

Problem 1.[15 points].

Describe the chemical, thermal, and physical properties of the atmospheres of Venus, Earth, Mars, highlighting the differences. List at least three properties.

Venus, Earth, and Mars are all known as terrestrial planets. They all have relatively similar sizes and a rocky surface. For chemical properties, Venus consists of a very thick CO₂ atmosphere as well as sulfur clouds. The CO₂ contributes a lot to Venus's greenhouse effect and therefore results in very hot temperatures. Venus also has flake tectonics occurring underneath, in contrast to Earth's plate tectonics. The convection currents are much more vigorous which result in a crumbled surface. Venus also has no magnetic field. Mars has a very thin CO₂ atmosphere and low gravity. It is slightly smaller in size compared to Earth, and has huge extinct volcanoes. The temperature is also very cold, due to the fact that the planet is smaller and has a thin atmosphere. Earth on the other hand has a thick atmosphere, which is crucial to sustain life. It also has liquid water, plate tectonics, and volcanic activity.

Problem 2. [20 points]

Describe at least four key physical and chemical properties of Europa and Titan, highlighting the differences. You can consider global properties of the satellites, properties of their interior, properties of their surface, and properties of their atmosphere.

For Europa, it has a thin oxygen atmosphere, made with destroyed water molecules. It is covered with a layer of ice with lots of ridges, possibly due to the fact that water underneath breaks through the surface and fills the cracks. This is powered by the tidal heating from Jupiter, which results in so called "water tectonics". Europa is the second farthest Galilean moon from Jupiter, which results in the tidal heating, but not too much so that it causes crazy volcanic activity like Io. Europa is thought to have a rocky mantle and an iron core.

Titan is thought to be a strong contender for life outside of the solar system because of its properties. It is the only moon in the solar system with a sufficient atmosphere, which is about 1.5x the atmospheric pressure of Earth, and the atmosphere consists of 98% nitrogen. However, because it is so much further away from the Sun, the temperature is obviously much colder. In Titan, scientists have discovered the presence of hydrocarbons, which are compounds essential for life. We believe that these compounds can fall like rain on Titan, which forms streams and rivers. Titan has a core of a mixture of ice and rock, and the moon is differentiated into layers.

Titan has a much thicker atmosphere than Europa, and also has precipitation. Europa has a layer of ice with a liquid ocean underneath.

Problem 3. [15 points]

Explain why Jupiter and Saturn are planets and not stars. Would Jupiter and Saturn become a star if they were combined? Explain the reason why they would or would not become a star. [200 words maximum]

The definition of a planet is that it must orbit the Sun, it must be big enough to have enough gravity to force a spherical shape, and it must be big enough to have cleared its orbit. Jupiter and Saturn both fit this definition. In order to become a star, you need high enough temperatures to ignite nuclear fusion, and therefore a high enough mass. Jupiter is way too small to become a star (around 80 times), so even if you combined it with Saturn, the mass would not be sufficient to form a star.

Problem 4. [15 points]

What are the main facts that support the hypothesis that the solar system originated by a single proto-planetary disk? List at least three. [200 words maximum]

A few main facts that support the proto-planetary disk theory are the fact that the orbits of the majority of the objects in the solar system lie in the same plane. This supports it because as the disk spun faster and faster, it expanded and as a result, planets formed through accretion of material colliding with each other in the same plane. Another fact that supports it is that most planets rotate in the same direction. The planets that do not are thought to have been disturbed by some collision afterward. Lastly, the Sun could be evidence since it is evidence of a gravitational contraction of the center of the nebula.

Problem 5. [20 points]

List and compare the temperature of the atmospheres of Venus, Earth, and Mars. Explain why they are different, discussing at least two physical properties of each planet and of their orbits that contribute to the difference in temperature [200 words maximum]

Earth's temperature is around 14C, Mars is around -63C, and Venus is much larger at 460C. Mars is much colder because it is a smaller planet, further away from the Sun, and does not have a sufficient atmosphere to retain the heat. Venus on the other hand is the closest to the Sun out of these 3, and it has a thick layer of CO₂ atmosphere that results in a large greenhouse effect, retaining all the heat of the planet. The Earth's orbit is between Venus and Mars and has a moderate atmosphere which also helps the planet retain heat. This would make sense, as Earth's temperature is in the middle of the other two.

Problem 6. [30 points]

Earth, Europa, and probably Ganymede have vast reservoirs of liquid water. Explain in each case what is the source of energy that keeps the water liquid. In contrast, Mars and the Moon seem to only have frozen water. List two physical differences between Mars and Earth, and one physical between Europa, Ganymede and the Moon, that contribute to the different state of water in these bodies. [200 words maximum]

In Earth's case, the planet is located at a perfect distance from the Sun, far enough so that the water doesn't evaporate, and close enough so that the temperature isn't cold enough to turn it to ice.

For Mars and the Earth, some physical differences that contribute to the lack of liquid water on Mars would be that Mars has a much lower atmospheric pressure, lower temperatures overall, and size. Although Mars has polar ice caps, due to the low atmospheric pressure, the ice cannot convert to liquid form. Also, the temperature on Mars is much colder in general which also prevents water from forming, partially due to its smaller size and its further distance from the Sun.

For Ganymede and Europa are Moons of Jupiter, which means that the effect of tidal heating is much more significant than that of the Moon. The heat from this leads scientists to believe that there is a liquid ocean within them. Ganymede also is the only Moon to have a magnetic field, which could play a role in the existence of liquid water underneath.

