

**YOU MUST NOT USE YOUR LAPTOP, TABLET, CELLPHONE, or Textbook BRING A PICTURE ID.**

1. YOU MUST NOT USE YOUR LAPTOP, TABLET, TEXTBOOK, or CELLPHONE
  - a. Bring a calculator –(NOT the one on your cellphone) Do Not cheat off your neighbor!
  - b. Bring a Number 2 Pencil and an eraser.
2. HINTS ON TAKING "OPEN NOTES" TESTS-- WHEN STUDYING:
  - a. Carefully read the Chapter Summary, learn the "New Terms"
  - b. Try to do the Review Questions, and the Discussion Questions.
  - c. Work as many problems as you can. Feel free to ask me if you are having problems doing them.
3. TAKING THE TEST
  - a. Read the test questions carefully!
  - b. Go through the test once and answer all the questions that you can. Then go back and do the other questions.
  - c. You may mark on the test booklet: cross off obviously wrong answers, work the problems, and show your work.
  - d. Circle the answer on the test booklet - this is the last resort if you have made a mistake on the answer sheet.
  - e. Carefully darken in the answer on the answer sheet, do not rip, mutilate, fold, or spindle it.
  - f. Check your answer sheet. Make sure you have answered all 50 questions.
  - g. MAKE SURE THAT YOUR NAME IS ON THE ANSWER SHEET AND YOU HAVE PUT IN YOUR FULL UNIVERSITY ID NUMBER-LEFT JUSTIFIED. **FILL IN THE CIRCLES!** I will subtract points if this is not done.
  - h. BRING A PICTURE ID.

**Chapter 12: The Moon and Mercury: Airless Worlds.**

**MOON:**

1. The key similarity between the Moon and Mercury is their heavily cratered surfaces. Their surfaces provide a history of the early formation of the Solar System.
2. The Moon keeps the same face toward the Earth because of Tidal Coupling.
3. Where is the Terminator (the answer is not: "in California")? What is a Mare (plural is Maria)?
4. Why are the highlands on the Moon thought to be very old? And older than the Maria?
5. Read about impact craters - I went into this in some detail in class. What do the rays from some craters tell us? What and when was the Late Heavy Bombardment? (Pages 244-245)
6. Where and what is Mare Orientale?(Page 245)
7. Is there any evidence that impacts on the Moon blasted off rocks that fell onto the Earth? (Yes)
8. Know about the various missions to the Moon in the 1960's and 1970's. (Table 12-1)
9. All the rocks brought back to the earth are igneous - formed by the solidification of molten rock. (Page 247)
10. What is meant by anorthosites, breccias, regolith, vesicules? (Figure 12-5)
11. How did we learn about the internal structure of the moon?
12. How did the Maria form? (Figure 12-8) About how long ago? How do we know that they are younger than the highlands?
13. The only currently viable hypothesis for the formation of the Moon is the Large-Impact hypothesis originated by Al Cameron and collaborators. However, recent studies suggest that it must have been multiple smaller impacts (Figure 12-9)

**MERCURY:**

1. How long is the Mercury Day? How does it compare to the Mercury year (Figure 12-11)?
2. What does the surface of Mercury look like? What kind of craters are found on Mercury? (Figure 12-12)
3. Remember that Mercury is tidally locked to the sun but does not keep the same face to the Sun.
4. What is the Caloris Basin? How did its formation produce the lineated terrain? (Figure 12-13)
5. What caused the dark lava Plains? The Lobate Scarps?
6. Mercury also has smooth plains that date from after the Late Heavy Bombardment (Figure 12-14)
7. What do we know about the internal structure of Mercury? It's origin and evolution?
8. We know less about the interior of Mercury because it does not have a moon. It was only recently that the MESSENGER satellite orbited Mercury. It impacted a couple of years ago.
9. One of the Messenger discoveries about Mercury is that at one time it had a large number of volcanoes. (Stated in class with figures from MESSENGER)

**Chapter 13 Venus and Mars:**

**VENUS**

1. Does Venus go through phases as seen from the Earth? (Yes)
2. What is the rotation period of Venus, why is the direction of its rotation unusual? (Clockwise) How was it determined? (Radar)
3. Why is it difficult to see the surface? What are the clouds made of? What is the composition of the Venusian atmosphere? (The most abundant molecule is carbon dioxide but the clouds consist of droplets of sulfuric acid.)
4. The high temperatures on Venus are a result of a runaway Greenhouse effect.

