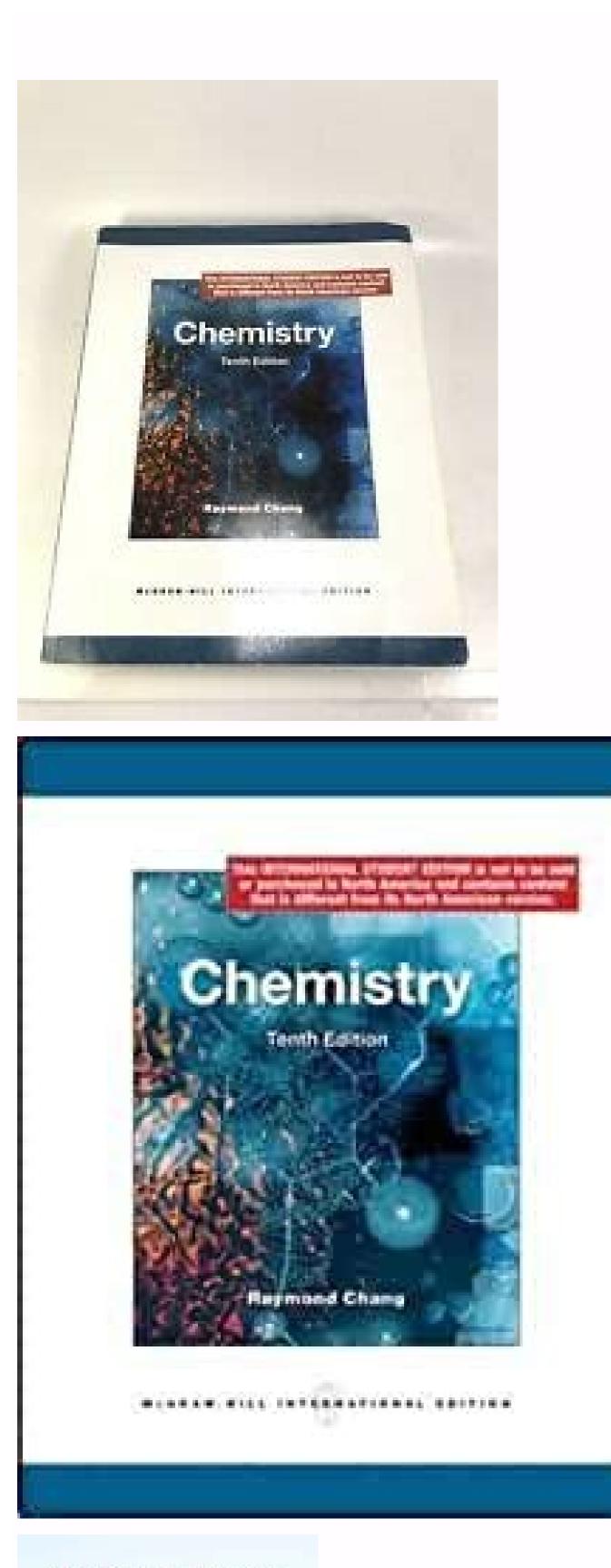




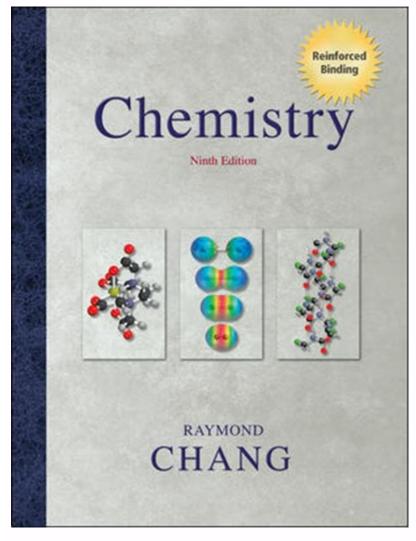
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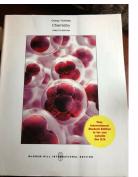
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CHEMISTRY







Chemistry by raymond chang 9th edition. Chemistry a modern view book 1 answer.

