Solar System B - Solar System - University of Chicago B - 01-15-2022

1. (1.00 pts) Approximately how many confirmed exoplanets do we know of as of 2022? (order-of-magnitude)?

- A) 50
- B) 5,000
- C) 500
- D) 50,000
- E) 500,000

2. (1.00 pts) In 2020, an international team led by Dr. Jane Greaves reported the discovery of phosphine gas in the atmosphere of which of the following planets?

- A) Venus
- B) Jupiter
- C) Neptune
- D) Uranus
- E) Saturn
- F) Earth

3. (1.00 pts) In 2019, water vapor was discovered in the atmosphere of an exoplanet for the first time ever. Which exoplanet was it?

- A) Kepler 138d
- B) K2-33b
- C) K2-18b
- D) None of the Above

4. (1.00 pts) True or False: most known “Hot Jupiters” orbit at an average distance of less than one astronomical unit (1 AU) from their host star.

- True
- False

5. (1.00 pts)
Approximately how many moons of Jupiter are known to date? (note that scientists sometimes disagree on the exact answer to the first question so choose the closest answer. Currently unnamed moons count as “known” for sake of this question)

- A) 53
- B) 79
- C) 118
- D) 47
- E) 91
- F) 71

6. (1.00 pts) A “catena” is a type of surface feature found on rocky bodies in the Solar System. Which of the following is the best definition for this term?

- A) low-elevation plain
- B) canyon
- C) crater chain
- D) type of volcanic plume
- E) ice geyser
- F) None of the above

7. (1.00 pts) Jupiter’s atmosphere is primarily dominated by which gas?

- A) Hydrogen gas (H_2)
- B) Ammonia
- C) Methane
- D) Carbon Dioxide (CO_2)
- E) Helium gas (He)
- F) None of the above

8. (1.00 pts) Select the statements that are true about the “Grand Tack model.” (choose multiple if necessary; must get exactly correct to earn the point)

(Mark **ALL** correct answers)

- [ ] A) Jupiter formed at a greater distance from the Sun than its current position
- [x] B) Jupiter once migrated inward toward the Sun
- [x] C) Jupiter once migrated outward away from the Sun
- [x] D) The Grand Tack model successfully explains the relatively small mass of Mars
- [ ] E) None of the above are true

9. (1.00 pts) The “Cassini Division” separates which two rings of Saturn? Also, True or False: the “F Ring" is Saturn’s innermost ring.

- A) F and A rings; True
- B) F and A rings; False
- C) A and B rings; True
- D) A and B rings; False
- E) D and F rings; True
- F) D and F rings; False

10. (1.00 pts) What is the approximate angle between the ecliptic plane, on which most of the Solar System’s planets lie, and the Galactic plane?

- A) 0 degrees
- B) 30 degrees
- C) 60 degrees
- D) 90 degrees

11. (1.00 pts) Rank the following planets by density, from most dense to least dense: Mercury, Venus, Earth Mars

- A) Mars, Venus, Mercury, Earth
- B) Mercury, Venus, Earth, Mars
- C) Mars, Earth, Venus, Mercury
- D) Earth, Venus, Mercury, Mars
- (●) E) Earth, Mercury, Venus, Mars
- F) None of the above

12. (1.00 pts) True or False: Earth's moon has a smaller diameter than Pluto.

- True
- (●) False

13. (1.00 pts) What mechanism best explains Io's high rate of volcano activity?

- (●) A) Tidal heating
- B) Meteor Impacts
- C) Tectonic plate movement
- D) Warming of ice causing an increase in nitrogen gas pressure
- E) None of the Above

14. (1.00 pts)
Many experiments mapping the interiors of planets (for example, NASA's InSight Mission on Mars) rely on measuring time delays between "P" and "S" waves. Which type is faster, and what does the "S" stand for?

- A) P-waves are faster; S stands for "seismic"
- (●) B) P-waves are faster; S stands for "secondary"
- C) P-waves are slower; S stands for "seismic"
- D) P-waves are slower; S stands for "secondary"

15. (1.00 pts) Arrokoth is a/an _____. (select multiple answers if necessary)

(Mark **ALL** correct answers)
- [x] A) Kuiper Belt Object
- [x] B) Trans-Neptunian Object
- [x] C) Contact Binary
- [ ] D) Interstellar Object
- [ ] E) Object originally discovered by the New Horizons spacecraft

16. (1.00 pts) Which of the following is NOT one of the four Galilean moons of Jupiter?