5. How do we know what the surface of Venus looks like? (Figure 13-2) What was the purpose of the Magellan mission? (Figure 13-3)
6. The surface of Venus has both lava flows and rolling plains. There are both impact and volcanic craters on Venus. (Figure 13-5)
7. Venus also has Shield Volcanoes. Where are some prominent shield volcanoes on the Earth?
8. The discussion of both Shield and Composite volcanoes is found on pages 270-271. Also for Earth, Venus, and Mars.
8. What are Coronae? (Figure 13-8) What is the evidence that Plate Tectonics did not occur on Venus?
9. Who sent landers to the surface of Venus? What did they show? (Figure 13-2)

### **MARS:**

1. What do we know about the surface of Mars? What are the names of the various orbiters and landers? (Page 277)
2. What is the composition of the Martian atmosphere? How did it probably originate? Could we live on Mars without breathing apparatus? (No)
3. What molecules were able to escape from Mars (Figure 13-11)? I showed this figure for all the Jovian planets and their moons.
4. What is the importance of the amount of argon gas in the Martian atmosphere? (Mars once had a thick atmosphere)
5. Does Mars have a magnetic field? (No)
6. Mars has huge dust storms that last for months.
7. Mars has both shield volcanoes and impact craters - but in different regions. (Figure 13-14)
8. What is Olympus Mons? (Figure 13-15) What is Valles Marineris (Figure 13-14)
9. What is the evidence that there were large amounts of flowing water on the surface of Mars billions of years ago?(Figures 13-16 and 13-17)
10. What are outflow channels? Runoff channels? Where do we think the water is now? (Polar Caps)
11. What is the composition of the Martian polar caps? Are the two caps identical?(Figure 13-18)
12. What do we know about the Martian meteorites?
13. What are Phobos and Deimos? They most closely resemble captured asteroids.( Section 13-3)
14. Be familiar with the material on pages 286-287.

### **Chapter 14: Jupiter and Saturn**

#### **JUPITER**

1. Jupiter is the largest planet in the solar system and the second most massive object after the Sun. Section 14-1 introduces the outer planets except for Pluto which is discussed in Chapter 15.
2. Jupiter can be considered a Failed Star - why? It radiates more heat than it receives from the Sun. What is the heat source? (It is still contracting from its formation nearly 5 billion years ago)
3. We find Jupiter sized planets around other stars. How do we know this? (Figure 10-16)
4. The Great Red Spot is a very long lived storm. Who first saw it? (Page 298)
5. How does the average density of Jupiter compare to that of the Earth?
6. What is the average composition of Jupiter and Saturn? Of the atmosphere of Jupiter and Saturn? How deep do we see into their atmospheres? (Page 295)
7. Jupiter is not a perfect sphere. It is oblate (flattened) because it is rotating rapidly.
8. What are the rotation periods and how fast do the winds move on Jupiter and Saturn? (Shown in class)
9. We detect radio waves from Jupiter. They are produced by what feature of Jupiter? (Figure 14-3)
10. Do Jupiter and Saturn have Aurorae? (Yes)
11. What is the Io Plasma Torus? What is Io?
12. What are the Belts and Zones of the Jovian atmosphere? What are they telling us about the heat flow from the interior? Which are rising and which are falling? (Pages 298-299)
13. What happened to the Galileo Probe?
14. All the Jovian planets have rings. When were the rings of Jupiter discovered and how? (Figure 14-13)
15. What is the Roche Limit? What does it have to do with Planetary Rings?
16. I discussed the Shoemaker-Levy 9 impact. Do we have any evidence that such impacts have occurred elsewhere in the Solar system? (Yes! And on Jupiter more recently - picture shown in class) (see also Figures 16-23 and 16-24)
17. What do we know about the Jovian and Saturnian interiors? What happens to hydrogen gas as the pressure increases?
18. Why do we think that Jupiter and Saturn might have dense cores since we can't see deep into the atmosphere?
19. Why does Saturn radiate more energy than it receives from the Sun? (Page 308)
20. I discussed the Galilean Moons of Jupiter in some detail. They are Io, Europa, Ganymede, and Callisto. (Know Table 14-2)
21. You will need to know the distinguishing features of these moons. Why is Io so interesting? Why is Europa so important?
22. Io has a large number of erupting volcanoes. These blast sulfur into space to form the Io torus. (Figure 14-12) What causes the heating that results in volcanoes on Io? (Figure 14-11)
23. Europa probably has a liquid ocean underneath a thick ice layer. (Figures 14-9 and 14-10). Why do we think this?
24. Ganymede has both old and young surface regions. The craters look like they were formed by impacts with shaved ice.
25. Callisto has cratered regions and an old surface. It has not suffered as much tidal heating as the other moons. (Figure 14-6)
26. Are the rings of Jupiter old? (Figure 14-13: Page 307)