(d) Carbon-14 can also be represented as 14C. The multimedia package for the new edition stretches students beyond the confines of the traditional textbook. Practice Exercise A roll of aluminum foil has a mass of 1.07 kg. All others 5.3% Magnesium 2.8% Calcium 4.7% Oxygen 45.5% Iron 6.2% Silicon 27.2% (a) 52 Aluminum 8.3% Oxygen 65% Carbon 18% (b) All others 1.2% Phosphorus 1.2% Calcium 1.6% Nitrogen 3% Hydrogen 10% 53 2.5 Molecules and Ions majority of known elements are metalloids. (Harnessing solar energy has no such detrimental effects on the environment.) By using fuel-efficient automobiles and more effective catalytic converters, we should be able to drastically reduce harmful auto emissions and improve the air quality in areas with heavy traffic. How many moles of H are in 1 mole of urea? Convert this number to g/L. 1.10 What is the number of known elements? —Raymond Chang Study Tools Chapter opening page: Set yourself up for success by reviewing the chapter outline. by taking the first part of the element name (chlorine) and adding "-ide." Potassium bromide (KBr), zinc iodide (ZnI2), and aluminum oxide (Al2O3) are also binary compounds. Similar calculations show that the atomic mass of oxygen is 16.00 amu and that of iron is 55.85 amu. (c) When the polarity of the magnet is reversed, the ray bends in the opposite direction. What chemical properties make them specially suitable for making coins and jewelry? 20, so the number of neutrons is 20 2 11 5 9. She first weighs the crucible in air and then weighs it suspended in water (density 5 0.9986 g/mL). Yet even the dead ends contribute something to the continually growing body of knowledge about the physical universe. We have seen that 1 mole of carbon-12 atoms has a mass of exactly 12 g and contains 6.022 3 1023 atoms. Next, we consider how scientific notation is handled in arithmetic operations. His often-quoted comment to his students was that "all science is either physics or stamp-collecting." ‡ Johannes Hans Wilhelm Geiger (1882-1945). Strategy How do atomic masses of different elements combine to give the molecular mass of a compound? The estimated reserves of these fuels will last us another 50-100 years, at the present rate of consumption, so it is urgent that we find alternatives. Molecules A molecule is an aggregate of at least two atoms in a definite arrangement held together by chemical forces (also called chemical bonds). (a) length, (b) volume, (c) temperature, (d) mass. 54 Atom, p. 4. Basti North Carolina A&T State University Laurance Beauvais San Diego State University Vladimir Benin University of Dayton Miriam Bennett San Diego State University Christine V. For example, 98.90 percent becomes 98.90/100, or 0.9890. Compounds are formed by the chemical combination of atoms of different elements is true? When she drops a small object into the mixture, she finds that the object becomes suspended in the liquid; that is, it neither sinks nor floats. Note that oxygen (O2) and ozone (O3) are allotropes of oxygen. The mass of each ion (and hence its parent atom or molecule) is deflection. The classifications of matter include substances, mixtures, elements, and compounds, as well as atoms and molecules, which we will consider in Chapter 2. Each set is made of three quarters, one nickel, and two dimes. The Celsius scale divides the range between the freezing point (0°C) and boiling point (100°C) of water into 100 degrees. 1.60 The speed of sound in air at room temperature is about 343 m/s. I have tried to strike a balance between the organized end to illustrate basic principles. with everyday examples whenever possible. Calculate this speed in miles per hour. Within the chapter, icons are used to refer to the items shown in the Student Interactive Activity list. (1 mi 5 1609 m.) 2.9 Use the helium-4 isotope to define atomic number and mass number. (See Example 6.1 on page 237.) A margin note lists similar problems in the end-of-chapter problems section, enabling the student to apply new skill to other problems of the same type. The SI-derived unit for density is the kilogram per cubic meter (kg/m3). We need two conversion factors: molar mass and Avogadro's number. Matter includes things we can see and touch (such as water, earth, and trees), as well as things we cannot (such as air). 