Unit 2 Notes

- The first activity in unit 2 was the diffusion of a scented gas. From this activity we concluded that particles of a gas are in constant motion. Because the gas reached everyone in the room, the particles must be colliding against one another randomly. Due to all particles having inertia, they move with constant speed and in a straight line between collisions. However, the speed of particles changes after every collision as particles transfer energy between one another.
- We wondered if this type of behavior was exclusive to gases so we tested the diffusion of a dye (food coloring) in a liquid. There were two containers with the same amount of water and a drop of a dye was added to both. The particles of the dye spread, showing that diffusion also occurs in liquids. The dye diffused noticeably faster in one container. We found out that this container was hotter and concluded that temperature is a measure of the average speed of the particles
- We then saw the Eureka videos dealing with particles in the solid, liquid and evaporation and condensation. You can review these videos online
- We had two test tubes, one filled with water and the other with ethanol. The test tubes were placed in a hot water bath and we saw how the level of the liquids rose. We concluded that liquids expand. Ethanol expanded more because the attraction between the particles was less than that of water. This led to the idea of using expanding and contracting liquids to measure how hot or cold something is, in other words, this is the basis of a thermometer. We saw two more Eureka videos, expansion and contraction and how Anders Celsisus developed the mercury thermometer.
- The very common phenomenon of using a straw was studied. Most people had no idea about how a straw was able to bring a liquid to your mouth. We concluded that as you covered the straw with your lips and "sucked" extra room was made in your mouth and lungs allowing the air particles inside the straw to, on their own motion, move inside you. This lowered the amount of particles pushing down against the water inside the straw. The air outside the straw was pushing harder than the air inside which forces the liquid up the straw. We concluded that gases are able to exert a force on the surfaces of any object. This force exerted by the particles of a gas over a surface is called pressure.
- We demonstrated how powerful the pressure of a gas can be by "blowing up" a student. The air blown inside the bag by 4 kids was able to lift a student weighing at least 150 lbs up in the air. We also showed how air pressure can crush a can very rapidly when the pressure inside the can is reduced.
- The question was posed, can we use a very long straw to drink a liquid from a very high place. We concluded that even if you create a perfect vacuum inside the straw, the air pressure outside can only lift a certain amount of water. As the water is going up the straw, it is getting heavier and at one point, the weight of the water equals the force applied by the air. During a normal day, this height is about 34 ft or 10.3 meters of water. Evangelista Torricelli concluded that atmospheric pressure can be measured by the height of a column of liquid air can support. This is the reasoning behind a barometer. Using water as the liquid in a barometer is impractical because the equipment will be 34 ft tall. Because mercury is 13.6 times more dense than water, the column of mercury has to be 13.6 times shorter to equal the atmospheric push. This is how the standard atmospheric pressure is 760 mm of mercury (mm Hg).

- Now that we understand how to measure atmospheric pressure, can we find a way to measure the pressure inside a container? By using a U-shaped tube connected to the gas container we can compare the pressure applied by the gas to the pressure applied by the atmosphere. Such a device is called a manometer. Pressure can be measured with other devices such as a pressure sensor.
- Since it is possible for us to measure the pressure inside a container, we set up three experiments to find the effect of volume, amount of particles and temperature on pressure. For each experiment, a variable was manipulated (independent variable) and the pressure was measured (dependent variable) and the two other variables were kept constant (control variable).
- In part 1 the volume was changed and the pressure was recorded. The P vs. V plot showed a hyperbola which represents and inverse relationship between pressure and volume. On inspection, it was noticed that as the volume doubled, the pressure halved and vice versa. This shows that the relationship is inversely proportional. To confirm this, we plotted P vs 1/V and obtained a straight line.
- In part 2 the amount of particles were changed and pressure was measured. It is impossible to actually count how many particles of the gas there are in a container; however, we knew that the amount of particles in the syringe change proportionally with the volume in the syringe. Therefore, different initial volumes represented different amounts of air. After allowing different amounts of air, the syringe was returned to the constant volume once connected to the sensor. A unit to represent amount of particles was developed and each group gave it their own name. This unit (bobs, jigglypuffs, etc) was equivalent to the amount of particles that fit in a mL of the syringe. The plot between pressure and amount of particles was a straight line with a zero intercept showing direct proportionality. For some groups, the y-intercept was nonzero and not negligible according to the 5% rule. This means that when there are no particles in the syringe, there was still some pressure. We concluded that air particles are still present inside the sensor and account for this significant intercept.
- In part 3, volume and amount of particles were kept constant by putting a stopper on a flask and sealing the amount of gas in. The stopper is connected to the pressure sensor and the flask was submerged in different temperature water baths. The plot P vs T was also linear but the y-intercept was clearly not zero. At 0ºC the particles were still in motion. Pressure and Celsius temperature are not directly proportional. Because temperature measures the average amount of energy in the particles, a value of zero temperature should represent particles which are no longer in motion. This would occur when the pressure is zero. Finding the x-intercept of our plots, we found that at a temperature of -273.15ºC the pressure would be zero. This point became the new zero temperature in the Kelvin scale. If temperature is converted to Kelvin, the pressure is directly proportional to temperature. Doubling the Kelvin temperature would be equivalent to doubling the energy of the particles and doubling the pressure.
- We used the proportionality developed in the experiments to solve problems involving pressure, temperature, volume and amount of particles (PVTn problems)