General chemistry petrucci 10th edition türkçe pdf

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Integrative and Advanced Exercises 552 Feature Problems 554 Self-Assessment Exercises 556 13 Solutions and Their Physical Properties 557 Types of Solutions: Some Terminology 558 Solution Concentration 558 Intermolecular Forces and the Solution Process 562 Solution Formation and Equilibrium 567 Solubilities of Gases 570 Vapor Pressures of Solutions 573 Osmotic Pressure 577 Freezing-Point Depression and Boiling-Point Elevation of Nonelectrolyte Solutions 581 13-9 Solutions of Electrolytes 584 13-10 Colloidal Mixtures 587 Summary 590 Integrative Example 591 Exercises 592 Integrative and Advanced Exercises 597 Feature Problems 599 Self-Assessment Exercises 600 13-1 13-2 13-3 13-4 13-5 13-6 13-7 13-8 14 Chemical Kinetics 602 The Rate of a Chemical Reaction 603 Measuring Reaction Rates 605 Effect of Concentration on Reaction Rates: The Rate Law 608 14-4 Zero-Order Reactions 611 14-5 First-Order Reactions 612 14-6 Second-Order Reactions 619 14-7 Reaction Kinetics: A Summary 620 14-8 Theoretical Models for Chemical Kinetics 622 14-9 The Effect of Temperature on Reaction Rates 626 14-10 Reaction Mechanisms 629 14-11 Catalysis 637 Summary 642 Integrative Example 643 Exercises 645 Integrative and Advanced Exercises 650 Feature Problems 652 Self-Assessment Exercises 654 14-1 14-2 14-3 15 Principles of Chemical Equilibrium 15-1 15-2 15-3 15-4 15-5 Dynamic Equilibrium 656 The Equilibrium Constant Expression 656 Relationships Involving Equilibrium Constants 663 The Magnitude of an Equilibrium Constant 669 The Reaction Quotient, Q: Predicting the Direction of Net Change 670 Altering Equilibrium Conditions: Le Châtelier s Principle 673 Equilibrium Calculations: Some Illustrative Examples 679 Summary 686 Integrative Example 686 Exercises 688 Integrative and Advanced Exercises 693 Feature Problems 694 Self-Assessment Exercises 695 15-6 15-7 665 226 Chapter Gases When high-pressure UF61g2 is forced through a barrier having millions of submicroscopic holes per square centimeter, molecules containing the isotope 235 U pass through the barrier slightly faster than those containing 238U, just as expected from expression (6.25), and therefore UF61g2 contains a slightly higher ratio of 235U to 238U than it did previously The gas has become enriched in 235U Carrying this process through several thousand passes yields a product highly enriched in 235U 6-9 Nonideal (Real) Gases Compressibility factor, PV/nRT The data in Table 6.2 provide us with clear evidence that real gases are not ideal We should comment briefly on the conditions under which a real gas is ideal or nearly so and what to when the conditions lead to nonideal behavior A useful measure of how much a gas deviates from ideal gas behavior is found in its compressibility factor The compressibility factor of a gas is the ratio PV>nRT From the ideal gas equation we see that for an ideal gas, PV>nRT = For a real gas, the compressibility factor can have values that are significantly different from Values of the compressibility factor are given in Table 6.5 for a variety of gases at 300 K and 10 bar The data in Table 6.5 show that the deviations from ideal gas behavior can be small or large, depending on the gas At 300 K and 10 bar, He, H 2, CO, N2, and O2 behave almost ideally 1PV>nRT L 12 but NH and SF6 not 1PV>nRT L 0.882 In Figure 6-20, the compressibility factor is plotted as a function of pressure for three different gases The principal conclusion from this plot is that all gases behave ideally at sufficiently low pressures, say, below atm, but that deviations set in at increased pressures At very high pressures, the compressibility factor is always greater than one Nonideal gas behavior can be described as follows: Boyle s law predicts that at very high pressures, a gas volume becomes extremely small and 1.5 1.0 H2 TABLE 6.5 van der Waals Constants and Compressibility Factors (at 10 bar and 300 K) for Various Gases O2 Ideal gas Gas 0.5 CO2 200 400 600 800 1000 Pressure, atm FIGURE 6-20 The behavior of real gases compressibility factor as a function of pressure at *C Values of the compressibility factor less than one signify that intermolecular forces of attraction are largely responsible for deviations from ideal gas behavior Values greater than one are found when the volume of the gas molecules themselves is a significant fraction of the total gas volume H2 He Ideal gas N2 CO O2 CH NF3 CO2 N2O C2H NH SF6 C3H SO2 van der Waals Constants a, bar L2 mol-2 b, L mol-1 0.2452 0.0346 1.370 1.472 1.382 2.303 3.58 3.658 3.852 5.580 4.225 5.580 9.39 7.857 0.0265 0.0238 0.0387 0.0395 0.0319 0.0431 0.0545 0.0429 0.0444 0.0651 0.0371 0.0651 0.0905 0.0879 Compressibility Factor 1.006 1.005 0.998 0.997 0.994 0.983 0.965 0.950 0.945 0.922 0.887 0.880 a a Source: van der Waals constants are from the CRC Handbook of Chemistry and Physics, 83rd ed., David R Lide (ed.)., Boca Raton, FL: Taylor & Francis Group, 2002 Compressibility factors are calculated by using data from the National Institute of Standards and Technology (NIST) Chemistry WebBook, available online at aAt 10 bar and 300 K, C H and SO are liquids 6-9 (a) Nonideal (Real) Gases 227 (b) FIGURE 6-21 The effect of finite molecular size In (a), a significant fraction of the container is empty space and the gas can still be compressed to a smaller volume In (b), the molecules occupy most of the available space The volume of the system is only slightly greater than the total volume of the molecules approaches zero This cannot be, however, because the molecules themselves occupy space and are practically incompressible, as suggested in Figure 6-21 Because of the finite size of the molecules, the PV product at high pressures is larger than predicted for an ideal gas, and the compressibility factor is greater than one Another consideration is that intermolecular forces exist in gases Figure 6-22 shows that because of attractive