# 1141 Exam 3 Study Guide

November 5, 2021

## 1 General Planet Knowledge

a. What is the greenhouse effect? What gases are large contributors to it?

- The Greenhouse Effect is the warming of a planet by sunlight and by having its own emitted radiation trapped by its atmosphere, much like a greenhouse.
- Carbon Dioxide and Water Vapor
- This is why people talk about 'carbon emissions' on Earth. The carbon dioxide human activity puts into the atmosphere increase the greenhouse effect, possibly causing the planet to heat up overall (global warming)

b. What happens during a runaway greenhouse effect? What planet can we see the effects of this on?

- The heat generated by the greenhouse effect causes water to evaporate which puts more water vapor into the atmosphere. This causes a stronger greenhouse effect, which evaporates more water. This feedback loop causes it to 'runaway' until incredibly high temperatures are reached.
- Venus is currently undergoing a runaway greenhouse effect

c. What is a planet's albedo?

- The albedo is a measure of how reflective the planet's surface is to incoming radiation.
- An albedo of 0 means that all incoming radiation is absorbed, very little is reflected (think about asphalt).
- An albedo of 1 means that all incoming radiation is reflected (think about snow).

d. Why is it helpful to have the mass and radius of a planet/moon?

- These two will let you determine the density, which tells you about the composition.
- Denser planets and moons are rockier, made of heavier elements
- Less Dense planets are made of lighter elements, like gases or ices

e. How are planets magnetic fields generated? What factors into determining how strong they are?

- The dynamo effect: the spinning of a planet with a metallic core generates a magnetic field
- Rotation speed plays an important role, If two planets have similar cores, the one spinning faster about its axis will have a stronger magnetic field.

## 2 Terrestrial versus Jovian Planes

a. What are the Terrestrial Planets? What makes them different?

- Mercury, Venus, Earth, and Mars
- They are primarily rocky and dense, made of heavy elements and iron cores
- Because they are closer to the sun, they are hotter than the jovian planets
- If they have an atmosphere, it is made of heavier gases like carbon dioxide or nitrogen. Hydrogen and helium escape their weak gravity

b. What are the Jovian Planets? What makes them different?

- Jupiter, Saturn, Uranus, Neptune
- They are larger and more massive, but also less dense. They are made of mostly gas and ice, rather than rocky materials
- Because they are farther from the sun, they are colder than the terrestial planets
- They have lots of lighter gases like hydrogen and helium that inner planets don't because they are bigger and colder

c. Why are the Jovian planets more massive than the terrestial planets?

- They accreted enough planetismals to form a large solid core which lets them gravitationally collect light elements in a runaway effect.

## 3 Mercury

a. What is the ratio of Mercury's orbital period to rotational period? What does this imply about the solar day on Mercury?

- Mercury's year is 1.5x its sidereal day.
- This implies that the solar day (the time it takes for the Sun to get to the same point on Mercury's sky) is actually 2 Mercury years

b. Why is Mercury's surface similar to that of the Moon's? What feature do they share that causes this?

- Both the Moon and Mercury have no atmosphere.

- This means they both have little protection from meteors and are thus heavily crated by such objects.
- Other bodies, such as the Earth, also experience impacts, but are somewhat more protected by their atmosphere. If these bodies are active as well, these craters can be resurfaced.
- Unlike the Moon, however, Mercury has a rather larger iron and much denser.

c. What is unique about Mercury's composition?

- It is unusually dense, attributed to an unusually large metal core and thinner relative size of its rocky crust.

d. Mercury is the closest planet to the sun. Does this mean it is also the hottest planet in our solar system?

- No. Normally it would, but because of the runaway greenhouse effect on Venus, Venus is actually hotter than mercury.
- However, because of it's lack of atmosphere, it does have the highest difference between day temperature and night temperature of any planet in the solar system.

## 4 Venus

a. Why would Venus be considered a "twin" or "sister" of Earth? What properties do they share?

- Venus is the most similar planet to Earth in terms of its size, mass, density and distance from the sun.
- Mars, however, is closer in terms of length of day.

b. Why does Venus have a weak magnetic field?