- A) Io
- (●) B) Titan

C) Callisto
D) Europa
E) Ganymede

17. (1.00 pts) Which of the following distance ranges best describes the position of the asteroid belt in our Solar System?

A) 6.0 AU to 7.0 AU from the Sun
B) 1.8 AU to 2.8 AU from the Sun
C) 5.3 AU to 6.3 AU from the Sun
D) 2.8 AU to 3.8 AU from the Sun
E) 3.2 AU to 4.2 AU from the Sun
F) 2.2 AU to 3.2 AU from the Sun

18. (1.00 pts) Rank the following planets by their magnetic field strength (from strongest to weakest): Jupiter, Earth, Venus

A) Earth, Jupiter, Venus
B) Earth, Venus, Jupiter
C) Venus, Earth, Jupiter
D) Jupiter, Earth, Venus
E) Jupiter, Venus, Earth

19. (1.00 pts) Pluto revolves around the Sun with an orbital period of 248 years. During how much of this time is Pluto closer to the Sun than Neptune (approximately)?

A) 0 years; Pluto is always further to the Sun than Neptune
B) ~10 years
,
C) ~20 years
D) ~30 years
E) ~40 years
F) ~80 years

20. (1.00 pts) Uranus' moons are generally named after which of the following categories?

A) water/sea deities
B) Shakespeare characters
C) lovers or descendants of Zeus
D) characters with ties to Hades
E) None of the above

21. (2.00 pts)
Name the Solar System object in the image below. (We will audit all responses by hand. 2 points will be awarded if spelling is perfect; 1 point if there are any minor mistakes; 0 points if the spelling is more than just a typo/minor mistake)

lapetus

22. (2.00 pts)
The Solar System object in the image above is known for having a very strong difference in "reflectivity" between its leading hemisphere and its trailing hemisphere. What is the technical term that scientists often use to describe the "reflectivity" of a Solar System body to the Sun's radiation? Hint: it takes a value from 0 to 1, and starts with the letter "a". We will audit all responses by hand. 2 points will be awarded if spelling is perfect; 1 point if there are any minor mistakes; 0 points if the spelling is more than just a typo/minor mistake.

albedo

23. (1.00 pts) The image below shows the Krun Macula, which can be found on which Solar System body?

- (●) A) Pluto
- ( ) B) Triton
- ( ) C) Enceladus
- ( ) D) Io
- ( ) E) Charon
- ( ) F) Arrokoth

24. (1.00 pts) The image below shows a protoplanetary disk around a very young star. What is the name of that star?

- (●) A) HL Tauri
- ( ) B) TOI-561
- ( ) C) HR 8799
- ( ) D) The Sun
- ( ) E) Kepler-138

25. (1.00 pts)
The incredibly sharp image of the protoplanetary disk shown in the image from the previous question was taken by ALMA.

Choose True or False for the three following claims (1) ALMA is a spacecraft (2) ALMA primarily observes at millimeter wavelengths (3) within the image in the previous question, planets would likely form within the dark gaps between the rings.

- (●) A) False, True, True
- ( ) B) False, True, False
- ( ) C) False, False, False
- ( ) D) True, False, True
- ( ) E) True, True, True

26. (1.00 pts)
The dark brown region in the above image is a plain on the surface of Pluto. What is the name of this region? (this region is sometimes seen in images with a redder color - remembe that images are often in "false color"!)

- ( ) A) Sputnik Planitia

- B) Tombaugh Regio
- C) Mordor Macula
- D) Cthulhu Macula
- E) Tartarus Dorsa
- F) None of the above

27. (1.00 pts) The visible light coloration in the image below is due to the presence of which substance?

- A) Water
- B) Methane
- C) Ozone
- D) Hydrogen
- E) Ammonia
- F) Carbon Dioxide

28. (2.00 pts) Name the spacecraft seen in the image below.

Magellan

29. (1.00 pts) Name the Solar System body in the image below, famous for its retrograde orbit.

- A) Callisto
- B) Haumea
- C) Pluto
- D) Io
- E) Enceladus
- F) Triton

30. (2.00 pts)
The image below shows an artist's impression of _____, which is where scientists believe most long-period comets originate. (note: the Sun is at the center of this image.)

