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Postulates of kinetic theory of gases ppt

Experimental curves for different gasses, different masses, different pressures all extrapolate to a common zero. Dinitrogen monoxide (N2O), laughing gas, is used by dentists as an anesthetic. Gases are one of the most pervasive aspects of our environment on the Earth. 69. It seems like this variable should either be very easy to work with or nonexistent. The Gas Laws are a mathematical interpretation of the behavior of gases. Rearrange ideal gas law for unknown P P = nRT V Substitute values of n, R, T and V and solve for P P = (2.86 mol)(62.4L-mmHg)(296 K) (20.0 L) (K-mol) 68. If the gas is not in a container, then the pressure variable refers to the pressure it could produce on the walls of a container if it were in one. It represents the amount of space available for the gas particles to move around in. Remer) 56. The final gas law variable is the quantity of gas. Therefore, the mole will standardize the mathematics for all gases and minimize the chances for errors. 4) Most Gases have low densities Gas densities are on the order of grams per liter whereas liquids and solids are grams per cubic cm, 1000 times greater. Kinetic Theory Assumptions ◦ Point Mass ◦ No Forces Between Molecules ◦ Molecules Exert Pressure Via Elastic Collisions With Walls xx (courtesy F. No collision. At an atmospheric pressure of 714, what is the partial pressure (mm Hg) N2 in the air? From STP, we know the P and T. Behave as described by the ideal gas equation; no real gas is actually ideal Within a few %, ideal gas equation describes most real gases at room temperature and pressures of 1 atm or less In real gases, particles attract each other reducing the pressure Real gases behave more like ideal gases 26. 2) Gases are thermally expandable When a gas sample is heated, its volume increases, and when it is cooled its volume decreases. As this container of gas is heated, the temperature increases. 27 The Mean Collision TimeThe mean collision time is average time elapsed between successive collisions. With the increase in kinetic energy, the force on the available amount of surface area increases. absolute zero = no molecular motion no molecular motion = zero force on the inside 61. For example, the atmospheric pressure felt by a man is the weight of the column of air above his body divided by the area the air is resting on P = (Weight of column)/(Area of base) Standard Atmospheric Pressure: 1 atmosphere (atm) 14.7 lbs/in2 (psi) 760 Torr (mm Hg) 1013.25 KiloPascals or Millibars (kPa = N/m2) 30. He also noticed that height of the mercury varied with changes in outside weather conditions. 30 The Mean Free Path 31 The Collision Density We define the collision density as the total rate of collisions per unit volume. Substitute (1.00 atm) mol-K = 0.0446 mol O2/L (0.0821 L-atm) (273 K) Change moles/L to g/L 0.0446 mol O2 x 32.0 g O2 = 1.43 g/L 1 L 1 mol O2 Therefore the density of O2 gas at STP is 73. The volume being referred to here is the volume of the container, not the volume of the gas particles. – Boyles's Law (2) If volume is kept constant, the pressure of a unit mass of gas is proportional to temperature. Plan: The pressure is in mmHg, so we use the conversion factors from Table 5.2(p.178) to find the pressure in the other units. At constant temperatures and low to moderate pressures, collisions between gas particles are perfectly elastic 12. 5) Gases are infinitely miscible Gases mix in any proportion such as in air, a mixture of many gases. 7. Considering the large difference in mass of the many different gases available, using mass as a measurement of quantity would cause major errors in the Kinetic Molecular Theory. Remember, according to the Kinetic Molecular Theory, the volume of the gas particles is set at zero. 75. 66. Considering the large number of known gases in the World, the task of trying to describe each one of them individually would be an awesome task. Atmospheric pressure results from the collisions of air molecules with objects ◦Decreases as you climb a mountain because the air layer thins out as elevation increases Barometer is the measuring instrument for atmospheric pressure; dependent upon weather 32. 36 The Reduced Mass The reduced mass of two particles 1 and 2 is defined as follows 37 Mean Free Paths in Heteronuclear CollisionsFor substance 1 colliding with substance 2 38 Mean Free Paths (Cont'd)For substance 2 colliding with substance 1 39 Heteronuclear Collision FrequenciesThe collision frequency of molecule 1 with molecule 2 is given by 40 Heteronuclear Collision Frequencies (cont'd)The collision frequency of molecule 2 with molecule 1 is given by 41 Heteronuclear Collision DensityThe total rate of heteronuclear collisions per unit volume 2 Kinetic and Molecular Theory of Gases This ideal-gas law equation describes how gases behave, but it does not explain why they behave as they do. Find mole of O2 28.0 g NH3 x 1 mol NH3 x 5 mol O2 17.0 g NH3 4 mol NH3 = 2.06 mol O2 V = nRT = (2.06 mol)(0.0821)(297K) = 52.9 L 82. We can measure the density of the atmosphere by measuring the pressure it exerts. The mean collision diameter. 