- It rotates very slowly (¿ 20 Earth days) and so the dynamo in its core is not nearly as strong as Earth's.
- In fact, Venus rotates backwards with respect to its orbit than the rest of the planets. It's day is longer than its year!

c. What are the main gases in Venus' atmosphere?

- Carbon Dioxide and Sulfuric Acid. Since acid can turn into a liquid easily, it can even condense into clouds and rain down like water on Earth.

d. What are some of the differences between the Greenhouse Effect on the Earth versus that on Venus?

- Venus is in a runaway state where the effect keeps compounding in on itself. As such, it is the primary determinant of Venus' temperature.
- The effect is still only moderate on the Earth, raising the temperature by only 20-30 degrees (Kelvin/Celsius) compared to what it would be from the Sun alone.
- The Earth also has organic processes that recycles some of the heavy Greenhouse elements, unlike Venus, where they remain locked in the atmosphere.

## 5 Earth and Moon

a. Roughly, what is the temperature at the surface of the Earth (in Kelvin)?

- 300 K

b. What saves the Earth from the solar wind?

- Its magnetic field, which deflects the incoming ionize particles.
- A loop of charged particles follow these magnetic field lines from the earth to make up the Van Allen belts.

c. Why does the Earth have lots of oxygen compared to, say, Venus?

- Plants and other organic bodies are able to free the oxygen locked in CO2.

d. What is the most common elements in Earth's atmosphere?

- Nitrogen is the most abundant, making up 78% of the atmosphere.
- Oxygen and Argon make up 21 % and 1% respectively.
- The remaining 1% is various other gases like Carbon Dioxide

e. What are the major layers of the Earth?

- Solid inner core, liquid (iron) outer core, mantle, and then crust.

f. Briefly describe plate tectonics.

- The lithosphere on the crust is split into sections call plates and move around the Earth's surface.
- Interesting phenomena happen because of this, such as the continents drifting away from each other forming rift zones (like the Mid-Atlantic) and forming mountains/volcanoes where the plates collide.

g. Compare and contrast the highlands and marias on the Moon. How can tell which are older and younger.

- Highland - The lighter cratered part of the moon's surface. The are the oldest part of the surface, with large craters formed from early bombardment. Are much more disparate in height, as you might imagine.
- Marias - The darker spots on the moons surface. They are younger regions formed when lava partially filled in older craters and then cooled. Tend to be flatter than the highlands.
- We can tell the Maria are younger because they have much less cratering, which would have been forming over time. Because their formation wiped away lots of craters, they are much smoother.

# 6 Mars

a. How do Mars' mass, size, day and year compare to Earth's?

- Mass = 0.1 Earth masses
- Radius $\approx$ 0.5 Earth radii
- Day $\approx$ 1.03 Earth days
- Year = 1.88 Earth Years

b. How does Mar's average temperature compare to the Earth's? What about Mars' maximum temperature?

- Mars' average temperature is 220 K, much colder than Earth's.
- Its maximum temperature, however, is 293 K, or about 70 degrees Fahrenheit.

c. Does Mars have seasons?

- Yes, Mars has an axial tilt similar to that of the Earth.
- The seasons are even stronger because it has a larger eccentricity orbit around the Sun than the Earth does.

d. What are the polar ice caps on Mars made of?

- Frozen CO2, also known as dry ice, with frozen water underneath.

e. What is the name of the extremely large volcano on Mars? Why are volcanoes much larger on Mars than on Earth?

- Olympus Mons.
- Volcanoes are larger because Mars has much less surface gravity to fight against, so the land can rise up higher.

f. We see evidence that there used to be liquid water on Mars. If it can't stay there now, how did it before?

- In the past, Mars did have a thicker atmosphere. This thicker atmosphere allowed it to be warmer and permitted liquid water.

g. What sort of weather do we see on Mars?

- Mostly, we see dust storms blowing around, whipping up the light dirt and dust of the martian surface all over the place, and cooling the surface as it obscures the sun.
- Observations of these dust storms were actually used to test theories of a "nuclear winter" on Earth.

