

Solar System — 2019

Section 1: Images

Note: unless otherwise specified, all questions are worth one (1) point.

The image at right shows Earth and one of the objects on the Official Rules Sheet.

1. Which object is visible at the right side of the photo?
(Hint: don't overthink this.)
2. Where is the Sun relative to the photo?
A. Off the top side C. Off the right side
B. Off the bottom side D. Off the left side
3. The distance between the camera and Earth is closest to which of the following lengths?
A. 3,000 km C. 3,000,000 km
B. 300,000 km D. 300,000,000 km
4. What kind of rocks would you find if you landed on the surface of the object in the photo?
A. Igneous C. Sedimentary
B. Metamorphic D. None of the above



In the image at right you can see several planets, as well as the Sun and some objects named on the Official Rules Sheet.

5. Which class of objects is shown by green dots at roughly 2 o'clock and 10 o'clock positions?
- A. Trans-Neptunian objects
 - B. Centaurs
 - C. Trojans
 - D. Main belt asteroids

6. The objects in Question 5 are best described as which of the following?

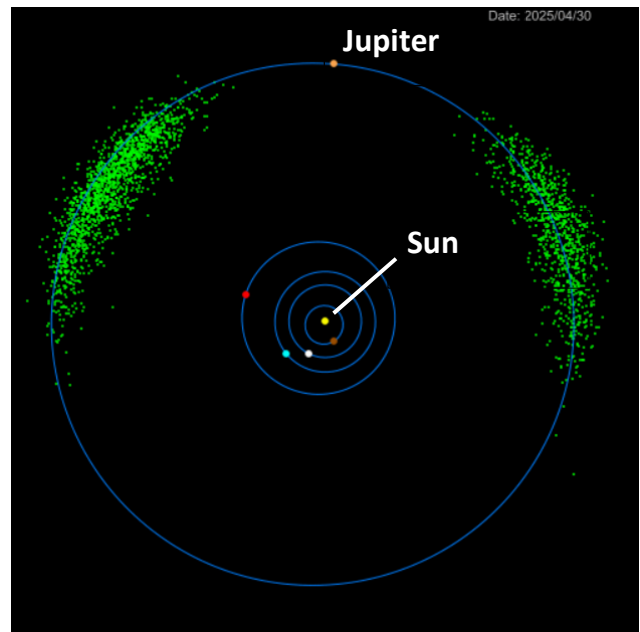
- A. Comets
- B. Kuiper belt objects
- C. Asteroids
- D. Dwarf planets

7. About how long does it take these objects to complete one orbit around the Sun?

- A. 1 year (almost the same as Earth)
- B. 2 years (almost the same as Mars)
- C. 12 years (almost the same as Jupiter)
- D. 84 years (almost the same as Uranus)

8. What property of Jupiter caused these two populations (2 o'clock and 10 o'clock) to form?

- A. Its chemical composition
- B. Its electric charge
- C. Its magnetic field
- D. Its gravity



9. Which object on the Official Rules sheet is shown in the image at right?

10. The object is classified as which of the following?

- A. Hildas asteroid
- B. Dwarf planet
- C. Moon
- D. Comet

11. Which space mission took the image at right?

- A. Dawn
- B. New Horizons
- C. Voyager 2
- D. Cassini

12. What do scientists infer from the smooth, light region near the middle of the image?

- A. The object is geologically active
- B. The object has cleared its orbit of meteors and asteroids
- C. The object is differentiated into a rocky core and icy crust
- D. There is ice transfer from a nearby moon to the surface of the object



The image at right is of an unusual object, listed on the Official Rules Sheet.

13. Which object on the rule sheet is shown in the image?

14. What makes this object so unusual?

- A. It emitted radio waves
- B. It showed both comet- and asteroid-like behavior
- C. It originated outside the Solar System
- D. It was artificial, likely constructed by aliens

15. The image is an artist's conception of the object, not an actual photograph. How did scientists determine the object is long and thin instead of spherical like many Solar System objects?

- A. They measured how its brightness changed with time
- B. They sent a probe to take photos
- C. They took a photo with the Hubble telescope
- D. They used the shape of its orbit



16. Scientists think as many as 10 objects like this pass through the Solar System each year. Why have we not seen more before last 2018?

- A. The objects are normally too dim to detect with a telescope
- B. The objects pass too far from the Sun to detect with a telescope
- C. Scientists have not been looking in the right places
- D. The objects are typically cloaked and hidden from view

The image at right is of Haumea, an object on the Official Rules Sheet.



