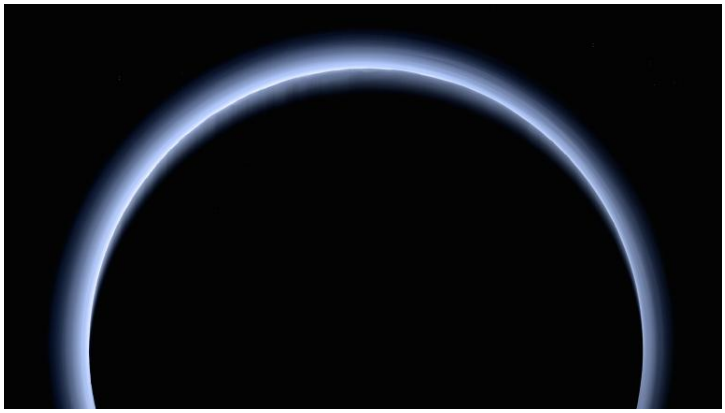
Science Olympiad
Solar System
UT Austin Regional 2019

February 23, 2019
Austin, Texas



School: _____

Team Number: _____

Name(s): _____

Directions:

- You are allowed to bring in two 8.5" × 11" sheets of paper with information on both sides as notes, but no calculators.
- Please write all answers on the answer sheets; any marks elsewhere will not be scored.
- You are more than welcome to take apart the test as long as you restaple the pages in the correct order at the end. Page numbers have been added for your convenience.
- There is no penalty for wrong answers. Answer every single question, even if you aren't sure if you're correct.
- Above all else, just believe!

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Section:	A	B	C	Total
Points:	35	48	138	221
Score:				

Section A

Determine whether the following statements are true or false. Each question is worth 1 point for a total of 10 points.

1. ____ Pluto has 3 moons.
2. ____ The Kuiper Belt refers to the family of rocks between Mars and Jupiter.
3. ____ Ceres is in the Asteroid Belt.
4. ____ Haumea is in the Asteroid Belt.
5. ____ Phoebe is believed to be a captured centaur that originated in the Kuiper belt.
6. ____ Centaurs are magical horses that gallop from planet to planet in the Solar System.
7. ____ Scientists believe that most comets originate from the Oort Cloud.
8. ____ 'Oumuamua has an orbital period of roughly 1,000 years.
9. ____ Eris is farther from the Sun than Pluto.
10. ____ (225088) 2007 OR_{10} is an example of a Trans-Neptunian Object.
11. ____ Tombaugh Regio is a surface feature on Charon.
12. ____ Bright spots known as *faculae* have been discovered on the surface of Ceres.
13. ____ Astronomers believe that Haumea is an ellipsoid (essentially, a squashed sphere).
14. ____ The surface of Charon is believed to be dominated by crystalline water ice.
15. ____ Based on *Cassini* observations, scientists believe that the surface of Phoebe has a low specific heat and therefore cools very quickly.

Complete the following statements with the name of an object from the rules. No object will be used more than once. Each blank is worth 2 points for a total of 20 points.

16. _____ was once the ninth planet and was demoted to a dwarf planet in 2006.
17. _____ is the largest object in the Asteroid Belt.
18. _____ is Pluto's largest moon.
19. _____ was visited by the Apollo missions.
20. _____ is the most massive dwarf planet and has one moon named Dysnomia.
21. _____, home to the crater *Herschel*, is the smallest astronomical body that is known to be rounded in shape because of self-gravitation.
22. _____ are small celestial bodies that share the orbit of a larger one, such as Jupiter.
23. _____ was the first TNO we've discovered with a ring system.
24. Although originally codenamed "Easterbunny" because of its discovery shortly after Easter, this Classical Kuiper Belt Object is now known as _____.
25. The first satellite to be discovered photographically was _____, one of Saturn's moons.

Section B

Choose the correct answer to the following multiple choice questions to the best of your ability. Each question is worth 2 points for a total of 48 points.

