## YOU MUST NOT USE YOUR LAPTOP, TABLET OR YOUR CELLPHONE 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 |
| h. | UNIVERSITY ID NUMBER-LEFT JUSTIFIED. I will subtract points if this is not done. |
| h. | BRING A PICTURE ID. |

## Chapter 9: Perspective origins:

1. I only covered 9-1: Pages 176-177
2. Know the material in the numbered paragraphs on Page 177.

## Chapter 10. Origin of the Solar System:

1. Remember the difference between rotation and revolution. A planet rotates on its axis and revolves around the Sun.
2. What are the facts that must be explained in order to understand the formation of our own solar system? Know the Solar System characteristics in Table 10-3.
3.What are the major similarities and differences between the inner Terrestrial planets and the outer Jovian planets? (Look at pages 198-199 and read the figure captions)
3. What is the importance of impact craters in determining the evolution of the solar system? The earliest theories for the formation of the solar system assumed that the sun was already present and the planets formed later. This is WRONG! (The Sun and Planets formed at the same time from the same material)
4. Where are the Asteroids found? Comets? The Kuiper belt?
5. How is the age of the solar system determined? What is meant by the half-life of a radioactive element? What are some of the elements that are used to date the Solar System? (Figure 10-5)
6. Radioactive dating is used to determine the age of the solar system. The half-life is the time it takes for half of a parent radioactive isotope to decay into its daughter isotope.
7. We measure the proportion of the original isotope to the daughter isotope to see how much time has passed.
8. Radioactive elements are produced in nova and supernova explosions. Possibly one went off nearby and caused the gas cloud to start collapsing into our Sun and planets.
9. LaPlace was the first to propose the nebular hypothesis in which the solar system formed from a contracting nebula. LaPlace understood gravity a lot better since he had the work of Newton on which to build.
10. What was the Angular Momentum problem? (The Sun rotates slowly - most of the angular momentum in the Solar System is in Jupiter)
11. The atoms in your body (except for hydrogen and helium) were formed by nuclear processes in stars.
12. The Solar Nebula Hypothesis assumes that the sun and planets were formed at the same time out of the same material but the sun formed slightly faster than the planets. This is slightly different from what is said in the textbook but more correct.
13. What is the evidence that the Solar nebula hypothesis is probably correct? (Observations of forming stars.)
14. What is a planetesimal? Protoplanet? Which comes first. What is meant by accretion?
15. What happens during differentiation? Is the Earth differentiated? Look at Figure 10-10.
16. What is meant by the condensation sequence of the gas in the solar nebula? (Table 10-2)
17. The planets formed in the spinning disk around the sun. Small particles condensed to form larger particles which collided to form planetesimals which collected into the proto planets. The planets closest to the sun lost most of their gas, those farther away did not.
18. Large amounts of gas from young stars is blown out into space at high speeds. This gas eventually accumulates with other gas to form new stars.
19. What is meant by differentiation of a planetary interior? The planet must be molten. ( Figure 10-10)
20. What is the Jovian Problem?
21. What is meant by outgassing? How is this related to the present atmosphere of our earth? The first atmosphere?
22. What is an Extra-Solar planet? What physical principal is used to find these planets (the Doppler Shift discussed in an earlier chapter and figure 10-16) ? Which planets in our solar system do they resemble? (See section 10-4)
23. What is liquid hydrogen and metallic hydrogen? Where are they found?
24. Why are the 4 largest satellites of Jupiter called the Galilean Satellites?
25. Radiation pressure describes the fact that light exerts a force on gas and small particles.
26. The nebular theory has been confirmed by studying other solar systems and regions of space where stars are forming. (Pages 213218)
27. The inner planets have higher densities - they are rocks and iron rich material. The outer planets are mostly thick atmosphere gas giants. They may have small rocky cores.
28. Asteroids and comets are the left-overs from the formation of the solar system. (The turkey on Friday the 28th).
29. There were enough asteroids and comets around in the young Solar System to fall onto the surfaces of all the planets and cause craters and reheating in some cases. We cannot see the surfaces of the outer planets but their moons (except Io) also show impacts.
30. We are searching, even as you read this, for possible large bodies that might impact the earth.
31. Deimos and Phobos are captured asteroids.
32. Our own Moon was probably caused by the impact of a large, Mars sized, object with the Earth after differentiation had occurred.

That is why its composition resembles the mantle and crust of the earth.
34. The latest results from the Kepler satellite is that virtually all stars that you see in the night sky have planets.
35. Kepler found planets by staring at a large number of stars and watching for the planet to cross in front of the star. It would then measure the dip in brightness caused by this eclipse.

## Chapter 11: Planet Earth

Know the celestial profile for each Planet. The one for Earth is on page 228.