17. Which space mission took the photo?

- A. Lucy
- B. Dawn
- C. New Horizons
- D. None; this is an artist's conception

18. Why is Haumea not spherical?

- A. Tidal forces from a nearby moon
- B. Unmixed interior composition
- C. Rapid rotation
- D. An ancient meteor strike

19. What evidence is there for the reddish-brown spot at the lower left corner of the image?

- A. Direct photographs of the region
- B. Changes to Haumea's rotational period
- C. Theoretical evidence based on the presence of a moon/moons
- D. Changes in Haumea's spectrum at different times

20. Haumea's perihelion places it closer to the Sun than how many planets? (Don't count dwarf planets—only consider the big eight!)

Section 2: Compositions and formation processes

Note: unless otherwise specified, all questions are worth one (1) point.

The density of water ice is 1 g/cm^3 , the density of rock is approximately 3 g/cm^3 , and the density of iron is about 8 g/cm^3 . Use this information to determine the composition of the objects in questions 21–25. For questions 21–24, choose from the answers listed at right. **Some answers may be used more than once; some may not be used at all.**

21. Ceres (density 2.16 g/cm^3)

22. Earth (density 5.51 g/cm^3)

23. Mimas (density 1.15 g/cm^3)

24. Earth's moon (density 3.35 g/cm^3)

Composition:

A. Mostly ice, with some rock

B. Mostly rock, with some ice

C. Mostly rock, with some metal

D. Significant amounts of metal

25. The nucleus of comet 67P/Churyumov–Gerasimenko has a mean density of just 0.5 g/cm^3 .

What does this mean for its composition?

A. It is almost entirely water ice

B. Its interior is mostly empty space

C. It has an extended gas envelope like Jupiter or Saturn

D. It has a liquid interior of primarily propane

26. In sufficiently large Solar System objects, denser materials sink to the core, leaving lighter materials to form the mantle and/or crust. What is this process called?

A. Upwelling

C. Annealing

B. Hydrostatic mixing

D. Differentiation

27. (2 pts) Jupiter's moon Ganymede has iron and water layers, both of which might have solid and liquid shells (see the image at right).

How many of the following statements are true about these layers?

A. Tetragonal ice is denser than liquid water.

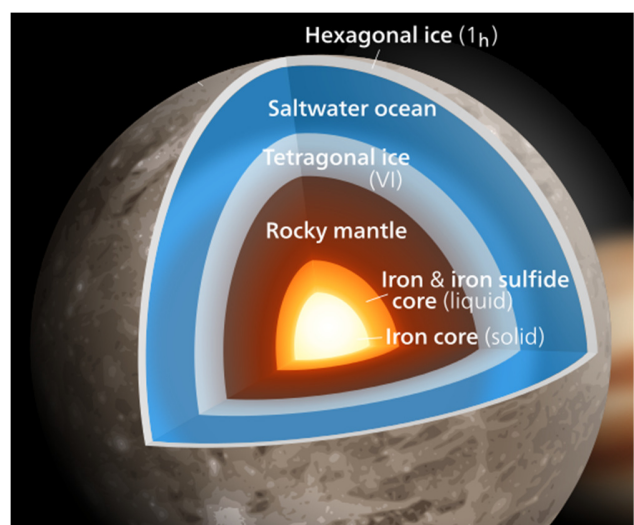
B. Solid iron is denser than liquid iron.