forces between the molecules, the force of the collisions of gas molecules with the container walls is less than expected for an ideal gas Intermolecular forces of attraction account for compressibility factors of less than one These forces become increasingly important at low temperatures, where translational molecular motion slows down To summarize: Gases tend to behave ideally at high temperatures and low pressures Gases tend to behave nonideally at low temperatures and high pressures The van der Waals Equation A number of equations can be used for real gases, equations that apply over a wider range of temperatures and pressures than the ideal gas equation Such equations are not as general as the ideal gas equation They contain terms that have specific, but different, values for different gases Such equations must correct for the volume associated with the molecules themselves and for intermolecular forces of attraction Of all the equations that chemists use for modeling the behavior of real gases, the van der Waals equation, equation (6.26), is the simplest to use and interpret aP + an2 V2 b 1V - nb2 = nRT (6.26) The equation incorporates two molecular parameters, a and b, whose values vary from molecule to molecule, as shown in Table 6.5 The van der Waals equation and the ideal gas equation both have the form pressure factor * volume factor = nRT The van der Waals equation uses a modified pressure factor, P + an2>V2, in place of P and a modified volume factor, V - nb, in place of V In the modified volume factor, the term nb accounts for the volume of the molecules themselves The parameter b is called the excluded volume per mole, and, to a rough approximation, it is the volume that one mole of gas occupies when it condenses to a liquid Because the FIGURE 6-22 Intermolecular forces of attraction Attractive forces of the red molecules for the green molecule cause the green molecule to exert less force when it collides with the wall than if these attractions did not exist The van der Waals equation reproduces the observed behavior of gases with moderate accuracy It is most accurate for gases comprising approximately spherical molecules that have small dipole moments We will discuss molecular shapes and dipole moments in Chapter 10 228 Chapter Gases molecules are not point masses, the volume of the container must be no smaller than nb, and the volume available for molecular motion is V - nb As suggested in Figure 6-21(b), the volume available for molecular motion is quite small at high pressures To explain the significance of the term an2>V2 in the modified pressure factor, it is helpful to solve equation (6.26) for P: P = * In Chapter 12, we will examine intermolecular forces of attraction in greater detail and establish why the strength of the attractive intermolecular forces increases as the sizes of the molecules increase EXAMPLE 6-17 nRT an2 - V - nb V Provided V is not too small, the first term in the equation above is approximately equal to the pressure exerted by an ideal gas: nRT>1V - nb2 L nRT>V = Pideal The equation given above for P predicts that the pressure exerted by a real gas will be less than that of an ideal gas Figure 6-22 illustrates why Because of attractive forces, molecules near the container walls are attracted toward the molecules behind them; as a result, the gas exerts less force on the container walls The term an2>V2 takes into account the decrease in pressure caused by intermolecular attractions In 1873, the Dutch physicist Johannes van der Waals reasoned that the decrease in pressure caused by intermolecular attractions should be proportional to the square of the concentration, and so the decrease in pressure is represented in the form an2>V2 The proportionality constant, a, provides a measure of how strongly the molecules attract each other A close examination of Table 6.5 shows that the values of both a and b increase as the sizes of the molecules increase The smaller the values of a and b, the more closely the gas resembles an ideal gas Deviations from ideality, as measured by the compressibility factor, become more pronounced as the values of a and b increase In Example 6-17 we calculate the pressure of a real gas by using the van der Waals equation Solving the equation for either n or V is more difficult, however (see Exercise 121) Using the van der Waals Equation to Calculate the Pressure of a Gas Use the van der Waals equation to calculate the pressure exerted by 1.00 mol Cl21g2 confined to a volume of 2.00 L at 273 K The value of a = 6.49 L2 atm mol -2, and that of b = 0.0562 L mol -1 Analyze This is a straightforward application of equation (6.26) It is important to include units to make sure the units cancel out properly Solve Solve equation (6.26) for P P = nRT n 2a - V - nb V Then substitute the following values into the equation n = 1.00 mol; V = 2.00 L; T = 273 K; R = 0.08206 atm L mol -1 K -1 L2 atm = 6.49 L2 atm n2a = 11.0022 mol2 * 6.49 mol2 nb = 1.00 mol * 0.0562 L mol -1 = 0.0562 L 6.49 L2 atm 1.00 mol * 0.08206 atm L mol -1 K -1 * 273 K P = 12.00 - 0.05622L 12.0022 L2 P = 11.5 atm - 1.62 atm = 9.9 atm Summary 229 Assess The pressure calculated with the ideal gas equation is 11.2 atm By including only the b term in the van der Waals equation, we get a value of 11.5 atm Including the a term reduces the calculated pressure by 1.62 atm Under the conditions of this problem, intermolecular forces of attraction are the main cause of the departure from ideal behavior Although the deviation from ideality here is rather large, in problem-solving situations, you can generally assume that the ideal gas equation will give satisfactory results Substitute CO21g2 for Cl21g2 in Example 6-17, given the values a = 3.66 L2 bar mol -2 and b = 0.0427 L mol Which gas, CO2 or Cl2, shows the greater departure from ideal gas behavior? [Hint: For which gas you find the greater difference in calculated pressures, first using the ideal gas equation and then the van der Waals