26. Which of the following best describes the Sun?
    A. Comet
    B. Planet
    C. Star
    D. Galaxy

27. What is at the center of our Solar System?
    A. Earth
    B. Sun
    C. The moon
    D. Jupiter

28. Which of the following is the biggest, in terms of physical size?
    A. The moon
    B. Sun
    C. Earth
    D. The Milky Way

29. How many planets are in the Solar System?
    A. 6
    B. 7
    C. 8
    D. 9
    E. 10

30. The Asteroid Belt is between which two planets?
    A. Earth and Mars
    B. Mars and Jupiter
    C. Jupiter and Saturn
    D. Neptune and Pluto

31. Which of the following objects is in the Kuiper Belt?
    A. Earth
    B. Mars
    C. Pluto
    D. Ceres
    E. Trojans

32. What is the name of the most recent mission to Saturn?
    A. Cassini
    B. Phoenix
    C. Curiosity
    D. OSIRIS-REx
    E. Dawn

33. Which of the following is the largest? *Note: this object is not necessarily the most massive.*
    A. Ceres
    B. Eris
    C. Haumea
    D. Pluto

34. Which of the following is not a moon of Pluto?
    A. Nix
    B. Titan
    C. Charon
    D. Hydra
    E. Kerberos

35. Which of the following is the closest (in terms of distance) dwarf planet to Earth?
    A. Charon
    B. Ceres
    C. Pluto
    D. Makemake

36. Which of the following is not a moon?
    A. Phoebe
    B. Charon
    C. Haumea
    D. Dysnomia
    E. Ganymede

37. What spacecraft visited Ceres?
    A. Dawn
    B. New Horizons
    C. Cassini
    D. Lucy

38. What class of objects is the main focus of the *Lucy* mission?
    A. Kuiper Belt Objects
    B. Centaurs
    C. Trojans
    D. Asteroids

39. Which of the following did the *Voyager 2* spacecraft not visit?
    A. Jupiter
    B. Saturn
    C. Uranus
    D. Neptune
    E. Pluto

40. Which of the following objects do not have natural satellites (moons)?
    A. Earth
    B. Pluto
    C. Ceres
    D. Eris
    E. Makemake

41. Which of the following is the closest (distance) dwarf planet to Earth?
    A. Charon
    B. Ceres
    C. Pluto
    D. Makemake
    E. Eris

42. Which of the following best describes the orbit of 'Oumuamua?
    A. Circular
    B. Elliptical
    C. Parabolic
    D. Hyperbolic

43. Which of the following best describes the total mechanical energy of the orbit of 'Oumuamua?
    A. Negative
    B. Zero
    C. Positive
    D. Imaginary

44. Which of the following is not a surface feature on Pluto?
    A. Sputnik Planitia
    B. Cthulhu Macula
    C. Acadia Planitia
    D. The Brass Knuckles

45. Which scientist discovered Phoebe?
    A. William Henry Pickering
    B. William Herschel
    C. Issac Newton
    D. Galileo Galilei

46. What does KBO stand for?
    A. Kuiper Belt Object
    B. Kuiper-Bernoulli Orbit
    C. Keplerian Bicyclic Orbit
    D. Kappa Binary Object

47. Which of the following is not one of Kepler's Laws of Planetary Motion?
    A. *All stable orbits have positive total mechanical energies.*
    B. *All planets move in elliptical orbits, with the Sun at one focus.*
    C. *A line that connects a planet to the Sun sweeps out equal areas in equal times.*
    D. *The square of the period of any planet is proportional to the cube of the semimajor axis of its orbit.*

48. Suppose Planet A orbits the Sun at a distance D and has a period P. Planet B orbits the Sun with a distance $9R$. What is its period, in terms of P?
    A. $128P$
    B. $81P$
    C. $27P$
    D. $8P$

49. Pluto has a relatively elliptical orbit. When Pluto is at its closest distance to the Sun in its orbit...
    A. It is travelling at its slowest
    B. It is travelling at its fastest
    C. None of the above

Section C

Use the attached Image Set for the questions in this section. Each part/subpart is worth 3 points for a total of 138 points.

50. (a) Which object is shown in Image 2?
    (b) Which of the following best describes Image 2? Choose from artist illustration, photograph, and graph.
    (c) This object was discovered when it was within the Inner Solar System, but it is not from there. What do astronomers believe is special about the origin/home of this object?

51. (a) Which object is shown in Image 3?
    (b) Which spacecraft took this image?
    (c) What is the name of the large crater visible in this picture?

52. (a) Which object is shown in Image 4?
    (b) Which of the following best describes this object? Choose from star, planet, dwarf planet, asteroid, and comet.
    (c) Image 4 shows this object's moon as a small white dot to the left of center. What is the name of this moon?
    (d) Explain how astronomers used this moon to help determine the mass of this object. If this object didn't have a moon, would that make determining its mass easier or harder?

