Chapter 14

Gases & Plasmas

What is a *Gas*?

A gas is the third of the common states of matter. Let's remind ourselves of the properties described thus far:

Solids retain their volume and shape. The atoms and molecules are bonded to each other by electrical forces and vibrate about their fixed atomic position.

Liquids retain their volume, but not their shape. Which sufficient energy, the atoms and molecules can break free of their atomic bonds a start to move freely past each other, However, the do not get far apart from each other due to electrical interactions.

Gases retain neither there volume nor their shape. Gases expand to fill the available volume of their container. The atoms and molecules have sufficient energy to move far apart from each other.

The Atmosphere

Two competing factors determine the thickness of our atmosphere: 1) gravity pulling the molecules to the surface and 2) the kinetic energy of the molecules which try to spread the molecules further apart.

There is no exact height to the atmosphere. Gases are easily compressible. Like foam brick stacked on top of each other, the air density at higher altitudes just becomes less and less (due to the less weight above it) until it simply fades into space:

Below 5.6 km (3.5 miles), lies 50% of the atmosphere.

Below 18 km (11 miles), lies 90% of the atmosphere.

Below 30 km (19 miles), lies 99% of the atmosphere.

Atmospheric Pressure

Just as pressure in a liquid is caused by the weight of the water acting on a unit area, atmospheric pressure is caused by the weight of the air acting on a unit area.

Imagine a vertical pipe with an inner cross-section of 1 cm^2. extending from the ground to higher than 30 km. The weight of the air inside the pipe would weigh about 10 N.

Hence, atmospheric pressure is about 10 N/cm^2.

Converting cm^2 to m^2: 1 m^2 = (100cm)(100cm) = 10^4 cm^2, gives about 10^5 N/m^2 = 10^5 Pascals.

More exactly, 1 “atmosphere” = 1.01325 x 10^5 Pa

Boyle's Law

In the 17th century, Robert Boyle discovered the relationship between the pressure and volume of an enclosed gas. This relationship is Boyle's Law.

Pressure is inversely proportional to volume.

$$P \propto \frac{1}{V}$$

In other words: PV = constant.

Another way to say this is: $P_1V_1 = P_2V_2$.

Archimedes' Principle (again)

Recall that Archimedes' principle states:

The magnitude of the buoyant force F_B on a submerged object is equal to the weight of the fluid displaced by the object. That is,

$$F_B = (m_{fluid\ displaced})g = (D_f)(V_{submerged})g$$

This applies to gases as well as liquids. So, an object "submerged" in air is buoyed up by a buoyant force equal to the weight of the displaced air.

Sinking and Floating in Air

As described in the previous chapter, objects that are more dense than the fluid in which they are submerged will sink, whereas objects that are less dense than the fluid in which they are submerged will float.

A helium filled balloon floats upward in air because the weight of the helium and balloon is less than the weight if the air displaced by the filled balloon.

The same applies to hot-air balloons in which the hot air inside is less dense than the surrounding cold air.

Bernoulli's Principle

Bernoulli's principle states that where speed of a fluid increases, the internal pressure in the fluid decreases (and vice versa).

Bernoulli's relates pressure, speed and elevation principle and follows from Newton's 2^{nd} law and is a consequence of conservation of energy. It applies to constant-density fluids in smooth laminar (not turbulent) flow.

For example, strong horizontal winds can lift a roof off a building as the fast moving air above the roof creates lower pressure. The (stagnant) air inside the building has higher pressure. Over a large area, the lift force can be very large.

Plasma

Often called the fourth state of matter, a plasma is an electrified gas that contains positive ions and free electrons. On Earth, plasmas are created by heating gases to such high temperatures that electrons literally "boil away" from the atoms.

While least abundant in our everyday environment, the plasma state is the most abundant in the (visible) universe. Our own Sun and other stars are largely big balls of plasma.

Earthly examples of plasma include lightning, the auroras, and flames. When energized, the neon gas inside advertising signs is converted into plasma. Fluorescent lights as well as the color pixels in plasma TVs contain plasma when activated.