C. Hexagonal ice is denser than liquid water.

D. Tetragonal ice is denser than hexagonal ice.

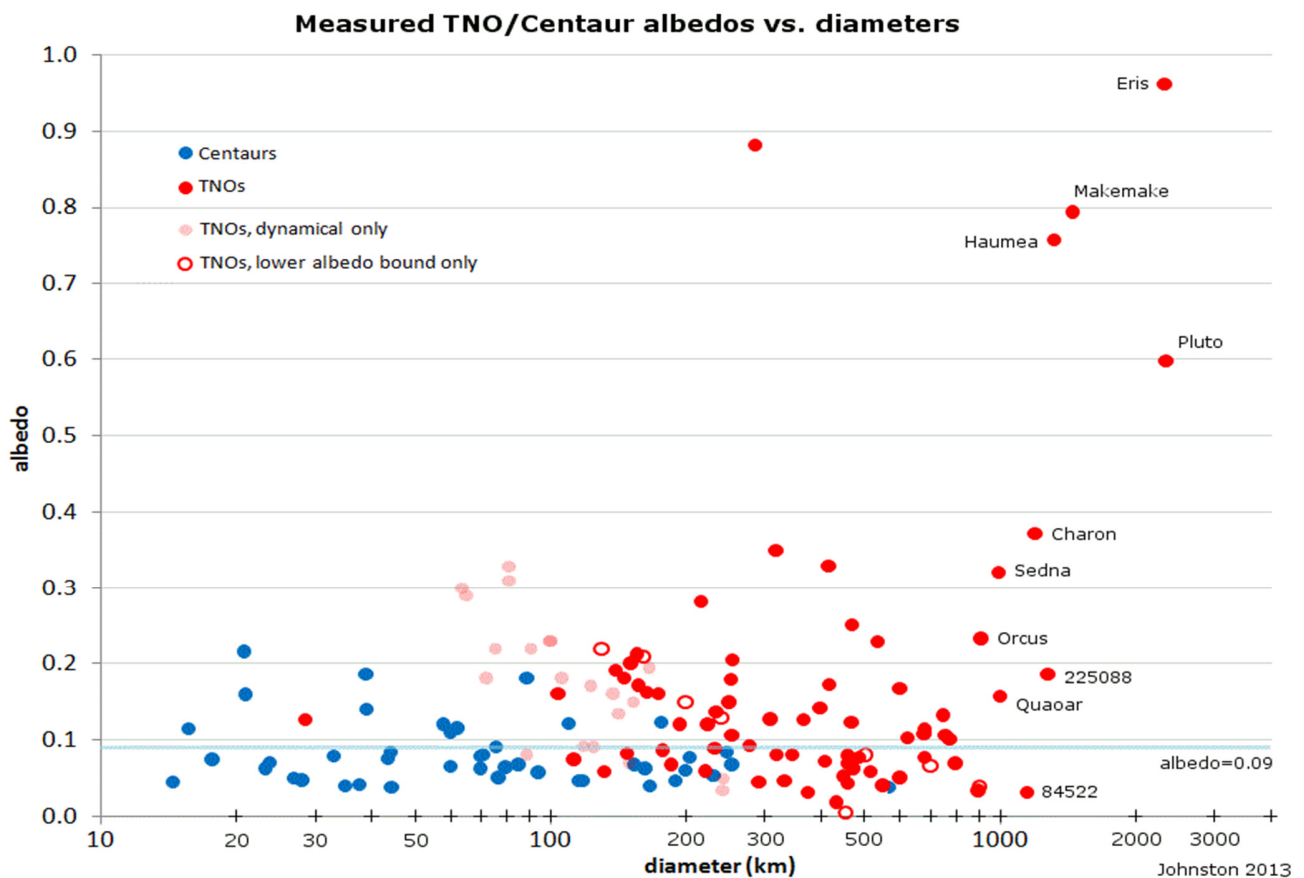
ice.

E. Solid iron is denser than rock.



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28. At a certain distance from the Sun (or another star), water ice can exist even in direct sunlight. What is the term for this distance, which separates objects with plentiful surface ice from those with rocky surfaces?
- A. Roche limit
 - B. Accretion zone
 - C. Snow line
 - D. SID sphere
29. Inside the distance mentioned in question 28, water ice that is exposed to sunlight undergoes a phase change from solid to gas, without passing through liquid first. What is this called?
- A. Melting
 - B. Sublimation
 - C. Boiling
 - D. Freezing
 - E. Deposition
 - F. Condensation
30. Both the dwarf planet Ceres and the planet Mars have subsurface ice, even though they are closer to the Sun than the distance in question 28. Why is this?
- A. The ice is covered with rock, so it is not exposed to sunlight
 - B. Ceres and Mars are massive enough to prevent the ice from escaping
 - C. The water ice is mostly heavy water
 - D. The ice is continually deposited by asteroid/comet impacts
31. There is nitrogen ice on the surface of Pluto, but none is observed on the surface of Mimas, which is closer to the Sun. Why is this?
- A. The inner Solar System was nitrogen-poor when planet/moon formation happened
 - B. Spacecraft have not passed close enough to Mimas to detect nitrogen ice
 - C. The magnetic field of Saturn prevents nitrogen accumulation
 - D. The distance in question 28 is different for nitrogen and water

Questions 32-35 use the following graph, showing the size and the albedo of various objects in the outer Solar System.