equation?] PRACTICE EXAMPLE A: -1 Substitute CO1g2 for Cl21g2 in Example 6-17, given the values a = 1.47 L2 bar mol -2 and b = 0.0395 L mol -1 Including CO2 from Practice Example 6-17A, which of the three gases Cl2, CO 2, or CO shows the greatest departure from ideal gas behavior? PRACTICE EXAMPLE B: 6-10 CONCEPT ASSESSMENT Following are the measured densities at 20.0 °C and atm pressure of three gases: O2, 1.331 g>L; OF2, 2.26 g>L; NO, 1.249 g>L Arrange them in the order of increasing adherence to the ideal gas equation [Hint: What property can you calculate and compare with a known value?] www.masteringchemistry.com The blanket of gases surrounding Earth forms our atmosphere It not only protects us from harmful radiation but also plays an essential role in moving water, essential to life, from the oceans to the land For a discussion of the regions and composition of Earth s atmosphere, go to the Focus On feature for Chapter on the MasteringChemistry site Summary 6-1 Properties of Gases: Gas Pressure A gas is described in terms of its pressure, temperature, volume, and amount Gas pressure is most readily measured by comparing it with the pressure exerted by a liquid column, usually mercury (equation 6.2) The pressure exerted by a column of mercury in a barometer and called the barometric pressure is equal to the prevailing pressure of the atmosphere (Fig 6-4) Other gas pressures can be measured with a manometer (Fig 6-5) Pressure can be expressed in a variety of units (Table 6.1), including the SI units pascal (Pa) and kilopascal (kPa) Also commonly used are bar; millimeter of mercury (mmHg); torr (Torr), where Torr = mmHg; and atmosphere (atm), where atm = 760 mmHg = 760 Torr 6-2 The Simple Gas Laws The most common sim- ple gas laws are Boyle s law relating gas pressure and volume (equation 6.5, Fig 6-6); Charles s law relating gas volume and temperature (equation 6.8, Fig 6-7); and Avogadro s law, relating volume and amount of gas Some important ideas that originate from the simple gas laws are the Kelvin (absolute) scale of temperature (equation 6.6), the standard conditions of temperature and pressure (STP), and the molar volume of a gas at STP 22.7 L>mol (expression 6.10) 6-3 Combining the Gas Laws: The Ideal Gas Equation and the General Gas Equation The simple gas laws can be combined into the ideal gas equation, PV = nRT (equation 6.11), where R is called the gas constant A gas whose behavior can be predicted with this equation is known as an ideal, or perfect, gas The ideal gas equation can be solved for any one of the variables when all the others are known The general gas equation (equation 6.12) is a useful variant of the ideal gas equation for describing the behavior of a gas when certain variables are held constant and others are allowed to change 6-4 Applications of the Ideal Gas Equation An important application of the ideal gas equation is its use in determining molecular masses (equation 6.13) and gas densities (equation 6.14) 6-5 Gases in Chemical Reactions Because it relates the volume of a gas at a given temperature and pressure to the amount of gas, the ideal gas equation often enters into stoichiometric calculations for reactions involving gases In calculations based on the volumes of two gaseous reactants and/or products measured at the same temperature and pressure, the law of combining volumes is generally applicable 230 Chapter Gases 6-6 Mixtures of Gases The ideal gas equation kinetic energy and Kelvin temperature (equation 6.21) An important aspect of the kinetic-molecular theory is the concept of a distribution of molecular speeds (Figs 6-15 and 6-16) applies to mixtures of ideal gases as well as to pure gases The enabling principle, known as Dalton s law of partial pressures, is that each gas expands to fill the container, exerting the same pressure as if it were alone in the container (Fig 6-12) The total pressure is the sum of these partial pressures (equation 6.16) A useful concept in dealing with mixtures of gases is that of mole fraction, the fraction of the molecules in a mixture contributed by each component (equation 6.17) In the common procedure of collecting a gas over water (Fig 6-13), the particular gas being isolated is mixed with water vapor 6-8 Gas Properties Relating to the KineticMolecular Theory The diffusion and effusion of gases (Fig 6-19) can be described by the kinetic-molecular theory Using an approximation known as Graham s law, molar masses can be determined by measuring rates of effusion (equation 6.23) 6-9 Nonideal (Real) Gases Because of finite molec- 6-7 Kinetic-Molecular Theory of Gases The ular size and intermolecular forces of attraction (Figs 6-21 and 6-22), real gases generally behave ideally only at high temperatures and low pressures Other equations of state, such as the van der Waals equation (equation 6.26), take into account the factors causing nonideal behavior and often work when the ideal gas equation fails kinetic-molecular theory of gases yields a basic expression (equation 6.18) from which other relationships can be established between the root-mean-square speed 1urms2 of molecules, temperature, and molar mass of a gas (equation 6.20), and the average molecular translational Integrative Example Combustion of 1.110 g of a gaseous hydrocarbon yields 3.613 g CO and 1.109 g H2O, and no other products A 0.288 g sample of the hydrocarbon occupies a volume of 131 mL at 24.8 °C and 753 mmHg Write a plausible structural formula for a hydrocarbon corresponding to these data Analyze Use the combustion data for the 1.110 g sample of hydrocarbon and the method of Example 3-6 on page 83 to determine the empirical formula Use the P - V - T data in equation (6.13) for the 0.288 g sample to determine the molar mass and molecular mass of the hydrocarbon By comparing the empirical formula mass and the molecular mass, establish the molecular formula Now write a structural formula consistent with the molecular formula Solve Calculate the number of moles