

**1) Why do astronomers consider the space between planets to be a vacuum, in comparison with the atmosphere near sea level?**

- Astronomers refer to the space between planets to be a vacuum because it contains less than one atom per liter, whereas air at sea level contains  $2.7 \times 10^{22}$  atoms per liter.

**2) What is Earth's magnetic field?**

- Earth's magnetic field is a dipole, meaning it has a North and South pole (two poles).

**3) How does the magnetic field interact with solar wind? Be sure to consider the magnetosphere, the Van Allen radiation belts, and the aurorae.**

- The solar wind distorts the magnetic field so that it tapers away from the sun in a teardrop shape. Earth's magnetic field acts as a shield against solar wind by deflecting most of the wind so that the particles in the wind do not reach Earth's surface. The Van Allen radiation belts consist of solar wind particles that were strong enough to get through the weaker magnetic fields farther from Earth, but cannot get through the stronger magnetic fields closest to Earth. By trapping cosmic rays, these belts protect Earth from dangerous radiation, and when these particles interact with gas atoms in the upper atmosphere, they cause the gases to glow and create spectacular aurorae.

**4) What is the Earth's atmosphere composed of, and how does it differ from the atmosphere of Venus and Mars? Why would you die of suffocation if you were to eject from a fighter plane at an elevation of 12km without taking an oxygen tank with you?**

- The Earth's atmosphere is composed of 78% nitrogen and 21% oxygen, with minor amounts of argon, carbon dioxide, neon, methane, ozone, carbon monoxide, and sulfur dioxide. Venus and Mars consist of mostly carbon dioxide.

**5) What is the proportion of land area to sea area on the Earth? From studies of the hypsometric curve, approximately what proportion of the Earth's surface lies at elevations about 2km?**

- The Earth is 70% surface water (oceans, lakes, and streams) and 30% dry land (continents and islands). Most of land lies within 1km of sea level.

**6) What are the two most abundant chemical elements in the Earth? Describe the major categories of materials constituting the Earth.**

- Iron & oxygen are the two most abundant chemical elements in the Earth.
- Major categories of materials:
  - i. Organic chemicals: carbon-containing compounds that either occur in living organisms, or have characteristics that resemble those of molecules in living organisms
  - ii. Minerals: solid substance in which atoms are arranged in an orderly pattern
  - iii. Glass: a solid in which atoms are not arranged in an orderly pattern
  - iv. Rocks: aggregates of mineral crystals or grains, and masses of natural glass
  - v. Sediment: an accumulation of loose mineral grains
  - vi. Metals: solids composed of metal atoms
  - vii. Alloys: a mixture containing more than one type of metal atom
  - viii. Melts: form when solid materials become hot and transform into liquid
  - ix. Volatiles: materials that easily transform into gas at the relatively low temperatures found at the Earth's surface

**7) What observations led to the realization that the Earth is largely solid and that the Earth's mass is largely concentrated toward the center?**

- First, the measure of the Earth's density and shape had to be conducted in order to further understand in inside of the Earth. Once it was determined that the density of Earth was greater than that of its surface rocks, scientists had to ask whether the density gradually increased with depth or if the shell was much less dense than the core. If the density gradually increased, the Earth would eventually flatten into a disk with time after spinning. Since this does not happen, it was concluded that Earth's mass is largely concentrated toward the center.

**8) What are earthquake waves? Does the velocity at which an earthquake wave travels change or stay constant as the wave passes through the Earth? What are the principal layers of the Earth? What happens to earthquake waves when they reach the boundary between layers?**

- Earthquake waves are the energy in the vibrations due to the original earthquake. These waves travel at different velocities through different materials. When these waves reach boundaries between layers, they change velocities.
- Principal Layers:
  - i. Crust: composed of rocks such as granite, basalt, and gabbro
  - ii. Mantle: in between the crust and core; composed of a then-unknown material
  - iii. Core: also composed of a then-unknown material

**9) How do temperature and pressure change with increasing depth in the Earth? Explain the geothermal gradient.**

- Temperature and pressure change by increasing with increasing depth. Pressure increased because the downward push from the weight of the overlying rock increases with depth, making its weight heavier than that above it. Temperature increases with depth due to the geothermal gradient. The geothermal gradient averages about 15-50 C in the crust, with a rate of 10 C increase per km (ie. 35km below the surface of a continent averages 400-700 C).