

Solar System B

UT Regional 2018



Exploring the World of Science

Competitors: _____

School Name: _____

Team Number: _____

This test contains 4 parts, worth 150 points in total. As always, you'll have 50 minutes to complete the test. You may separate the pages; be sure to put your team number at the top of every page. You may use two letter-sized notes sheets. Good Luck, Have Fun! And always remember: The Eyes of Texas Are Upon You!

Page:	1	2	3	4	5	7	Total
Points:	45	15	15	25	25	25	150
Score:							

1 Matching

3 points each. Each choice might be used 0, 1, or more times. This section will be used for tiebreakers.

A	Nitrogen	B	Mercury	C	MESSENGER
D	Protoplanets	E	Phobos	F	Ethane
G	Titan	H	Saturn	I	Carbon Dioxide
J	Venus	K	Deimos	L	Callisto
M	Cassini	N	Planetesimals	O	Voyager 2
P	Mars	Q	Pluto	R	Planets
S	Planetoids	T	Miranda	U	Oxygen
V	Potassium	W	Ceres	X	The moon

1. D Planets are thought to form when these coalesce.
2. I The main chemical component of the Martian atmosphere.
3. L This moon is a Galilean moon.
4. W This body is located in the asteroid belt.
5. J The planet most similar in size to the Earth.
6. J This body features a plateau called Lakshmi Planum.
7. C This spacecraft is the only one to have orbited Mercury for observation.
8. V A component of lunar KREEP.
9. L This body has the most cratered surface in the solar system.
10. E This body's features are named after people and places from *Gulliver's Travels*.
11. B The precession of this planet's orbit was explained by general relativity.
12. D Planetary embryos which are large enough to have undergone internal melting.
13. J This planet has a surface atmospheric density nearly 100 times that of Earth.
14. P This planet has an axial tilt of 25.2 degrees (the most similar to Earth's).
15. K This body features craters named *Swift* and *Voltaire*.

2 Multiple Choice

General solar system astronomy, 3 points each.

16. Which of these is NOT valid evidence for the Giant Impact Hypothesis?
- A. The isotope ratios of lunar and terrestrial rock are identical.
 - B. The Moon is approximately the same size as the Great Atlantic Basin.**
 - C. The spin of the Earth is aligned with the revolution of the Moon.
 - D. The Moon has lower density than the Earth.
17. The Earth reaches perihelion
- A. Monthly
 - B. Twice a year
 - C. Annually**
 - D. Once every 138 years
18. The shape of a planetary orbit can always be mathematically defined by a/an
- A. Sphere
 - B. Circle
 - C. Oval
 - D. Ellipse**
19. Which of these is NOT a moon of Jupiter?
- A. Miranda**
 - B. Callisto
 - C. Ganymede
 - D. Europa
20. Ceres is considered a dwarf planet because
- A. It has not undergone planetary differentiation.
 - B. It has not cleared its orbital neighborhood.**
 - C. It has not been rounded by its own gravity.
 - D. It undergoes thermonuclear fusion.

21. Which of these is true about the formation of the Solar System?
- A. The sun formed about 4.6 million years ago.
 - B. The terrestrial planets were much larger than they are now.
 - C. The sun was one of the first stars in the universe.
 - D. The Earth formed about 4.6 billion years ago.**
22. Venus is unique among terrestrial planets for its
- A. Retrograde revolution
 - B. Retrograde rotation**
 - C. Prograde revolution
 - D. Prograde rotation
23. Jupiter's Great Red Spot is best described as a giant
- A. Crater
 - B. Moon
 - C. Aurora
 - D. Hurricane**
24. A comet's tail always points
- A. Opposite the direction of the comet's motion
 - B. In the same direction of the comet's motion
 - C. Away from the sun**
 - D. Towards the sun
25. Which of the following protects us from the solar wind?
- A. The ozone layer
 - B. Clouds and other dense atmospheric structures
 - C. The magnetosphere**
 - D. The greenhouse effect

3 Short Answer

26. (25 points) Planetary differentiation is an important process in the geologic lifespan of planets.

(a) (5 points) What is planetary differentiation?

Solution: The process of separating out different constituents of a planetary body as a consequence of their physical or chemical behaviour, where the body develops into compositionally distinct layers.

(b) (5 points) Give an example of a planet (other than Earth) that has undergone differentiation, and a moon that has undergone differentiation.

Solution: Answers may vary. All planets have undergone differentiation. Large moons such as Earth's moon, Ganymede, and Titan have undergone differentiation.

(c) (5 points) Explain why many terrestrial planets have iron-nickel cores.

