Kinetic molecular theory essay sample

The gas laws developed by Boyle, Charles, and Gay-Lussac are based upon empirical observations and describe the behavior of a gas in macroscopic terms, that is, in terms of properties that a person can directly observe and experience. An alternative approach to understanding the behavior of a gas is to begin with the atomic theory, which states that all substances are composed of a large number of very small particles (molecules or atoms). In principle, the observable properties of gas (pressure, volume, temperature) are the consequence of the actions of the molecules making up the gas.

The Kinetic Molecular Theory of Gases begins with five postulates that describe the behavior of molecules in a gas. These postulates are based upon some simple, basic scientific notions, but they also involve some simplying assumptions. In reading a postulate, do two things. First, try to understand and appreciate the basic physical idea embodied in the postulate; this idea will ultimately be important in understanding the macroscopic properties of the gas in terms of the behavior the microscopic molecules making up the gas. Second, identify possible weakness or flaws in the postulates. Inaccurate predictions by a theory derive from flawed postulates used in the derivation of the theory. Postulates

1. A gas consists of a collection of small particles traveling in straight-line motion and obeying Newton’s Laws. 2. The molecules in a gas occupy no volume (that is, they are points). 3. Collisions between molecules are perfectly elastic (that is, no energy is gained or lost during the collision). 4. There are no attractive or repulsive forces between the molecules. 5. The average kinetic energy of a molecule is 3kT/2. (T is the absolute temperature and k is the Boltzmann constant.)

How the Kinetic Molecular Theory Explains the Gas Laws

The kinetic molecular theory can be used to explain each of the experimentally determined gas laws. The Link Between P and n

The pressure of a gas results from collisions between the gas particles and the walls of the container. Each time a gas particle hits the wall, it exerts a force on the wall. An increase in the number of gas particles in the container increases the frequency of collisions with the walls and therefore the pressure of the gas.

Amontons' Law (PT)

The last postulate of the kinetic molecular theory states that the average kinetic energy of a gas particle depends only on the temperature of the gas. Thus, the average kinetic energy of the gas particles increases as the gas becomes warmer. Because the mass of these particles is constant, their kinetic energy can only increase if the average velocity of the particles increases. The faster these particles are moving when they hit the wall, the greater the force they exert on the wall. Since the force per collision becomes larger as the temperature increases, the pressure of the gas must increase as well. Boyle's Law (P = 1/v)

Gases can be compressed because most of the volume of a gas is empty space. If we compress a gas without changing its temperature, the average kinetic energy of the gas particles stays the same. There is no change in the speed with which the particles move, but the container is smaller. Thus, the particles travel from one end of the container to the other in a shorter period of time. This means that they hit the walls more often. Any increase in the frequency of collisions with the walls must lead to an increase in the pressure of the gas. Thus, the pressure of a gas becomes larger as the volume of the gas becomes smaller. Charles’ Law (V T)

The average kinetic energy of the particles in a gas is proportional to the temperature of the gas. Because the mass of these particles is constant, the particles must move faster as the gas becomes warmer. If they move faster, the particles will exert a greater force on the container each time they hit the walls, which leads to an increase in the pressure of the gas. If the walls of the container are flexible, it will expand until the pressure of the gas once more balances the pressure of the atmosphere. The volume of the gas therefore becomes larger as the temperature of the gas increases.

Avogadro’s Hypothesis (V N)

As the number of gas particles increases, the frequency of collisions with the walls of the container must increase. This, in turn, leads to an increase in the pressure of the gas. Flexible containers, such as a balloon, will expand until the pressure of the gas inside the balloon once again balances the pressure of the gas outside. Thus, the volume of the gas is proportional to the number of gas particles. Dalton’s Law of Partial Pressures ($P_t = P_1 + P_2 + P_3 + \ldots$)

Imagine what would happen if six ball bearings of a different size were added to the molecular dynamics simulator. The total pressure would increase because there would be more collisions with the walls of the container. But the pressure due to the collisions between the original ball bearings and the walls of the container would remain the same. There is so much empty space in the container that each type of ball bearing hits the walls of the container as often in the mixture as it did when there was only one kind of ball bearing on the glass plate. The total number of collisions with the wall in this mixture is therefore equal to the sum of the collisions that would occur when each size of ball bearing is present by itself. In other words, the total pressure of a mixture of gases is equal to the sum of the partial pressures of the individual gases.