77. The mass units will not work in gas law mathematics. There are four variables used mathematically for describing a gas phase system. What is the molar mass of a gas if 0.250 g of the gas occupy 215 mL at 0.813 atm and 30.0°C? 5 Kinetic Theory Postulates (Cont'd)Average kinetic energy (K.E.) of molecules depends on absolute temperature (T) only. 3) Gases have high viscosity Gases flow much easier than liquids or solids. Experience has shown that the number of objects in a system is more descriptive than the mass of the objects. Remer) 55. 85. A real gas is most like an ideal gas when the real gas is at low pressure and high temperature. When a scuba diver is several hundred feet under water, the high pressures cause N2 from the tank air to dissolve in the blood. If temperature increase so will pressure, assuming no change in the volume of the gas. As a result, the average kinetic energy of the particles in the system increases. 6 Kinetic Theory of Gases 7 Explanation of PressureGas pressure - collisions of gas molecules with the container walls. What is the molecular formula of the gas? If the walls of the container were reduced in total surface area, there would be a change in the pressure of the system. Why did the balls eventually stop swinging? Pressure = Force per Unit Area Atmospheric Pressure is the weight of the column of air above a unit area. Accordingly, an increase in pressure will cause an increase in density of the gas and a decrease in its volume. The Volume variable is represented by the symbol V. Thus, increasing temperature of a unit mass of 53. In order to simplify this task, the scientific community has decided to create an imaginary gas that approximates the behavior of all real gases. For climatological and meteorological purposes, standard sea-level pressure is said to be 76.0 cm or 29.92 inches or 1013 millibars 31. Torricelli determined from this experiment that the pressure of the atmosphere is approximately 30 inches or 76 centimeters (one centimeter of mercury is equal to 13.3 millibars. 4 Postulates of Kinetic Theory of GasesGases consist of molecules of mass m and diameter d. Converting Units of Pressure Problem: A chemist collects a sample of carbon dioxide from the decomposition of limestone (CaCO3) in a closed end manometer, the height of the mercury is 341.6 mm Hg. Calculate the CO2 pressure in torr, atmospheres, and kilopascals. lb Fe —→ g Fe —→ mol Fe —→ mol H2 —→ L H2 1.00 x 103 lb x 453.6 g x 1 mol Fe x 1 mol H2 1 lb 55.9 g 1 mol Fe x 22.4 L H2 = 1.82 x 105 L H2 1 mol H2 78. +vi,xt These molecules don't reach the wall! These molecules come into contact with the wall! 11 The Total Momentum ChangeThe total momentum change is calculated form the sum of the momentum changes for the individual particles. All collisions are elastic. Change in average atmospheric pressure with altitude. While the units used for the variables may differ from problem to problem, the conceptual aspects of the variables remain unchanged. 3 Assumptions of Kinetic TheoryTotal energy of the system Intermolecular attractive interactions are negligible. Kinetic Molecular Theory (KMT) for an ideal gas states that all gas particles: are in random, constant, straight-line motion. Yes, because kinetic energy was transferred with each collision 11. Kinetic-Molecular Theory is model that... Designed By: Dr. Sagir 2. This would cause the pressure to increase. 1. ....Ka-Boom 47. Therefore, the volume term V seems like it should be zero. Remer) 23. d2 d1 Mean collision diameter d12 = ½ (d1+d2) 34 The Collision Zone For a collision occurring along the x and y axis. V, or Volume, is a measure of the volume of the container that the gas could occupy. At high pressures gas particles are close therefore the volume of the gas particles is considered. 22. The gas consists of objects with a defined m The gas particles travel randomly in straight- All collisions involving gas particles are elast The gas particles do not interact with each o The gas phase system will have an average k 19. We continually exist with constant exposure to gases of all forms. What would Polly Parcel look like if she had no gas molecules inside? Replace with the ensemble average 14 The Mean Square Speed Kinetic Molecular Theory of Gases allows us to relate macroscopic measurements to molecular quantities P, V are related to the molar mass and mean square seed 15 The Root Mean Square Speed1/3 Mi2 = RT 2 = 3RT / Mi (2)1/2 = vrms = (3RT/Mi)1/2 vrms = the root mean square speed 16 The Maxwell Probability DistributionIn kinetic theory, we are interested in the fraction of molecules having a particular range of speeds. 