of C and H in the 1.110 g sample of hydrocarbon based on the masses of CO2 and H2O obtained in its combustion mol CO2 mol C * = 0.08209 mol C 44.01 g CO2 mol CO2 mol H2O mol H ? mol H = 1.109 g H2O * * = 0.1231 mol H 18.02 g H2O mol H2O Use these numbers of moles as the provisional subscripts in the formula C0.08209H0.1231 Divide each provisional subscript by the smaller of the two to obtain the empirical formula C0.08209 H CH1.500 = C2H3 To determine the molar mass, use a modified form of equation (6.13) M = The empirical formula mass is a2 C atoms * The molar mass based on the empirical formula, 27.0 g mol -1, is almost exactly onehalf the observed molar mass of 54.3 g mol -1 The molecular formula of the hydrocarbon is The four-carbon alkane is butane, C4H10 Removal of H atoms to obtain the formula C4H6 is achieved by inserting two C-to-C double bonds ? mol C = 3.613 g CO2 * 0.08209 0.1231 0.08209 0.288 g * 0.08206 atm L K-1 mol-1 * 124.8 + 273.22 K mRT = PV 1753 mmHg * atm>760 mmHg2 * 0.131 L = 54.3 g mol -1 12.0 u 1.01 u b + a3 H atoms * b = 27.0 u C atom H atom C2 * 2H2 * = C4H6 H 2C CH ¬ CH CH or H 2C C CH ¬ CH Exercises Two other possibilities involve the presence of a C-to-C triple bond H3C ¬ C C ¬ CH3 or H3C ¬ CH2 ¬ C 231 CH Assess The combination of combustion data and gas-law data yields a molecular formula with certainty However, because of isomerism the exact structural formula cannot be pinpointed All that we can say is that the hydrocarbon might have any one of the four structures shown, but it might be still another structure, for example, based on a ring of C atoms rather than a straight chain PRACTICE EXAMPLE A: When a 0.5120 g sample of a gaseous hydrocarbon was burned in excess oxygen, 1.687 g CO2 and 0.4605 g H2O were obtained The density of the compound, in its vapor form, is 1.637 g/L at 25 °C and 101.3 kPa Determine the molecular formula of the hydrocarbon, and draw a plausible structural formula for the molecule PRACTICE EXAMPLE B: An organic compound contains only C, H, N, and O When the compound is burned in oxygen, with appropriate catalysts, nitrogen gas 1N22, carbon dioxide 1CO22, and water vapor 1H2O2 are produced A 0.1023 g sample of the compound yielded 151.2 mg CO2, 69.62 mg H2O, and 9.62 mL of N21g2 at 0.00 °C and 1.00 atm The density of the compound, in its vapor form, was found to be 3.57 g L-1 at 127 °C and 748 mmHg What is the molecular formula of the compound? You ll find a link to additional self study questions in the study area on www.masteringchemistry.com Exercises Pressure and Its Measurement Convert each pressure to an equivalent pressure in atmospheres (a) 736 mmHg; (b) 0.776 bar; (c) 892 Torr; (d) 225 kPa Calculate the height of a mercury column required to produce a pressure (a) of 0.984 atm; (b) of 928 Torr; (c) equal to that of a column of water 142 ft high Calculate the height of a column of liquid benzene 1d = 0.879 g>cm32, in meters, required to exert a pressure of 0.970 atm Calculate the height of a column of liquid glycerol 1d = 1.26 g>cm32, in meters, required to exert the same pressure as 3.02 m of CCl41l2 1d = 1.59 g>cm32 What is the pressure (in mmHg) of the gas inside the apparatus below if Pbar = 740 mmHg, h1 = 30 mm and h2 = 50 mm? What is the pressure (in mmHg) of the gas inside the apparatus below if Pbar = 740 mmHg, h1 = 30 mm and h2 = 40 mm? Pbar h1 Gas h2 Pbar Mercury (Hg) h1 Gas h2 Mercury (Hg) At times, a pressure is stated in units of mass per unit area rather than force per unit area Express P = atm in the unit kg>cm2 [Hint: How is a mass in kilograms related to a force?] Express P = atm in pounds per square inch (psi) [Hint: Refer to Exercise 7.] 232 Chapter Gases The Simple Gas Laws A sample of O21g2 has a volume of 26.7 L at 762 Torr What is the new volume if, with the temperature and amount of gas held constant, the pressure is (a) lowered to 385 Torr; (b) increased to 3.68 atm? 10 An 886 mL sample of Ne(g) is at 752 mmHg and 26 °C What will be the new volume if, with the pressure and amount of gas held constant, the temperature is (a) increased to 98 °C; (b) lowered to - 20 °C? 11 If 3.0 L of oxygen gas at 177 °C is cooled at constant pressure until the volume becomes 1.50 L, then what is the final temperature? 12 We want to change the volume of a fixed amount of gas from 725 mL to 2.25 L while holding the temperature constant To what value must we change the pressure if the initial pressure is 105 kPa? 13 A 35.8 L cylinder of Ar(g) is connected to an evacuated 1875 L tank If the temperature is held constant and the final pressure is 721 mmHg, what must have been the original gas pressure in the cylinder, in atmospheres? 14 A sample of N21g2 occupies a volume of 42.0 mL under the existing barometric pressure Increasing the pressure by 85 mmHg reduces the volume to 37.7 mL What is the prevailing barometric pressure, in millimeters of mercury? 15 A weather balloon filled with He gas has a volume of 2.00 * 103 m3 at ground level, where the atmospheric pressure is 1.000 atm and the temperature 27 °C After the balloon rises high above Earth to a point where the atmospheric pressure is 0.340 atm, its volume increases to 5.00 * 103 m3 What is the temperature of the atmosphere at this altitude? 16 The photographs show the contraction of an argon-filled balloon when it is cooled by liquid nitrogen To what approximate fraction of its original volume will the balloon shrink when it is cooled from a room temperature of 22 °C to a final temperature of about - 22 °C? 17 What is the mass of argon gas in a 75.0 mL volume at STP? 18 What volume of gaseous chlorine at STP would you need to obtain a 250.0 g sample of gas? 19 A 27.6 mL sample of PH 31g2 (used in the manufacture of flame-retardant chemicals) is obtained at STP (a) What is the mass of this gas, in milligrams? (b) How many molecules of PH are present? 20 A 5.0 * 1017 atom sample of radon gas is obtained (a) What is the mass of this sample, in micrograms? (b) What is the volume of this sample at STP, in microliters? 