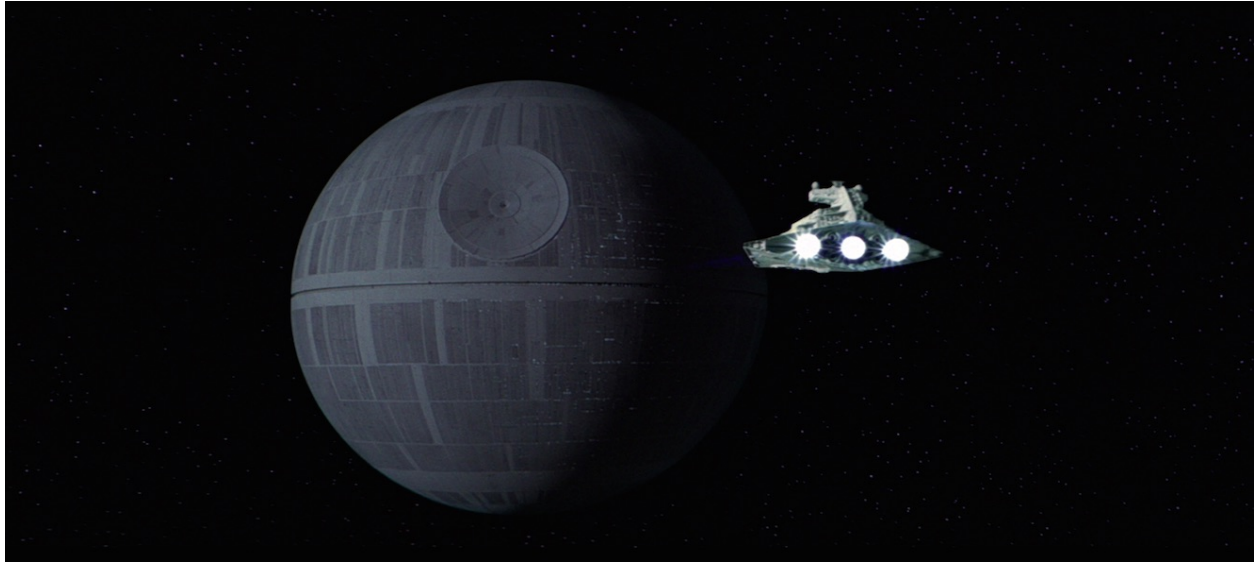
Solution: Iron and nickel are the heaviest abundant elements in the universe; because of this, they tend to sink to the center of differentiating bodies.

(d) (5 points) Explain why asteroids and other such objects typically are not differentiated.

Solution: Their lower mass means that they have lower gravity, which is not conducive to differentiation. In addition, due to the relatively low velocity of collisions between smaller bodies, they don't heat up as much, which means that they don't stay hot enough to form a differentiating magma.

(e) (5 points) When did Earth begin to differentiate? When did it stop differentiating?

Solution: The earth began to differentiate early in its life (about 4.5 billion years ago). It is still differentiating (albeit slowly); this is what tectonic activity is.



27. (25 points) *“That’s no moon... it’s a space station!”* –Obi-wan Kenobi

- (a) (5 points) The Death Star was a giant, spherical, planet-destroying space station built by the evil Empire. Its center was a hollow chamber which housed the main reactor. Which moon in our solar system was once hypothesized by scientists to be hollow?

Solution: Phobos

- (b) (5 points) Suppose that the Death Star had half the surface area of Pluto, and one-tenth the mass. What is the density of the Death Star in terms of Pluto’s density? You are not required to compute the decimal answer; an expression is fine. Show work for full credit.

Solution: Observe that the surface area of a sphere has proportionality $S \propto r^2$, and that volume has proportionality $V \propto r^3$. Then $V \propto S^{3/2}$. Since $S_{DS} = \frac{1}{2}S_P$, we can raise the whole equation to the $3/2$ power to get

$$V_{DS} = \left(\frac{1}{2}\right)^{3/2} V_P.$$

Since $M_{DS} = 0.1M_P$, and density is given by $\rho = M/V$, we have

$$\rho_{DS} = \frac{0.1M_P}{\left(\frac{1}{2}\right)^{3/2}V_P} = \frac{1}{10} \cdot \frac{1}{2}^{-3/2} \cdot \rho_P = \frac{1}{10} \cdot 2^{3/2} \cdot \rho_P.$$

- (c) (10 points) In *A New Hope*, the Empire planned to use the Death Star to destroy Yavin 4. The weapon orbited the helpless planet while it made preparations to obliterate it.
- i. (5 points) Suppose the Death Star orbited at an altitude of 1000 km, and Yavin 4 had a diameter of 9500 km. If the Death Star is orbiting at 1.5 km/s, what is the orbital period in hours? Show work.