53. (a) Which object is shown in Image 6?
    (b) Around which planet does this object orbit?
    (c) This image shows several bright spots which are most likely craters, while the rest of the object is very dark. What does this suggest about the composition and layering of this object's surface?

54. (a) Image 7 shows a surface feature named Kwanzaa Tholus. Briefly explain what a *tholus* is.
    (b) Which other image shows a surface feature from the object Kwanzaa Tholus is on?
    (c) Based on the altitude map on the right, estimate the height of Kwanzaa Tholus, in kilometers.
    (d) Ice is generally not strong enough to preserve tall, large structures, like mountains. Ahuna Mons is the largest mountain on this object. With of the two features (Ahuna Mons or Kwanzaa Tholus) do you think is older? Why do you think so?

55. (a) Which object's light curve is shown in Image 10?
    (b) In Image 10, does the brightness of the object increase or decrease as you go up the y-axis?
    (c) Two other images show this object. Which ones are they?

56. (a) What object is shown in Image 12?
    (b) Which spacecraft flew by this object in 2015?
    (c) Which instrument on this spacecraft took this image?
    (d) What is the name of the heart-shaped region visible towards the bottom of the object?
    (e) A student wonders why the spacecraft flew by this object instead of orbiting it, since that would allow the spacecraft more time to make observations. Why did this spacecraft only complete a flyby?

57. Image 13 shows a close-up of the heart-shaped region shown in Image 12.
    (a) What type of surface feature is represented by the purple regions?

(b) Which color shows the location of Wright Mons, a suspected cryovolcano?

(c) What do the craters, shown in yellow towards the left of the image, tell us about the age of the brown region, particularly relative to the surrounding regions?

58. (a) Which object's spectrum is shown in Image 14?

(b) What region of the Solar System is this object in? Choose from Asteroid Belt, Kuiper Belt, or Oort Cloud.

(c) Based on Image 14, which of the two models (blue or red) best represents the composition of the surface of this object?

(d) Methane (CH_4) is the simplest hydrocarbon. How do the more complex hydrocarbons, such as ethane (C_2H_6) or paraffin, form in the outer Solar System?

59. Image 15 shows two different families of asteroids in the Solar System.

(a) What family of asteroids is shown in magenta?

(b) What family of asteroids is shown in green?

(c) The asteroids in green exist in Jupiter's Lagrange Points (specifically, L_4 and L_5). Briefly explain what a Lagrange point is.

60. Image 16 shows Charon. The top panel of the inset is a photograph taken by the LORRI instrument, while the bottom panel shows the same photograph, but color coded by elevation, with red being higher and green being lower.

(a) What is the name of the surface feature shown in the inset? *Hint: it is named after the spacecraft in the TV show Firefly.*

(b) Scientists interpret the ridges and cracks shown in the inset as evidence that the surface of Charon has expanded due to a subsurface ocean freezing. From a chemistry perspective, why does water expand when it freezes, when nearly every other substance contracts?

(c) Although tidal heating is the cause of most subsurface oceans in the Solar System (such as those of Europa and Enceladus), it's not always the case. Name a different source of energy that could have caused a subsurface ocean in Charon's past.

61. Image 17 shows a plot for (225088) 2007 OR_{10} in which the negative logarithm of the false alarm probability is plotted on the y-axis and the frequency, in cycles per Earth days, is on the x-axis.

(a) Which other image shows (225088) 2007 OR_{10} as seen by a telescope?

(b) Which of the following best describes the location of (225088) 2007 OR_{10}? Choose from: Asteroid Belt, Scattered Disk, or Oort Cloud.

(c) Based on Image 17, what is the most likely rotational period (i.e. length of a "day") of this object, in hours?

(d) Image 17 doesn't give us the whole story, however. Additional measurements and analysis lead scientists to believe that the rotational period of this object is actually twice what we originally suspected, resulting in the double-peaked phase-folded light curve shown in Image 18. Propose an explanation for the double-peaked light curve.

62. Images 20-23 show different impact craters on the object shown in Image 19.

(a) Which object is shown in Image 19?

(b) Order the craters in Images 20-22 by size, from smallest to largest. *Note: you don't need to have any information about these craters on your notes - just look at their structure/complexity!*

(c) The crater shown in Image 23 is not completely surrounded by ejecta (look at the dark triangle in the bottom of the image). Propose an explanation for this.