21 You purchase a bag of potato chips at an ocean beach to take on a picnic in the mountains At the picnic, you notice that the bag has become inflated, almost to the point of bursting Use your knowledge of gas behavior to explain this phenomenon 22 Scuba divers know that they must not ascend quickly from deep underwater because of a condition known as the bends, discussed in Chapter 13 Another concern is that they must constantly exhale during their ascent to prevent damage to the lungs and blood vessels Describe what would happen to the lungs of a diver who inhaled compressed air at a depth of 30 m and held her breath while rising to the surface General Gas Equation 23 A sample of gas has a volume of 4.25 L at 25.6 °C and 748 mmHg What will be the volume of this gas at 26.8 °C and 742 mmHg? 24 A 10.0 g sample of a gas has a volume of 5.25 L at 25 °C and 762 mmHg If 2.5 g of the same gas is added to this constant 5.25 L volume and the temperature raised to 62 °C, what is the new gas pressure? 25 A constant-volume vessel contains 12.5 g of a gas at 21 °C If the pressure of the gas is to remain constant as the temperature is raised to 210 °C, how many grams of gas must be released? 26 A 34.0 L cylinder contains 305 g O21g2 at 22 °C How many grams of O 21g2 must be released to reduce the pressure in the cylinder to 1.15 atm if the temperature remains constant? Ideal Gas Equation 27 What is the volume, in milliliters, occupied by 89.2 g CO 21g2 at 37 °C and 737 mmHg? 28 A 12.8 L cylinder contains 35.8 g O2 at 46 °C What is the pressure of this gas, in atmospheres? 29 Kr(g) in a 18.5 L cylinder exerts a pressure of 11.2 atm at 28.2 °C How many grams of gas are present? 30 A 72.8 L constant-volume cylinder containing 7.41 g He is heated until the pressure reaches 3.50 atm What is the final temperature in degrees Celsius? 31 A laboratory high vacuum system is capable of evacuating a vessel to the point that the amount of gas remaining is 5.0 * 109 molecules per cubic meter What is the residual pressure in pascals? 32 What is the pressure, in pascals, exerted by 1242 g CO1g2 when confined at - 25 °C to a cylindrical tank 25.0 cm in diameter and 1.75 m high? Exercises 33 What is the molar volume of an ideal gas at (a) 25 °C and 1.00 atm; (b) 100 °C and 748 Torr? 233 34 At what temperature is the molar volume of an ideal gas equal to 22.4 L, if the pressure of the gas is 2.5 atm? Determining Molar Mass 35 A 0.418 g sample of gas has a volume of 115 mL at 66.3 °C and 743 mmHg What is the molar mass of this gas? 36 What is the molar mass of a gas found to have a density of 0.841 g>L at 415 K and 725 Torr? 37 What is the molecular formula of a gaseous fluoride of sulfur containing 70.4% F and having a density of approximately 4.5 g>L at 20 °C and atm? 38 A 2.650 g sample of a gaseous compound occupies 428 mL at 24.3 °C and 742 mmHg The compound consists of 15.5% C, 23.0% Cl, and 61.5% F, by mass What is its molecular formula? 39 A gaseous hydrocarbon weighing 0.231 g occupies a volume of 102 mL at 23 °C and 749 mmHg What is the molar mass of this compound? What conclusion can you draw about its molecular formula? 40 A 132.10 mL glass vessel weighs 56.1035 g when evacuated and 56.2445 g when filled with the gaseous hydrocarbon acetylene at 749.3 mmHg and 20.02 °C What is the molar mass of acetylene? What conclusion can you draw about its molecular formula? Gas Densities 41 A particular application calls for N21g2 with a density of 1.80 g>L at 32 °C What must be the pressure of the N21g2 in millimeters of mercury? What is the molar volume under these conditions? 42 Monochloroethylene is used to make polyvinylchloride (PVC) It has a density of 2.56 g>L at 22.8 °C and 756 mmHg What is the molar mass of monochloroethylene? What is the molar volume under these conditions? 43 In order for a the apparent molar mass of air, given that air is 78.08% N2, 20.95% O2, 0.93% Ar, and 0.036% CO 2, by volume? A mixture of N2O1g2 and O21g2 can be used as an anesthetic In a particular mixture, the partial pressures of N2O and O2 are 612 Torr and 154 Torr, respectively Calculate (a) the mass percentage of N2O in this mixture, and (b) the apparent molar mass of this anesthetic [Hint: For part (b), refer to Exercise 103.] Gas cylinder A has a volume of 48.2 L and contains N21g2 at 8.35 atm at 25 °C Gas cylinder B, of unknown volume, contains He(g) at 9.50 atm and 25 °C When the two cylinders are connected and the gases mixed, the pressure in each cylinder becomes 8.71 atm What is the volume of cylinder B? The accompanying sketch is that of a closed-end manometer Describe how the gas pressure is measured Why is a measurement of Pbar not necessary when using this manometer? Explain why the closed- Integrative and Advanced Exercises end manometer is more suitable for measuring low pressures and the open-end manometer more suitable for measuring pressures nearer atmospheric pressure 237 density as that of air at 25 °C and 1.00 atm? See Exercise 103 for the composition of air 113 Chlorine dioxide, ClO2, is sometimes used as a chlorinating agent for water treatment It can be prepared from the reaction below: Cl21g2 + NaClO1aq2 ¡ NaCl1aq2 + ClO21g2 In an experiment, 1.0 L Cl21g2, measured at 10.0 °C and 4.66 atm, is dissolved in 0.750 L of 2.00 M NaClO1aq2 If 25.9 g of pure ClO2 is obtained, then what is the percent yield for this experiment? 114 The amount of ozone, O3, in a mixture of gases can be determined by passing the mixture through a solution of excess potassium iodide, KI Ozone reacts with the iodide ion as follows: Gas 107 Producer gas is a type of fuel gas made by passing air or steam through a bed of hot coal or coke A typical producer gas has the following composition in percent by volume: 8.0% CO2, 23.2% CO, 17.7% H 2, 1.1% CH 4, and 50.0% N2 (a) What is the density of this gas at 23 °C and 763 mmHg, in grams per liter? (b) What is the partial pressure of CO in this mixture at 0.00 °C and atm? (c) What volume of air, measured at 23 °C and 741 Torr, is required for the complete combustion of 1.00 * 103 L of this producer gas, also measured at 23 °C and 741 Torr? [Hint: Which three of the constituent gases are combustible?] 