shown in Image T or Image S more likely to occur?
55. When the **Earth is at aphelion** in its orbit around **the Sun**, is the eclipse shown in Image T or Image S more likely to occur?

Consider the diagram of the Earth, Moon, and Sun shown in Image R.

56. Which kind of eclipse is shown in this diagram?
57. When will the first total eclipse of this kind occur in 2019?
58. What region is indicated by Number 3?
59. What region is indicated by Number 4?
60. If the moon were twice as large (and the Earth remained the same size), which kind of eclipses (solar and/or lunar) would still be possible?
61. If the moon were half as large (and the Earth remained the same size), which kind of eclipses (solar and/or lunar) would still be possible?

Consider the solar system object diagram shown in Image V. The letters J, S, U, N indicate the positions of the planets Jupiter, Saturn, Uranus, and Neptune, respectively.

62. Which kinds of objects have orbits with semi-major axis *between* those of the (outer) planets and are shown in this diagram in green?
63. Which kinds of objects have orbits with semi-major axis *the same* as those of the (outer) planets and are shown in this diagram in grey and purple? These objects orbit in the same orbital path as the gas giant planet they are associated with.
64. What is the name for the points in the orbital path relative to the planet in which these objects orbit?
65. It was discovered in November 2018 that the moon has two such objects orbiting in its orbital plane around the Earth. What is the name for these objects?
66. Do the objects indicated in purple or the objects indicated in green have more stable orbits?
67. What kind of objects, found in the Kuiper belt of the solar system, are shown in blue in this diagram?

68. Which phase of the moon would rise at dusk?
69. Which phase of the moon would be highest in the sky at dawn?
70. Which phase of the moon would rise at noon?

Consider the moon phases shown in Image U.

71. During which phases (by number) can the moon be observed during a lunar eclipse?
72. Is the progression of moon phases shown in Image U visible during the day or night?
73. Over the course of the lunar cycle, greater than 50% of the moon's surface is visible from Earth through libration. What is the name for the kind of libration resulting from the eccentricity of the orbit of the moon around Earth?
74. What is the name for the kind of libration resulting from the misalignment between the Moon's orbit axis and its rotational axis?
75. What is the name for the kind of libration resulting from the motion of an observer on Earth's surface relative to Earth's center of mass and the resulting different perspective of the moon?

For questions #76 – 89, refer to Image Sheet C.

Consider the missions listed in the event rules: New Horizons, Dawn, Cassini, Lucy, and Voyager 2. Reference the images AA – .

76. Which image shows Lucy?
77. Lucy's target objects of study are what kind of objects associated with Jupiter?
78. Scientists believe these objects were originally located elsewhere in the solar system and gravitationally captured by Jupiter. In which region of the solar system would they originally have been found?
79. Which colored band on the electromagnetic spectrum in Image KK corresponds to the region in which Lucy will make observations?

80. Which image shows Voyager 2?
81. In which region of the electromagnetic spectrum did Voyager 2 transmit signals back to Earth?
82. Which colored band on the electromagnetic spectrum in Image KK corresponds to the region in which Voyager made observations?

83. Which image shows Dawn?
84. What images show the two primary target of Dawn's observations?
85. Which colored band on the electromagnetic spectrum in Image KK corresponds to the region in which Dawn made observations?
86. Dawn was the first purely exploratory spacecraft to be powered by what mechanism?

87. Which image shows New Horizons?
88. What images show the two primary target of New Horizon's observations?
89. In 2016 the New Horizons team elected to extend the mission of New Horizons to study objects in the Kuiper Belt. What is the name of the primary Kuiper belt Object under study in this mission?

For questions #90 – 100, refer to Image Sheet D.

90. Which arrangement of the Sun, Earth, Moon system (Image LL or Image MM) shows neap tides?
91. Which arrangement of the Sun, Earth, Moon system (Image LL or Image MM) would result in higher tides at point A?
92. In what phase(s) could the moon be observed during spring tides?

Consider the object in Image NN and the plots OO, PP, QQ.

93. Which object is shown in Image NN?
94. According to the Plot OO, is there more or less **methane ice** on this object's red spot than the rest of its surface?
95. According to the Plot OO, is there more or less **water ice** on this object's red spot than the rest of its surface?
96. What is the significance of the band labelled "J" on Plot OO?
97. According to Plot PP, does the red spot on this object make it appear more or less bright than a uniform ellipsoid object of the same shape?
98. If the x axis of Plot PP was replaced with time, what would be the appropriate units for this diagram?
99. In which region of the electromagnetic spectrum was Plot QQ generated?
100. This plot shows the reflectivity of the surface of an object. What is the general name for how reflective an object is?