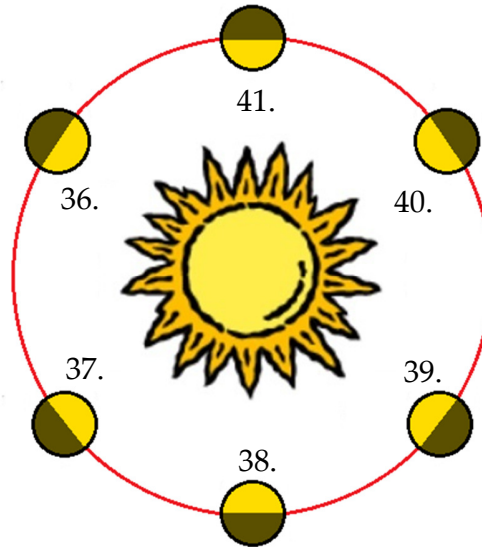
32. What is albedo, the property plotted on the Y axis?
- A. Density relative to Earth's C. Fraction of incoming light reflected away
- B. Angle between orbit and the ecliptic D. Surface coverage by ice or rock
33. Which object has the largest radius?
- A. Pluto C. Quaoar
- B. Makemake D. Haumea
34. How many TNOs have an albedo higher than 0.5?
35. Which of the following statements is true about the albedos of the objects in the plot?
- A. TNOs have a higher average albedo than centaurs
- B. The larger the radius of a centaur, the higher its albedo usually is
- C. There is more scatter in the albedos of centaurs than there is in the albedos of TNOs
- D. TNOs with dynamically-derived albedos have larger radii than other TNOs

Section 3: Rotation, libration, phases, and eclipses

Note: unless otherwise specified, all questions are worth one (1) point.

Venus isn't an object on your Official Rule Sheet, but it has phases just like the Moon does! The diagram at right (not to scale) shows six different places in the orbit of Venus, as well as the Sun and Earth.

For questions 36-43, choose from the answer choices listed below. **Each choice is used exactly once (you're welcome for the hint).**



Sets/rises before the Sun

A.

B.

C.

D.

E.

F.

G.

H.

Sets/rises after the Sun

36-41. For each position of Venus in the upper figure, decide how it would appear from Earth.

Pay close attention to whether Venus would be rising/setting before or after the Sun!

42. Which phase of Venus is it almost impossible to see from the surface of Earth?

43. How would Venus appear when it transits the Sun, which happened in 2012 and won't occur again until 2117?

The images at right show the Moon at two different times, as seen from the same place on Earth. The two images are at the same scale, and note the red bar near the bottom of each lunar disc (which is placed solely to help you see the different Moon sizes, and most certainly does *not* mean that I screencapped a YouTube video for these shots).

44. Which of the following differences between the two images is caused by lunar libration?

- A. Location of features on the Moon
- B. Size of the Moon
- C. Phase of the Moon
- D. Orientation of shadows on the Moon

45. In both images, there are extended dark patches on the lunar surface. What are these called?

- A. Impact basins
- B. Breccia
- C. Maria
- D. Lunar highlands

46. What is the reason the Moon has a different apparent size in the two images?

- A. A non-circular orbit around Earth
- B. Different phases
- C. Lunar libration
- D. Viewing latitude

47. The Moon always shows (almost) the same side to Earth. What process caused this?

- A. Magnetic braking
- B. Orbital nutation
- C. Tidal locking
- D. Eccentricity

48. It takes the Moon 29.5 days to go from full Moon to full Moon (return to the same position on the Earth-Sun line). Which of these “months” describes this length of time?

- A. Anomalistic month
- B. Sidereal month
- C. Draconic month
- D. Synodic month

49. It takes the Moon 27.3 days to complete one full orbit around Earth (return to the same position relative to distant stars). Which of these “months” describes *this* length of time?

- A. Tropical month
- B. Sidereal month
- C. Draconic month
- D. Synodic month



50. Why is there a difference in the two “months” listed in questions 48 and 49?
- A. The Earth is also orbiting the Sun
 - B. The Moon’s orbit is not perfectly circular
 - C. The Earth’s axis is tilted relative to the Solar System
 - D. The Moon does not orbit in a flat plane
51. Finally, a freebie question for reading this far. How many numbered Sections did this test have?

Well, you made it. It’s over. Turn in your answer sheet and take a deep breath. Those of you who advance to the State Tournament should expect a section with math questions. You’ve been warned!