108 The heat required to sustain animals while they hibernate comes from the biochemical combustion of fatty acids, such as arachidonic acid, C20H 32O2 What volume of air, measured at 298 K and 1.00 atm, is required to burn 2.00 kg C20H 32O2? Air is approximately 78.1% N2 and 20.9% O2, by volume Other gases make up the remaining 1.0% 109 A mixture of H 21g2 and O21g2 is prepared by electrolyzing 1.32 g water, and the mixture of gases is collected over water at 30 °C and 748 mmHg The volume of wet gas obtained is 2.90 L What must be the vapor pressure of water at 30 °C? electrolysis " H 1g2 + O 1g2 H O1l2 2 110 Aluminum (Al) and iron (Fe) each react with hydrochloric acid solution (HCl) to produce a chloride salt and hydrogen gas, H 21g2 A 0.1924 g sample of a mixture of Al and Fe is treated with excess HCl solution A volume of 159 mL of H gas is collected over water at 19.0 °C and 841 Torr What is the percent (by mass) of Fe in the mixture? The vapor pressure of water at 19.0 °C is 16.5 Torr 111 A 0.168 L sample of O21g2 is collected over water at 26 °C and a barometric pressure of 737 mmHg In the gas that is collected, what is the percent water vapor (a) by volume; (b) by number of molecules; (c) by mass? (Vapor pressure of water at 26 °C = 25.2 mmHg.) 112 A breathing mixture is prepared in which He is substituted for N2 The gas is 79% He and 21% O2, by volume (a) What is the density of this mixture in grams per liter at 25 °C and 1.00 atm? (b) At what pressure would the He O2 mixture have the same O31g2 + 3I -1aq2 + H 2O1l2 ¡ O21g2 + I -1aq2 + 2OH -1aq2 The amount of I 3- produced is determined by titrating with thiosulfate ion, S 2O 2-: I -1aq2 + S 2O 2-1aq2 ¡ 3I -1aq2 + S 4O - 1aq2 A mixture of gases occupies a volume of 53.2 L at 18 °C and 0.993 atm The mixture is passed slowly through a solution containing an excess of KI to ensure that all the ozone reacts The resulting solution requires 26.2 mL of 0.1359 M Na 2S 2O3 to titrate to the end point Calculate the mole fraction of ozone in the original mixture 115 A 0.1052 g sample of H 2O1l2 in an 8.050 L sample of dry air at 30.1 °C evaporates completely To what temperature must the air be cooled to give a relative humidity of 80.0%? Vapor pressures of water: 20 °C, 17.54 mmHg; 19 °C, 16.48 mmHg; 18 °C, 15.48 mmHg; 17 °C, 14.53 mmHg; 16 °C, 13.63 mmHg; 15 °C, 12.79 mmHg [Hint: Go to Focus On feature for Chapter on the MasteringChemistry site, www.masteringchemistry.com, for a discussion of relative humidity.] 116 An alternative to Figure 6-6 is to plot P against 1>V The resulting graph is a straight line passing through the origin Use Boyle s data from Feature Problem 125 to draw such a straight-line graph What factors would affect the slope of this straight line? Explain 117 We have noted that atmospheric pressure depends on altitude Atmospheric pressure as a function of altitude can be calculated with an equation known as the barometric formula: P = P0 * 10-Mgh>2.303RT In this equation, P and P0 can be in any pressure units, for example, Torr P0 is the pressure at sea level, generally taken to be 1.00 atm or its equivalent The units in the exponential term must be SI units, however Use the barometric formula to (a) estimate the barometric pressure at the top of Mt Whitney in California (altitude: 14,494 ft; assume a temperature of 10 °C) (b) show that barometric pressure decreases by onethirtieth in value for every 900-ft increase in altitude 118 Consider a sample of O 21g2 at 298 K and 1.0 atm Calculate (a) urms and (b) the fraction of molecules that have speed equal to urms 238 Chapter Gases 119 A nitrogen molecule 1N22 having the average kinetic energy at 300 K is released from Earth s surface to travel upward If the molecule could move upward without colliding with other molecules, then how high would it go before coming to rest? Give your answer in kilometers [Hint: When the molecule comes to rest, the potential energy of the molecule will be mgh, where m is the molecular mass in kilograms, g = 9.81 m s -2 is the acceleration due to gravity, and h is the height, in meters, above Earth s surface.] 120 For H 21g2 at °C and atm, calculate the percentage of molecules that have speed (a) m s -1; (b) 500 m s -1; (c) 1000 m s -1; (d) 1500 m s -1; (e) 2000 m s -1; (f) 2500 m s -1; (g) 3500 m s -1 Graph your results to obtain your own version of Figure 6-15 121 If the van der Waals equation is solved for volume, a cubic equation is obtained (a) Derive the equation below by rearranging equation (6.26) n3ab RT + bP n2a bV = bV2 + a V3 - n a P P P (b) What is the volume, in liters, occupied by 185 g CO21g2 at a pressure of 12.5 atm and 286 K? For CO21g2, a = 3.61 L2 atm mol -2 and b = 0.0429 L mol -1 [Hint: Use the ideal gas equation to obtain an estimate of the volume Then refine your estimate, either by trial and error, or using the method of successive approximations See Appendix A, pages A5 A6, for a description of the method of successive approximations.] 122 According to the CRC Handbook of Chemistry and Physics (83rd ed.), the molar volume of O21g2 is 0.2168 L mol -1 at 280 K and 10 MPa (Note: MPa = * 106 Pa.) (a) Use the van der Waals equation to calculate the pressure of one mole of O21g2 at 280 K if the volume is 0.2168 L What is the % error in the calculated pressure? The van der Waals constants are a = 1.382 L2 bar mol -2 and b = 0.0319 L mol -1 (b) Use the ideal gas equation to calculate the volume of one mole of O21g2 at 280 K and 10 MPa What is the % error in the calculated volume? 