1. What are the 4 stages of planetary evolution: differentiation, cratering, flooding, slow surface evolution? What is comparative planetology? (Figure 11-2)
2. What are the four processes that effect the geology of the earth and the other inner planets: impact craters, volcanism, plate tectonics (or its absence), and erosion.
3. What is seismology? How are pressure or p-waves and shear or s-waves used to determine the internal structure of the Earth? Look at figures 11-3, 11-4, and 11-5. I showed a number of different versions of Figure 11-5 in class.
4. What are the various parts of the interior of the earth and where are they located? The four layers of the Earth are the inner solid core, the liquid core, the mantle, and the crust. Why is the core thought to be iron rich material?
5. What are the heat sources in the Earth's interior? How do we know the ages of the rocks?
6. The Earth has a magnetic field that protects us from particles emitted from the Sun. What are the Van Allen Belts? How is the Earths magnetic field like a bar magnet? What is the evidence that the direction of the magnetic field changes with time:
7. What is the relationship between the Aurorae and the Earth's magnetic field and radiation belts?
8. What is Plate Tectonics? How are the mid ocean rise and mid ocean rift connected?
9. What is a subduction zone (See pages 234-235)? What is basalt rock formed out of? Look at the figure captions on page 234.
10. What mountain range is formed from the collisions of plates? (Himalayas)
11. A rift valley is formed when a crustal plate splits. Where is the crust of the earth thinnest? Thickest?
12. What will the continents look like in about 250 million years? Plates can slip along each other.
13. What is the evidence for plate tectonics and continental drift? What is a Convection Cell and how does it transfer heat from the interior to the surface? What is Magma?
14. The Hawaiian Islands are caused by a hot spot in a plate which brings magma to the surface and the overlying plate moves with respect to the hot spot. They are shield volcanoes. The types of volcanoes are discussed on pages 272-273 (The chapter on Mars).
15. What is the composition of the Earth's atmosphere? How is it similar to and different from other planetary atmospheres such as Mars and Venus? (Table 11-1)
16. What probably happened to Earth's first atmosphere? What is the source of our current atmosphere?
17. What is the source of the oxygen in the atmosphere?
18. What is the Greenhouse effect? What are the Greenhouse gases? Where else is the Greenhouse effect important in the solar system?
19. Our water probably came from outgassing via volcanoes and maybe the result of cometary impact.
20. Since the Earth did not freeze, the oceans could absorb carbon dioxide and reduce the amount of Greenhouse gases in the atmosphere.
21. Venus was so hot that water vapor escaped and allowed carbon dioxide to increase and produce a runaway Greenhouse effect.
22. What is meant by the Albedo of a planet? (The fraction reflected)
23. What is global warming and how is it related to the amount of carbon dioxide in the atmosphere? Discussed in Class!
24. Where is the Ozone layer located? Why is the Ozone layer important to life?

25 . What human effects have changed the ozone layer?
26. How does the depletion of Ozone affect life on the earth? What causes ozone depletion?
27. The best discussion of Volcanoes can be found on pages 272-273.

## 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 246-247)
6. Where and what is Mare Orientale?
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.
10. What is meant by anorthosites, breccias, regolith, vesicules? (Figure 12-5 on page 251)
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. (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?
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 12-14)
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 12-15)
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 began orbiting Mercury .
9. One of the Messenger discoveries about Mercury is that at one time it had a large number of volcanoes.

## 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)
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? 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 272-273. For Earth, Venus, and Mars.
9. What are Coronae? (Figure 13-8) What is the evidence that Plate Tectonics did not occur on Venus?
10. 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 281)
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)?
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?
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?
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.( Pages 289 and 292)
14. Be familiar with the material on pages 290-291.

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. It can be considered a Failed Star - why? It radiates more heat than it receives from the Sun. What is the heat source?
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 299)
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 14-4)
10. Do Jupiter and Saturn have Aurorae? (Yes)
11.What is the Io Plasma Torus? What is Io?
11. 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 302-303)
12. What happened to the Galileo Probe?
13. All the Jovian planets have rings. When were the rings of Jupiter discovered and how? (Figure 14-13 page 311)
14. What is the Roche Limit? What does it have to do with Planetary Rings?
15. 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) Figures 16-22 and 16-23.
16. What do we know about the Jovian and Saturnian interiors? What happens to hydrogen gas as the pressure increases?
17. Why do we think that Jupiter and Saturn might have dense cores since we can't see deep into the atmosphere?
18. Why does Saturn radiate more energy than receives from the Sun? (Page 314)
19. I discussed the Galilean Moons of Jupiter in some detail. They are Io, Europa, Ganymede, and Callisto. (Know Table 14-2)
20. You will need to know the distinguishing features of these moons. Why is Io so interesting? Why is Europa so important?
21. 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)
22. Europa probably has a liquid ocean underneath a thick ice layer. Figure 14-10. Why do we think this?
23. Ganymede has both old and young surface regions. The craters look like they were formed by impacts with shaved ice. Figure 147.
24. Callisto has cratered regions and probably an old surface. It has not suffered as much tidal heating as the other moons. Figure 14-6
25. Are the rings of Jupiter old? Figure 14-13 (No: Page 311)

## 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 314)
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 orbiting Saturn? What was 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 320-321)
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 sometime.
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. There are lots of unanswered questions.
12. The Huygens lander probed the atmosphere and surface of Titan. 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.

Plus gas is being ejected right now. Cassini just flew through the jets of gas being ejected to determine their composition (Nov 2015)
15. How do we determine the relative ages of the moon's surfaces? (Number of craters)