# 7 Jupiter

a. How do Jupiter's mass, size, day and year compare to Earth's?

- Mass = 318 Earth masses (1/1000 of a solar mass)
- Radius $\approx$ 11 Earth radii
- Day $\approx$ 0.4 Earth days
- Year = 11.86 Earth Years

b. Jupiter and Saturn seem to emit more energy than they receive from the sun. Where does the extra come from?

- Gravitational Contraction. The gas falls in closer to the planet, releasing energy which is then emitted outside the planet.
- This doesn't come from fusion. Jupiter is much too small to ignite fusion inside of itself, and so can't become a star at any point in its life

c. What properties of Jupiter lead to its strong magnetic field?

- It's large core and rapid rotation speed both combine to make a strong magnetic field
- Jupiter's solid core is surrounded by a large quantity of liquid, metallic hydrogen
- Jupiter is also rotating very rapidly, over twice as fast as the earth.

d. What are Jupiter's stripes? What about the big red spot on it?

- Alternating bands of convection belts where the atmosphere is rising and falling.
- Where it is rising, the bands are light and where it is falling, the bands are dark
- The Great Red Spot is a persistent storm on Jupiter. Similar to the dark spots that form on Neptune but more consistent.

e. What are the 4 Galilean Moons of Jupiter? Which is the largest moon in the solar system? Which is closest to Jupiter and what makes it special?

- The 4 moons are Io, Europa, Ganymede, and Callisto
- Callisto is the largest moon in the solar system, but it is less dense than Io or Europa
- Io is the closest moon to Jupiter. The tides of Jupiter squeeze the moon causing lots of volcanic activity and a very young surface (evident from the lack of craters)

## 8 Saturn

a. How do Saturn's mass, size, day and year compare to Earth's?

- Mass = 95 Earth masses
- Radius ≈ 9 Earth radii
- Day ≈ 0.4 Earth days
- Year = 29 Earth Years

b. What are Saturn's Rings made of? Where did they come from?

- Ice mostly, though there are some rocks
- It was most likely a failed moon. Instead of forming into a moon, the tides of Saturn tore it apart and formed it into rings

c. Are the rings continuous? What are shepherding moons?

- No, there are small gaps between rings populated by tiny moons
- Shepherding moons are the small moons between rings that help maintain the structure of the rings.

d. What is unique about Saturn's density? What is it's atmosphere made of?

- It is less dense than water. It is the least dense planet in the solar system.
- It's atmosphere is primarily hydrogen, unlike that of Uranus or Neptune

f. What is Saturn's largest moon? What is unique about it?

- Titan is Saturn's largest moon. Second largest in the solar system.
- It is thought to be similar to that of the primordial earth and possesses an atmosphere that is primarily methane. It's too small for lighter gases to stay.

## 9 Uranus and Neptune

a. William Herschel discovered which planet? Which planet was first predicted mathematically based on the orbits of other planets?

- Uranus was discovered by Herschel
- Neptune was predicted from orbits before it was observed

b. How do Uranus' mass, size, day and year compare with Earth's?

- Mass: 14.5 Earth masses.
- Radius: $\approx$ 4 Earth radii.
- Day: $\approx$ 0.7 Earth day.
- Year: 84 Earth years.

c. How do Neptune's mass, size, day and year compare with Earth's?

- Mass: 17 Earth masses.
- Radius: $\approx$ 3.9 Earth radii.
- Day: $\approx$ 0.7 Earth day.
- Year: 165 Earth years.

d. What's the tilt of Uranus' rotation axis compared with its orbit around the Sun? Why do we think this is?

- 98 degrees! It's essentially rolling around its orbit.
- We theorize that this is because something collided with it during the formation of the solar system, knocking it on its side.

e. What molecule is prominent in the atmosphere of Uranus and Neptune, giving them their colors?

- Methane

f. How do Uranus' and Neptune's rings compare to Saturn's? Are they stable?

- The are mostly rocks rather than ice and are unstable.
- Not nearly as impressive as Saturn's, they were first noticed when they blocked out background stars around the planets.