

Mentoring Advanced Placement Physics



Topics: Atmosphere, Pressure, and Ozone

Quick questions

Q: Our atmosphere contains substantially more of the green house gasses - carbon dioxide, water vapor, and methane - than gaseous ozone, but ozone is still considered important. Why?

Q: The green house gasses, carbon dioxide, methane, and water vapor, are important to human habitation of the earth. Why? What would happen without them?

Challenge:

Figure out a method for finding the weight of the entire earth atmosphere. Using this method, what is the weight?

QQ Solutions:

QQ 1. Though the green house gasses all contribute to insulating the earth and keeping its surface at a more livable temperature, ozone contributes additionally by absorbing radiation from the sun in the UV range. This happens because the molecule's size, and the size of bonds between its oxygen atoms, are of proper length to interact with UV wavelengths. Similar to how microwaves interact with water, UV rays give their energy to ozone and cause it to vibrate.

At the poles, ice crystals in the air give CFC's a stable platform to act on, increasing the rate of ozone decomposition. This leads to more rapidly thinning ozone at the polar regions.

QQ 2. These gasses act as insulation, regulating the earth's temperature. Without them the earth average surface temperature would drop from 13°C to roughly -17°C, and life would struggle. Insulation is important, but too much of it and the temperature rises, as many scientists would say is happening now.

Challenge Discussion and Solution

The earth's atmosphere behaves much like a liquid, with current and pressure gradients driving weather patterns. Though this liquid surrounds us, and a significant amount of atmospheric material envelops us at all times, most people pay little attention to it.

- Ask students to consider the affects of atmospheric pressure.
- How does drafting in sports address it?
- At sea level, we feel no external pressure. What would happen to our bodies if there actually was an atmospheric pressure of zero?
- When we breath, air flows into and out of our lungs. What does this say about air pressure in our lungs during the cycle? Some describe the inflow as a product of negative pressure in the lungs. How is this possible?/ Isn't negative pressure impossible.

Steps to solution:

1. At sea level, atmospheric pressure is defined as 1atm., equal to 15psi.

Since atmosphere is fluid like, methods for modeling pressure in fluids can be applied. This means that the pressure at sea level is a result of the downward pressure of all atmospheric material above sea level, as acted upon by gravity, similar to water pressure at a depth being dependant only upon the weight of the water, and atmosphere, above it. (Gravity is a central force, perpendicular vectors will balance and cancel out)

Thus, the net weight of a square inch column of air, from sea level to the atmosphere's end, is 15 pounds.

2. The radius of the earth is 6.4×10^6 m, or 2.5×10^8 in. For a sphere, surface area is $4\pi r^2$, making the surface area of the earth roughly 7.9×10^{17} in².

3. $(7.9 \times 10^{17} \text{in}^2)(15 \text{ lb/in}^2) = 1.2 \times 10^{19}$ lb

With 2000 lbs/ton, this is 5.9×10^{15} tons, 5,900,000,000,000,000 tons, or 5.9 quadrillion tons, of atmosphere.