## SATURN

1. Saturn is the second most massive planet and it has a lower density than Jupiter.
2. It also rotates rapidly, almost as rapidly as Jupiter, and so it is oblate (flattened).
3. It radiates nearly twice as much heat as it receives from the Sun. What is the source of heat for this planet? (Page 308)
4. Saturn also has a magnetic field. But it is weaker than that of Jupiter.
5. Why are the clouds of Saturn less distinct than those of Jupiter? (Methane haze)
6. What is the name of the spacecraft that was orbiting Saturn until September 2017? What is the name of the Titan lander? (Cassini and Huygens)
7. Read about the discovery that the rings are actually particles and not solid. The pictures from the various spacecraft flybys revolutionized our understanding. For example, the Spokes seen in Voyager images. The breaking up of the rings into many smaller narrower rings. The Shepherd satellites associated with the F ring. (Pages 316-317)
8. Saturn has a lot of moons. Some are more important and interesting than others. (Figure 14-17)
9. Titan is definitely known to have an atmosphere and the existence of this atmosphere has been known for a long time.
10. What are some of the organic compounds detected in the atmosphere of Titan? (Hydrocarbons -> table shown in class)
11. Titan probably has a rocky core but the rest is very icy. It is larger than Mercury.
12. The Huygens lander probed the atmosphere and surface of Titan- I showed pictures of the surface in class. (Figure 14-16)
13. Read about the smaller moons.
14. Parts of the surface of Enceladus resemble the surface of Europa: cracks and new surface plus regions that are heavily cratered. (Figure 14-19)
15. Gas is being ejected right now from Enceladus. Cassini flew through the jets of gas being ejected to determine their composition.
16. How do we determine the relative ages of the moon's surfaces? (Number of craters)

## Chapter 15: The Outermost Planets: Uranus, Neptune, Pluto

### Uranus:

1. Look at the Celestial Profiles (Page 335: Look at the Celestial Profiles for all the planets)
2. When was Uranus discovered and by whom? (Page 323)
3. How is the direction of rotation of Uranus different from that of the Earth? How does that affect the seasons on Uranus? (Figure 15-2)
4. What is the structure and composition of its atmosphere? How does it compare to Neptune's atmosphere? (Figure 15-4)
5. What do we know about the internal structure of Uranus? (Section 15-1d)
6. What is the direction and strengths of the magnetic fields of the outer planets? Why are those of Uranus and Neptune so unusual? (Figure 15-6)
7. How were the rings of Uranus and Neptune discovered? How do they differ from those of Saturn? (See pages 332-333)
8. What do we know about the Shepherd satellites of the Uranus rings?
9. How many moons does Uranus have? How many had we found before the Voyager flights? (15-8)
10. The largest moon is Titania. How does its size compare to that of our own Moon? (Figure 15-8)
11. Look at the pictures on Pages 330 and 331. What are the various explanations of the surface features of Miranda? (Figure 15-10)
12. Where, in the Solar System, is it thought that Uranus and Neptune originated? (Page 334)
13. What is the relationship to their motion outward from where they formed to the Late Heavy Bombardment?

