PART I: Energy and Mass

CHAPTER 1 - Composition and Structure of the Atmosphere

Review Questions:

1. Why is it difficult to define an absolute top of the atmosphere?

   Because as the density of atmospheric gases decreases with height, the atmosphere slowly merges to space.

2. What are the homosphere and the heterosphere?

   Layers of the atmosphere based on the composition of gases. The homosphere describes a layer, nearer the surface, which combines all gases in proportion to the total atmospheric composition. The heterosphere lies above this region. Here, gases separate into distinct layers based on atomic weight.

3. What is the difference between the permanent and variable gases of the atmosphere? Which gases are the most important in terms of their contribution to the total mass of the atmosphere?

   Permanent gases are relatively stable and as such they have very long residence times. Due to long residence times permanent gases constitute the bulk of the atmosphere's mass. Variable gases are those that are readily exchanged between the atmosphere and the surface of the Earth through various processes. They typically have relatively short residence times, as Earth/atmosphere processes are adept at removing them.

4. Given that variable gases are so rare, why are they considered at all?

   Variable gases such as water vapor and carbon dioxide are extremely important to life functions on earth. In addition, these small percentage gases are crucial to Earth's energy (radiation) balance.

5. Why has the concentration of carbon dioxide in the atmosphere been increasing over the last century?

   The principal cause for carbon dioxide increases in the atmosphere is human combustion of fossil fuels. Fossil fuels represent carbon stores over many millions of years. Human related combustion acts as a direct input of this stored carbon into the atmosphere.

6. What is ozone, and why is it both beneficial and harmful to life on earth?

   Life on Earth evolved without the presence of ultraviolet radiation. Ozone protects the surface from this radiation, which in high quantities is lethal to most life forms.

Additionally, ozone plays an important role in Earth's energy balance. This "good" ozone lies far above the surface in the stratosphere. Ozone itself is highly toxic. So, tropospheric ozone concentrations are considered a pollutant.

7. What are aerosols? Are they formed only be human activities or are they also naturally occurring?

   Solid and/or liquid particles (other than cloud drops and precipitation) suspended in the atmosphere. Aerosols have many human and natural sources. Natural sources include volcanic activity, sea spray (in the form of ejected salts), dust, pollen, and bacteria.

8. How do photosynthesis, respiration, and decay affect the carbon dioxide balance of the atmosphere?

   Photosynthesis and plant respiration deplete atmospheric carbon dioxide while building atmospheric oxygen, respectively. Decay of plant matter, and animal respiration adds to the total amount of atmospheric carbon dioxide. Therefore, these processes are critical to the carbon cycle and the resulting carbon balance of the atmosphere.

9. In what way does the density of the atmosphere vary with altitude?

   Due to the compressibility to gas, the density of the atmosphere decreases with height.

10. What are the distinguishing characteristics of the troposphere, stratosphere, mesosphere, and thermosphere?
    These layers are defined by their temperature characteristics with height. Distinguishing characteristics of the troposphere include an overall temperature decrease with height, the presence of virtually all of the atmosphere's store of water vapor, and vertical mixing and turbulence which contribute to general weather processes. Characteristics of the stratosphere include increasing temperatures with height due to the presence of the ozone layer. Inherent stability within this layer is also notable. The mesosphere is marked by a decrease in temperature with height, creating the atmosphere's coldest layer. The thermosphere is characterized by increasing temperatures with height. However, this is only a function of the air's molecular kinetic energy and not actual temperatures (due to the sparsity of gas concentrations in this layer).

11. What is the tropopause?

    The boundary between the troposphere below and the stratosphere above. Specifically, the tropopause represents the area where temperature stops decreasing with height.

12. In which thermal layer of the atmosphere is the ozone layer found? Why is the term "ozone layer" somewhat misleading?

    Ozone is found primarily in the stratosphere. The term "ozone layer" is misleading as ozone is spread throughout the stratosphere.

13. What percentage of the total mass of the atmosphere is contained in the troposphere and the stratosphere?

    99.9%.

14. Why does the troposphere contain much more mass than the stratosphere, despite the fact that the troposphere is a thinner layer than the stratosphere?

    Gases are compressible. Therefore, the weight of the overlying atmosphere compresses the bulk (80%) of atmospheric gases in a thin layer near the surface. This represents the troposphere.

15. How is the ionosphere distinct from the layers of the atmosphere defined by their temperature profiles?

    The ionosphere is based on its chemistry, and not a temperature profile. The ionosphere consists of charged particles, ions, which transcend the upper reaches of the mesosphere and the thermosphere.

16. What is outgassing and why was it important?

    Outgassing refers to the ejection of gases from cooling molten material. Early in Earth's history, outgassing created the atmosphere.

17. Why were anaerobic bacteria important to the evolution of the atmosphere?

    Anaerobic bacteria were the first respirators of oxygen. They are ultimately responsible for the buildup of significant quantities of oxygen in the atmosphere, which allowed other living species to thrive.

18. Briefly describe the effect that variations in pressure exert on other weather elements.

    Pressure variations, caused by temperature variations, are responsible for the transport of mass in the atmosphere via wind. Pressure and wind ultimately causes many other weather phenomena such as clouds and precipitation.

19. What are isobars?

    Lines of equal pressure (expressed in millibar). Like all contour lines, isobars represent a three dimensional phenomena on a two-dimensional map surface.

20. What are station models and what useful information do they depict?

    Station models represent a useful tool, which portrays critical weather information for a location. They are included on standard weather maps and portray data on temperature, dew point temperature, wind direction, wind speed, pressure, pressure tendency, cloud

cover, and precipitation.