123 A particular equation of state for O21g2 has the form PV = RT a1 + C B b + V V2 where V is the molar volume, B = - 21.89 cm3>mol and C = 1230 cm6>mol (a) Use the equation to calculate the pressure exerted by mol O21g2 confined to a volume of 500 cm3 at 273 K (b) Is the result calculated in part (a) consistent with that suggested for O21g2 by Figure 6-20? Explain 124 A 0.156 g sample of a magnesium aluminum alloy dissolves completely in an excess of HCl(aq) The liberated H 21g2 is collected over water at °C when the barometric pressure is 752 Torr After the gas is collected, the water and gas gradually warm to the prevailing room temperature of 23 °C The pressure of the collected gas is again equalized against the barometric pressure of 752 Torr, and its volume is found to be 202 mL What is the percent composition of the magnesium aluminum alloy? (Vapor pressure of water: 6.54 mmHg at °C and 21.07 mmHg at 23 °C) Feature Problems 125 Shown to the right is a diagram of Boyle s original apparatus At the start of the experiment, the length of the air column (A) on the left was 30.5 cm and the heights of mercury in the arms of the tube were equal When mercury was added to the right arm of the tube, a difference in mercury levels (B) was produced, and the entrapped air on the left was compressed into a shorter length of the tube (smaller volume) as shown in the illustration for A = 27.9 cm and B = 7.1 cm Boyle s values of A and B, in centimeters, are listed as follows: A: B: 30.5 0.0 27.9 7.1 25.4 15.7 22.9 25.7 20.3 38.3 A: B: 17.8 53.8 15.2 75.4 12.7 105.6 10.2 147.6 7.6 224.6 Barometric pressure at the time of the experiment was 739.8 mmHg Assuming that the length of the air column (A) is proportional to the volume of air, show that these data conform reasonably well to Boyle s law Pbar * 739.8 mmHg A * 27.9 cm B * 7.1 cm 126 In 1860, Stanislao Cannizzaro showed how Avogadro s hypothesis could be used to establish the atomic masses of elements in gaseous compounds Cannizzaro took the atomic mass of hydrogen to be exactly one and assumed that hydrogen exists as H molecules (molecular mass = 2) Next, he determined the volume of H 21g2 at 0.00 °C and 1.00 atm that has a mass of exactly g This volume is 22.4 L Then he assumed that 22.4 L of any other gas would have the same number of molecules as in 22.4 L of H 21g2 (Here is where Avogadro s hypothesis Feature Problems entered in.) Finally, he reasoned that the ratio of the mass of 22.4 L of any other gas to the mass of 22.4 L of H 21g2 should be the same as the ratio of their molecular masses The sketch below illustrates Cannizzaro s reasoning in establishing the atomic weight of oxygen as 16 The gases in the table all contain the element X Their molecular masses were determined by Cannizzaro s method Use the percent composition data to deduce the atomic mass of X, the number of atoms of X in each of the gas molecules, and the identity of X Relative mass * H Compound Molecular Mass, u Mass Percent X, % Nitryl fluoride Nitrosyl fluoride Thionyl fluoride Sulfuryl fluoride 65.01 49.01 86.07 102.07 49.4 32.7 18.6 31.4 Number of molecules equal to the Avogadro constant, NA: NA * 6.02 + 1023 mol,1 H H Relative mass * 22.4 L at °C and atm 22.4 L at °C and atm H2 O2 Weighs 2.00 g 127 In research that required the careful measurement of gas densities, John Rayleigh, a physicist, found that the density of O21g2 had the same value whether the gas was obtained from air or derived from one of its compounds The situation with N21g2 was different, however The density of N21g2 had the same value when the N21g2 was derived from any of various compounds, but a different value if the N21g2 was extracted from air In 1894, Rayleigh enlisted the aid of William Ramsay, a chemist, to solve this apparent mystery; in the course of their work they discovered the noble gases (a) Why you suppose that the N21g2 extracted from liquid air did not have the same density as N21g2 obtained from its compounds? (b) Which gas you suppose had the greater density: N21g2 extracted from air or N21g2 prepared from nitrogen compounds? Explain (c) The way in which Ramsay proved that nitrogen gas extracted from air was itself a mixture of gases involved allowing this nitrogen to react with magnesium metal to form magnesium nitride Explain the significance of this experiment (d) Calculate the percent difference in the densities at 0.00 °C and 1.00 atm of Rayleigh s N21g2 extracted from air and N21g2 derived from nitrogen compounds [The volume percentages of the major components of air are 78.084% N2, 20.946% O2, 0.934% Ar, and 0.0379% CO2.] 128 The equation d>P = M>RT, which can be derived from equation (6.14), suggests that the ratio of the density (d) to pressure (P) of a gas at constant temperature should be a constant The gas density data at the end of this question were obtained for O 21g2 at various pressures at 273.15 K 239 O Relative mass * 16 O O Relative mass * 32 Weighs 32.00 g (a) Calculate values of d>P, and with a graph or by other means determine the ideal value of the term d>P for O21g2 at 273.15 K [Hint: The ideal value is that associated with a perfect (ideal) gas.] (b) Use the value of d>P from part (a) to calculate a precise value for the atomic mass of oxygen, and compare this value with that listed on the inside front cover P, mmHg: d, g/L: 760.00 1.428962 570.00 1.071485 380.00 0.714154 190.00 0.356985 129 A sounding balloon is a rubber bag filled with H 21g2 and carrying a set of instruments (the payload) Because this combination of bag, gas, and payload has a smaller mass than a corresponding volume of air, the balloon rises As the balloon rises, it expands From the table below, estimate the maximum height to which a spherical balloon can rise given the mass of balloon, 1200 g; payload, 1700 g; quantity of H 21g2 in balloon, 120 ft at 0.00 °C and 1.00 atm; diameter of balloon at maximum height, 25 ft Air pressure and temperature as functions of altitude are: Altitude, km 10 20 30 40 50 60 Pressure, mb 1.0 5.4 2.7 5.5 1.2 2.9 8.1 2.3 * * * * * * * * 10 102 102 101 101 100 10-1 10-1 Temperature, K 288 256 223 217 230 250 250 256 240 Chapter Gases Self-Assessment Exercises 130 In your own words, define or