### Neptune:

1. When was Neptune discovered and by whom? ( A triumph of Newton's laws and the Law of Gravity) (Section 15-2a)
2. We know very little about Neptune - even with the Voyager flyby. It shows a lot more atmospheric features than does Uranus.
3. What do we know about the internal structure of Neptune? Remember that it has a source of internal heat.
4. Do the rings of Neptune also have shepherding satellites? (Yes)
5. What are some of the unusual features of Triton? What is its possible fate in the far future? (Figure 15-14)
6. How is the orbital plane of Triton and Nereid tilted with respect to the ecliptic? What causes the nitrogen plumes and geysers?
7. How and when were the nitrogen geysers discovered? (Figure 15-15)

### Pluto:

1. How was Pluto discovered? Could there be any more "planets" as large as Pluto in our Solar System but farther away? (Yes: larger)
2. What is the surface of Pluto like? (Figure 15-17)
3. What is Charon. How was Charon discovered? (Figures 15-17 and 15-18)
4. How many moons does Pluto have? (Lots)
5. Is Pluto massive enough to affect the orbit of Neptune? (No) How long have we known this? (Tombaugh knew this)
6. What was important about the transits of Charon across Pluto?
7. Does Pluto have an atmosphere? Yes
8. What are the Kuiper Belt Objects?
9. What space craft passed Pluto and Charon in July 2015? (New Horizons: Page 341) It is now on its way to another KBO and will reach it on January 1, 2019. Watch the papers.
10. The "heart" on the surface of Pluto is one of the more remarkable features on its surface. There are others.

## **Chapter 16. Solar System Leftovers: Meteorites, Asteroids, and Comets**

### **Meteorites:**

1. What are meteoroids, meteors, meteorites, meteorwongs? Where do the particles in meteor showers come from? What is a radiant? (Figures 16-5 and 16-6)
2. What is a Fall and what is a Find? (Page 349 and Table 16-1)
3. Where is the Barringer Crater? How old is it? (Figure 16-21)
4. What are the different kinds of meteorites? What is the importance of carbonaceous chondrites? (Figure 16-2)
5. What is meant by pre-solar grains in meteorites? (They appear to be almost unchanged since they were formed in stars atmospheres)
6. What do the existence of iron, stony-iron, and stony meteorites tell us about the asteroid belt? (Page 356-357)
7. Do some meteorites come from Asteroids? From the Moon? From Mars? (Yes to all)
8. When are some of the important meteor showers? (Table A-12 in the Appendix: page A-9) There is one just after Finals.
9. What is meant by the Radiant of a Meteor Shower? (Figure 16-5)
10. What is thought to be the origin of meteorites? (Figure 16-7)

### **Asteroids:**

1. Who was the first to discover an asteroid? When was this and which asteroid was it? How many are known now- roughly?(500,000)
2. Where are most of the asteroids located? What do they look like? What are their sizes? (Figure 16-10, Page 358)
3. What are the Trojan asteroids? Where are they located? What is the importance of earth crossing asteroids to us?
4. What is the evidence for asteroid collisions?
5. DAWN orbited and took pictures of which asteroid? (Figure 16-13)
6. What is so interesting about Mathilde? (It has a low density)
7. What are the major classes of asteroids? (C-type, S-Type, M-type –see page 357)
8. What recent spacecraft visited Vesta and took pictures (The Dawn Probe). It is took pictures of Ceres that I showed in class but it was turned off a few weeks ago.
9. What is the evidence that some meteorites come from Vesta? (Page 357)

### **Comets:**

1. What are the various parts of a comet? How big are they? What is the composition of the Coma?
2. What is a gas tail? A dust tail? What causes them to face away from the sun? What are the names of some famous comets? (Pages 362-363)
3. What does the nucleus of a comet look like? (Figure 16-15)
4. What happens to the debris from a comet after a passage near the sun? How is this material related to Meteor Showers?
5. How long does a comet last? How does its appearance change as it orbits the sun?
6. What was Shoemaker-Levy 9? What does its existence and behavior tell us about hits on the earth? (Figure 16-23)
7. What is the Oort cloud? The Kuiper belt? (Page 366-367)
8. What is meant by a “Shower of Comets” (discussed in class)
9. How often do collisions of asteroids and comets with the Earth occur? (Often if you count just small objects)
10. What is the evidence for these collisions? Is there a nearby crater? (Yes)
11. What is now thought to have caused the extinction of the dinosaurs? Where is the crater probably located? (Figure 16-25)
12. What was the Tunguska Event? When did it happen? What do people think was the cause? (Figure 16-21)
13. There was a large impact in Siberia 5 years ago and the flash was seen on dash-cams. They happen frequently.
14. The European ROSETTA mission reached Comet 67P/Churymov–Gerasimenko on August 6, 2014.
15. The comet has passed through perihelion and is now moving away from the Sun.
16. On November 12, 2014 the Philae lander reached the surface of the comet and bounced. I discussed this mission and the results in class.