Oort Cloud

31. (1.00 pts) The famous image featuring our home, the "Pale Blue Dot", is shown below. Which spacecraft took this image?

- A) New Horizons
- B) Kepler
- C) Magellan

- (●) D) Voyager 1
- ( ) E) Voyager 2
- ( ) F) Juno

32. (3.00 pts)
The image below shows the distribution of the orbital semi-major axes of objects in the asteroid belt. The vertical dashed lines mark the so-called "Kirkwood Gaps". What phenomenon causes these mathematically-predictable gaps? (your answer should be just a single sentence). This question is worth 3 points and will be a tiebreaker question.

Expected Answer: orbital resonances with Jupiter.

33. (1.00 pts) Below is a false-color image of the Sun. What part of the electromagnetic spectrum was the image below taken in?

- ( ) A) Radio
- ( ) B) Microwave
- ( ) C) Optical/Visual
- ( ) D) Infrared
- (●) E) Ultraviolet
- ( ) F) X-ray

34. (2.00 pts) A star + planetary system is shown below. Provide the name of the star.

HR 8799

35. (2.00 pts)
The image from the previous question shows the star obscured by a black circle on the image. This feature (ignoring the cartoon green star) was not added in post-processing - it is caused by a component of the telescope/instrument taking the image.

What is the name of the type of tool/instrument that creates this feature (hint: it starts with a "c") and why does it help us image exoplanets? (1pt for the tool's name; 1 pt for purpose - you can probably answer the second part without knowing the first). This type of tool/instrument is a very common tool for direct imaging of exoplanets.

Expected Answer: coronagraph; blocks out light from star so makes it easier to see planets (be pretty lenient on the second part)

36. (3.00 pts) Explain why Pluto was demoted from planet status (3 points).

Expected Answer:

37. (3.00 pts) We often see false-color images of Solar System bodies. Explain what a "false-color" image is (3 points).

Expected Answer:

38. (9.00 pts) Answer the following questions about exoplanet detection.

(a) What are the three exoplanet detection techniques described in the rules? (3 points)

(b) Briefly define how each of the above techniques works. (3 points)

(c) Which method provides information about a planet's mass? (1pt)

(d) Which method provides information about a planet's radius? (1pt)

(e) It is easier to detect planets around low-mass stars based on how they move. Provide one reason why this might be. (1pt)

Expected Answer:

39. (7.00 pts) Answer the following questions about Venus and the spacecraft that have studied it.

(a) Name two reasons ****other than temperature**** why Venus is inhospitable to human life (2 pt).

(b) Explain why Venus is the hottest planet in the Solar System, rather than Mercury. Provide as much detail as you can. (3pts)

(c) Mariner 2 was launched in 1962. Provide one reason why this mission was historically significant. (2pts; all or nothing, but multiple possible answers)

Expected Answer:

40. (8.00 pts)

Answer the following questions related to Kepler's Laws and gravitational interactions between objects. 8 points total.

(a, b, and c) In simple terms, explain Kepler's three laws of planetary motion. (6 points, 2 for each law)

(d) Fill in the blank. The force of gravity acting between any two objects is _____ proportional to the _____ of the separation distance between the object's centers. (2 points, 1 pt each for each blank)

Expected Answer:

41. (10.00 pts)
Answer the following questions related to Planetary Migration (10 pts).
(a) What is Planetary Migration? (2)
(b) Disk migration arises from the gravitational force exerted by a sufficiently massive body embedded in a disk on the surrounding disk's gas, which perturbs its density distribution. Provide one subtype of disk migration and explain what is notable about the indicated subtype. (4)
(c) Aside from Disk migration, what is another type of planetary migration? (2)
(d) What is one type of object from the rules that is generally produced by planetary migration? (2)

Expected Answer:

42. (8.00 pts) Answer the following questions about tidal forces in the Earth/Moon/Sun system:
(a) What is a tidal force? (2)
(b) What characterizes a spring tide? (2)
(c) What position are the Sun, Moon, and Earth when spring tide occurs? (1)
(d) What characterizes a neap tide? (2)
(e) What position are the Sun, Moon, and Earth when neap tide occurs? (1)

Expected Answer:

Great work! Stay tuned for scoring.