Solution: The distance between their centers (orbital radius) is given by $r = 1000 + 9500/2 = 5750$ km. So the circumference of the orbit is $C = 2\pi r \approx 36110$ km. Orbital period is given by total distance divided by speed, or

$$P = C/v = 36110/1.5 \approx 24073 \text{ s} = 6.69 \text{ h.}$$

- ii. (5 points) Suppose that Yavin had a mass of 4×10^{24} kg and the Death Star has mass 1×10^{21} kg. What is the gravitational force between the two, in Newtons? Show work.

Solution:

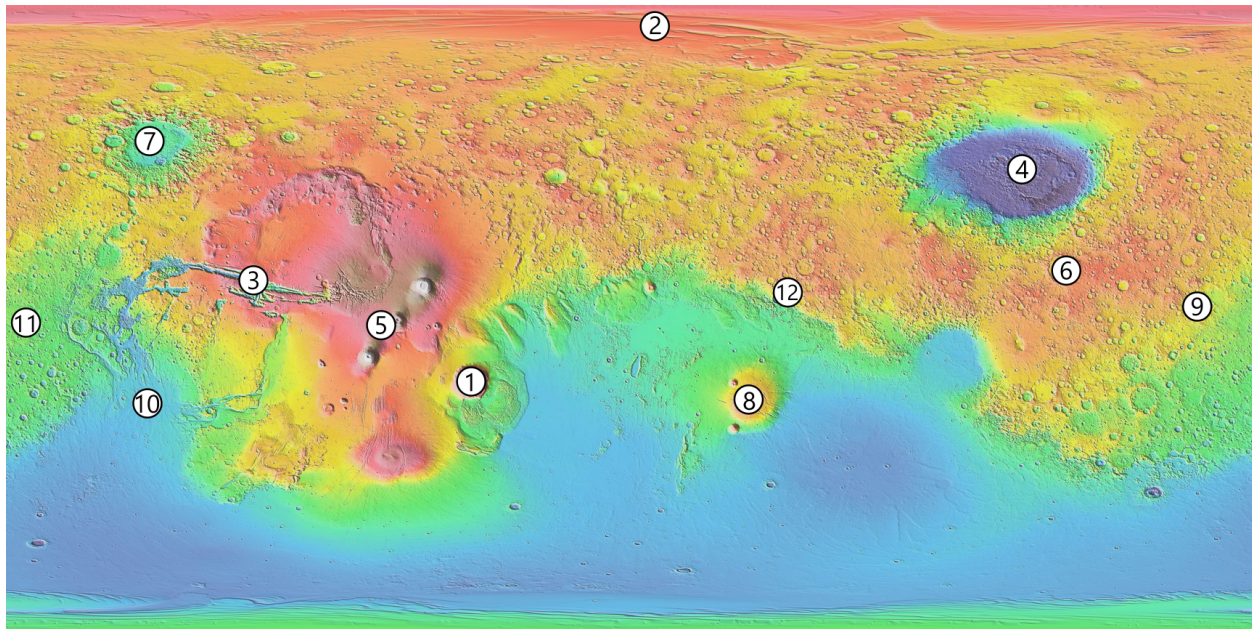
$$F_g = \frac{GMm}{r^2} = \frac{6.67 \times 10^{-11} \cdot 4 \times 10^{24} \cdot 1 \times 10^{21}}{5.75 \times 10^6} = 4.64 \times 10^{28} \text{ N.}$$

- (d) (5 points) After the rebels blew up the first Death Star, the Empire decided to build a second Death Star, this time over the forest moon of Endor. This forest moon had a substantial, breathable atmosphere. What is the only moon in the solar system with a substantial atmosphere?

Solution: Titan

4 Interpretive Task

The image below is an elevation map of the Martian terrain.



28. (12 points) Label the following features using their numbers:

- | | | |
|---------------------|--------------------|-----------------------------|
| 1. Olympus Mons | 5. Tharsis Montes | 9. Schiaparelli crater |
| 2. South Pole | 6. Huygens crater | 10. <i>Pathfinder</i> site |
| 3. Valles Marineris | 7. Argyre Planitia | 11. <i>Opportunity</i> site |
| 4. Hellas Planitia | 8. Elysium Mons | 12. <i>Curiosity</i> site |

29. (13 points) In this image, one hemisphere is mostly orange, while the other is mostly blue. What does this say about the geology of Mars? Explain the two most likely hypotheses for this geologic anomaly.

Solution: The northern hemisphere is, as a whole, at a much lower elevation than the Southern hemisphere. (3)

One possibility is that a giant impact (or many impacts) with the northern hemisphere in the planet's early history created an enormous, smooth basin. (5)

Another possibility is that plate tectonic processes could have been active earlier in Mars' history, and certain mantle convection patterns could have caused the lithosphere in the northern hemisphere to be thinner, smoother, and weaker. (5)