explain each term or symbol (a) atm; (b) STP; (c) R; (d) partial pressure; (e) urms 131 Briefly describe each concept or process: (a) absolute zero of temperature; (b) collection of a gas over water; (c) effusion of a gas; (d) law of combining volumes 132 Explain the important distinctions between (a) barometer and manometer; (b) Celsius and Kelvin temperature; (c) ideal gas equation and general gas equation; (d) ideal gas and real gas 133 Which exerts the greatest pressure, (a) a 75.0 cm column of Hg1l2 1d = 13.6 g>mL2; (b) a column of air 10 mi high; (c) a 5.0 m column of CCl41l2 1d = 1.59 g>mL2; (d) 10.0 g H 21g2 at STP? 134 For a fixed amount of gas at a fixed pressure, changing the temperature from 100.0 °C to 200 K causes the gas volume to (a) double; (b) increase, but not to twice its original value; (c) decrease; (d) stay the same 135 A fragile glass vessel will break if the internal pressure equals or exceeds 2.0 bar If the vessel is sealed at °C and 1.0 bar, then at what temperature will the vessel break? Assume that the vessel does not expand when heated 136 Which of the following choices represents the molar volume of an ideal gas at 25 °C and 1.5 atm? (a) 1298 * 1.5>2732 * 22.4 L; (b) 22.4 L; (c) 1273 * 1.5>2982 * 22.4 L; (d) 3298>1273 * 1.524 * 22.4 L; (e) 3273>1298 * 1.524 * 22.4 L 137 The gas with the greatest density at STP is (a) N2O; (b) Kr; (c) SO3; (d) Cl2 138 If the Kelvin temperature of a sample of ideal gas doubles (e.g., from 200 K to 400 K), what happens to the root-mean-square speed, urms? (a) urms increases by a factor of 12; (b) urms increases by a factor of 2; (c) urms decreases by a factor of 2; (d) urms increases by a factor of 4; (e) urms decreases by a factor of 139 Consider the statements (a) to (e) below Assume that H 21g2 and O21g2 behave ideally State whether each of the following statements is true or false For each false statement, explain how you would change it to make it a true statement (a) Under the same conditions of temperature and pressure, the average kinetic energy of O2 molecules is less than that of H molecules (b) Under the same conditions of temperature and pressure, H molecules move faster, on average, than O2 molecules (c) The volume of 1.00 mol of H 21g2 at 25.0 °C, 1.00 atm is 22.4 L (d) The volume of 2.0 g H 21g2 is equal to the volume of 32.0 g O21g2, at the same temperature and pressure (e) In a mixture of H and O2 gases, with partial pressures PH2 and PO2, respectively, the total pressure is the larger of PH2 and PO2 140 A sample of O21g2 is collected over water at 23 °C and a barometric pressure of 751 Torr The vapor pressure of water at 23 °C is 21 mmHg The partial pressure of O21g2 in the sample collected is (a) 21 mmHg; (b) 751 Torr; (c) 0.96 atm; (d) 1.02 atm 141 At °C and 0.500 atm, 4.48 L of gaseous NH (a) contains 6.02 * 1022 molecules; (b) has a mass of 17.0 g; (c) contains 0.200 mol NH 3; (d) has a mass of 3.40 g 142 To establish a pressure of 2.00 atm in a 2.24 L cylinder containing 1.60 g O21g2 at °C, (a) add 1.60 g O2; (b) add 0.60 g He1g2; (c) add 2.00 g He1g2; (d) release 0.80 g O21g2 143 Carbon monoxide, CO, and hydrogen react according to the equation below CO1g2 + H 21g2 ¡ C3H 81g2 + H 2O1g2 144 145 146 147 148 149 150 What volume of which reactant gas remains if 12.0 L CO1g2 and 25.0 L H 21g2 are allowed to react? Assume that the volumes of both gases are measured at the same temperature and pressure A mixture of and 5.0 * 10-5 mol H 21g2 -5 5.0 * 10 mol SO 21g2 is placed in a 10.0 L container at 25 °C The container has a pinhole leak After a period of time, the partial pressure of H 21g2 in the container (a) is less than that of the SO21g2; (b) is equal to that of the SO21g2; (c) exceeds that of the SO21g2; (d) is the same as in the original mixture Under which conditions is Cl2 most likely to behave like an ideal gas? Explain (a) 100 °C and 10.0 atm; (b) °C and 0.50 atm; (c) 200 °C and 0.50 atm; (d) 400 °C and 10.0 atm Without referring to Table 6.5, state which species in each of the following pairs has the greater value for the van der Waals constant a, and which one has the greater value for the van der Waals constant b (a) He or Ne; (b) CH or C3H 8; (c) H or Cl2 Explain why the height of the mercury column in a barometer is independent of the diameter of the barometer tube A gaseous hydrocarbon that is 82.7% C and 17.3% H by mass has a density of 2.35 g>L at 25 °C and 752 Torr What is the molecular formula of this hydrocarbon? Draw a box to represent a sample of air containing N2 molecules (represented as squares) and O2 molecules (represented as circles) in their correct proportions How many squares and circles would you need to draw to also represent the CO21g2 in air through a single mark? What else should you add to the box for this more complete representation of air? [Hint: See Exercise 103.] Appendix E describes a useful study aid known as concept mapping Using the method presented in Appendix E, construct a concept map illustrating the different concepts to show the relationships among all the gas laws described in this chapter ... Self-Assessment Exercises 448 11 Chemical Bonding II: Additional Aspects 11 -1 11- 2 11 -3 11 -4 11 -5 11 -6 11 -7 11 -8 What a Bonding Theory Should Do 450 Introduction to the Valence-Bond Method 4 51 Hybridization... 812 Integrative and Advanced Exercises 815 Feature Problems 816 Self-Assessment Exercises 817 18 -4 18 -5 18 -6 18 -7 18 -8 18 -9 745 19 Spontaneous Change: Entropy and Gibbs Energy 819 19 -1 19-2 19 -3... and Advanced Exercises 912 Feature Problems 914 Self-Assessment Exercises 915 21 Chemistry of the Main-Group Elements I: Groups 1, 2, 13 , and 14 917 21- 1 21- 2 21- 3 21- 4 21- 5 Periodic Trends and - Xem thêm - Xem thêm: Ebook General chemistry principles and modern applications (10th edition) Part 1, Ebook General chemistry principles and modern applications (10th edition) Part 1, Ebook General chemistry principles and modern applications (10th edition) Part 1