105 Chapter 5 Review Notes

- Any layer of gas that surrounds, and it gravitationally retained by, a planet or moon is referred to as an *atmosphere*
- The ability of a planet or moon to retain or hold onto a given gas in its atmosphere is controlled by the amount of gravity (determined primarily by the total amount of mass in the planet/moon) at or just above the planet's surface **and** by the temperature at the top of the atmosphere (a measure of how fast the gas molecules are moving)
- If a gas molecule achieves the ***escape velocity*** for the planet or moon (the velocity at which an object can leave the planet and not be pulled back by its gravity), then it will be lost. Escape velocity for any body can be determined using the following equation:

$$V_{esc} = (2GM/R)^{1/2}$$

  where G is the gravitational constant ($6.67 \times 10^{-11} Nm^2/kg^2$), M is the mass of the planet or moon, and R is the distance from the center of the planet or moon.

- If the temperature is such that the top of the atmosphere has molecules with average velocities above about 1/6 of V_{esc}, that gas will not be able to be retained in the planetary atmosphere over geologic time
- Only the gas giants (Jupiter, Saturn, Uranus, Neptune) are sufficiently large to have retained H_2 and He from the original solar nebula
- Earth and Venus can retain N_2, O_2, CO_2, H_2O.
- Mars can retain these gases, too, but less effectively, contributing to its thinner atmosphere
- The Moon and Mercury can't retain any of these gases, hence they lack any appreciable atmospheres
- Due to Pluto's low temperature, it is sometimes able to retain CO_2 and may therefore have an atmosphere part of the time
- The solar wind can also erode away an atmosphere if the planet/moon has no magnetic field and resulting magnetosphere to protect itself
- Mars' lack of any significant magnetic field has also contributed to the erosion of its atmosphere over time.
- Venus should also experience this, so it's thick CO_2 atmosphere has probably been actively supplied (primarily by volcanic eruptions) over geologic time
- Earth's low atmospheric CO_2 content is primarily the result of solution and precipitation (as limestone layers) of this gas in the oceans
- Greenhouse gases (like CO_2 and CH_4) can retain infrared radiation (heat) reflected from the surface of a planet and heat up the atmosphere (and planetary surface) significantly
- Venus' surface is blazing hot and completely dry (i.e., no water at all) due to a runaway greenhouse effect
- Global warming on Earth is occurring due to increase in atmospheric CO_2, particularly over the past 180 years or so, at least in part due to emissions from human activity like burning of fossil fuels in power plants and automobiles

- The composition of an atmosphere can be determined by observing absorption lines (cool gas) or emission lines (extremely hot gas, as in stars) in the electromagnetic spectrum
- Absorption lines are produced when electrons absorb light at very specific wavelengths to increase their energy levels, or when gas molecules absorb specific wavelengths of light to increase their vibrational or rotational motions (as with the heating of water by microwave radiation)
- Earth's atmosphere is largely fairly inert N_2, with a large amount of reactive free O_2, the latter being actively produced by photosynthesis in plants and marine plankton. If not for active supply, all of the oxygen would be taken up by oxidation of minerals and organic material on Earth's surface
- Variable amounts of water vapor also exist in Earth's atmosphere, from fractions of a percent to 4 percent plus in clouds, based on local temperature and pressure conditions
- The atmospheres of Venus and Mars are largely CO_2, because that gas is fairly inert, has been supplied in great quantities by volcanic eruptions over geologic time, and is fairly easily retained by their gravity
- Mars is cold enough in its south polar region for CO_2 gas to freeze out into a "dry ice" polar cap
- As noted above, Earth has only a fraction of a percent CO_2 in its atmosphere due to removal of this gas by ocean (and other) water, and formation of calcium carbonate (in limestones)
- The gas giants' atmosphere's are primarily H and He, with smaller amounts of CH_4, NH_3, and other trace gases
- Clouds form in atmospheres when the partial pressure of an individual gas (i.e,. the portion of the pressure produced by the mass of that gas alone) is sufficiently high to produce saturation and condensation. Fog and water clouds on Earth are produced when the relative humidity (that is, the percentage of water vapor saturation in the air) locally reaches 100%
- Water ice, CO_2, methane and ammonia ice clouds form in various atmospheres in our solar system by a similar saturation and condensation process
- The atmospheres of Venus, Mars and Earth are chemically oxidizing; those of the gas giants are chemically reducing
- Darker bands in gas giants' (like Jupiter) atmospheres are called "belts"; lighter bands have more bright clouds and are called "zones"