49. + m vix - m vix 10 Not All Particles Reach the Wall!How many particles actually reach the wall during a specified time interval t? 4 NH3(g) + 5 O2(g) 4 NO(g) + 6 H2O(g) 79. 2. On December 1, 1783, Charles used 1.00 x 103 lb of iron filings to make the first ascent in a balloon filled with hydrogen Fe(s) + H2SO4(aq) —→ FeSO4(aq) + H2(g) At STP, how many liters of hydrogen gas were generated? A fresh breeze on a mountain peak is a study in basic gas laws. (1) When temperature is held constant, the density of a gas is proportional to pressure, and volume is inversely proportional to pressure. R is known as the universal gas constant Using STP conditions P V R = PV = (1.00 atm)(22.4 L) nT (1mol) (273K) n T = 0.0821 L-atm mol-K 63. Notice that, unlike the other variables, it is in lower case. At low temperatures gas particles have low kinetic energy therefore particles have some attractive force Example Dry ice, liquid oxygen and nitrogen 25. In the kinetic theory model of an ideal gas, molecules are viewed as point particles ... Offers an explanation of the macroscopic behavior of gases Predicts experimental phenomena that haven't been observed (Maxwell-Boltzmann Speed distribution) The Four Postulates of ... The Property of Gases – Kinetic Molecular Theory explains why gases behave as they do Real data must be obtained above liquefaction temperature. Remer) 24. Using STP and density (1 L = 2.50 g) 2.50 g x 22.4 L = 56.0 g/mol 1 L 1 mol n = EF/ mol = 56.0 g/mol = 4 14.0 g/EF molecular formula CH2 x 4 = C4H8 76. 60. zero molecules = zero pressure inside zero pressure inside = zero force on the inside 42. P, or Pressure, is the measure of the amount of force per unit of surface area. It can best be expressed by the equation 45. The potential energy of the ball Which is converted to kinetic energy in the ball Which is converted to potential energy in the ball Is converted to kinetic energy in the ball Which is converted into the potential energy of the ball..... The Kinetic Molecular Theory is a single set of descriptive characteristics of a substance known as the Ideal Gas. Solve ideal gas equation for n (moles) n = PV RT = (735 mmHg)(5.0 L)(mol K) (62.4 mmHg L)(293 K) = 0. 12 The Definition of PressureThe pressure exerted by the gas is calculated as follows 13 Distribution of Molecular SpeedsThis speed in the above equation should be an average speed (some will always be fast, some slow). 27. Important Characteristics of Gases 1) Gases are highly compressible An external force compresses the gas sample and decreases its volume, removing the external force allows the gas volume to increase. 84. Hyperbolic Relation Between Pressure and Volume p V p – V Diagramp – V Diagram isotherms T1 T2 T3 T3 >T2>T1 (courtesy F. All real gases require their own unique sets of descriptive characteristics. Solution: PCO2 (torr) = 341.6 mm Hg x = 341.6 torr 1 torr 1 mm Hg converting from mmHg to torr: converting from torr to atm: PCO2(atm) = 341.6 torr x = 0.4495 atm 1 atm 760 torr converting from atm to kPa: PCO2(kPa) = 0.4495 atm x = 45.54 kPa101.325 kPa 1 atm 34. Then there cannot be any collisions, and thus no pressure – called a vacuum 37. The steam formed in the air during a hot shower is a gas. If 2.86 mol of gas occupies a 20.0 L tank at 23°C, what is the pressure (mmHg) in the tank in the dentist office? n = PV = (0.813 atm) (0.215 L) = 0.00703 mol RT (0.0821 L-atm/molK) (303K) Molar mass = g = 0.250 g = 35.6 g/mol 71. Kinetic Theory Postulate 1 – Gases consist of tiny particles (atoms or molecules) whose size is negligible. A gas has a % composition by mass of 85.7% carbon and 14.3% hydrogen. To fully understand the world around us requires that we have a good understanding of the behavior of gases. The phenomenon of pressure is really a force applied over a surface area. # Inside tube = Ndt 25 Collision Frequency (cont'd)For N-1 stationary particles The collision frequency - z1 Examine the case where all the molecules inside the collision tube are moving. The force of a collision depends on the number of collisions per unit time how hard gas molecules strike the container wall! 8 The greater the momentum of gas molecules, the greater the effect of the impact on the walls.Force/A = P 9 The Momentum Change During a CollisionParticle of mass mi collides with the wall with only the x component of the momentum changing. Thus, as stated before, the variable V is the volume of the container. Helium, which is inert, less dense, and does not dissolve in the blood, 87. have no attractive forces between them. Consequently, T values must be converted to the Kelvin Scale. 26 Collision Frequency (Cont'd)Relative speed of the colliding particles. 50. have collisions that may result in the transfer of energy between gas particles, but the total energy of the system remains constant. Gas molecules are in constant, rapid, straight-line motion. Linear Relation Between Temperature and Pressure P T (K) 0 100 200 300 P – T DiagramP – T Diagram isochorsisochorsV1 V2 V3 V1