3B 4B 5B 6B 7B 8B 1B 2B The transition metals are the elements in Groups 1B and 3B-8B (see Figure 2.10). French chemist. His only recreation was lawn bowling on Thursday afternoons. Thus, when HBrO3 is converted to HBrO, the acid is called hypobromous acid. substances. Smith University of Michigan-Dearborn David Speckhard Loras College Rick Spinney Ohio State University David Son Southern Methodist University Larry O. Frequently it is helpful to make a sketch that will help you to visualize the situation. 59 Ion, p. Some examples are water (H2O), ammonia (NH3), carbon dioxide (CO2), and methane (CH4). 1.3 (a) 621.5°F, (b) 78.3°C, (c) 2196°C. Humans have asked these questions for as long as we have been able to think. The considerably smaller engine thrust expressed in newtons resulted in a lower orbit and the ultimate destruction of the spacecraft. By purchasing E-books from McGraw-Hill, students can save as much as 50% on selected titles delivered on an advanced E-book platform. An English physicist, J. (Density of Al 5 2.699 g/cm3.) 1.89 Comment on whether each of the following is a homogeneous mixture or a heterogeneous mixture is NH2. The sum of the charges is 11 1 (21) 5 0, so no subscripts are necessary. All other units of measurement can be derived from these base units. With the important exception of the ammonium ion, NH1 4, all cations of interest to us are derived from metal atoms. So NH4ClO3 is also an (Continued) 61 62 Atoms, Molecules, and Ions ionic compound. Singly ionized helium atoms can still absorb light and are therefore detectable. 1.7

Measurement 19 Examples 1.1 and 1.2 show density calculations. 1.84 Measurements show that 1.0 g of iron (Fe) contains 1.1 3 1022 Fe atoms. The back inside cover shows a list of important figures and tables with page references. For example, if the mass number of a particular boron atom is 12 and the atomic number is 5 (indicating 5 protons in the nucleus), then the number of neutrons is 12 2 5 5 7. In balland-stick model kits, the atoms are wooden or plastic balls with holes in them. Thomson, R. (The distance from the sun to Earth is 93 million mi; the speed of light 5 3.00 3 108 m/s.) 1.44 A slow jogger runs a mile in 13 min. For example, there are three isotopes of hydrogen. 1.8 Handling Numbers Keep in mind the following two points. Check Should 6.07 g of CH4 equal less than 1 mole of CH4? 67 Beta (b) particles, p. The compound is ammonium chlorate. For example, the molecular mass of water is 18.02 g. E-books from McGraw-Hill will help students study smarter and quickly find the information they need. Harte, University Science Books, Mill Valley, CA 1988. (This conversion takes place at the boiling point of the liquid.) On the other hand, cooling a gas will cause it to condense into a liquid. The Chemistry in Action essay on page 21 shows why we must be careful with units in scientific work. Figure 3.3 Schematic diagram of one type of mass spectrometer. In this sample, there will be 40.92 g of C, 4.58 g of H, and 54.50 g of O. Highly accurate measurements are usually precise too. The second observation that supports Gamow's hypothesis is the detection of cosmic background radiation. EXAMPLE 1.4 Determine the number of significant figures in the following measurements: (a) 478 cm, (b) 6.01 g, (c) 0.825 m, (d) 0.043 kg, (e) 1.310 × 1022 atoms, (f) 7000 mL. In both (a) and (b), the smaller spheres represent Na1 ions and the larger spheres, Cl2 ions. Wright Central Connecticut State University of Wisconsin-Platteville William Zoller University of Washington xxvii Special thanks are due to the following individuals for their detailed comments and suggestions for specific chapters. (a) (b) (c) 2.33 Identify the following individuals for their detailed comments and suggestions for specific chapters. (b) (c) 2.33 Identify the following individuals for their detailed comments and suggestions for specific chapters. (a) (b) (c) 2.33 Identify the following individuals for their detailed comments and suggestions for specific chapters. (a) (b) (c) 2.33 Identify the following individuals for their detailed comments and suggestions for specific chapters. an indirect method, as we will see in Chapter 2. (b) In glucose there are 6 carbon atoms, 12 hydrogen atoms. We cannot convert directly from grams of urea to atoms of hydrogen. He is an editor of The Chemical Educator. How many moles of CH4 are present in 6.07 g of CH4? Percent by Mass* Oxygen Carbon Hydrogen. He is an editor of The Chemical Educator. How many moles of CH4 are present in 6.07 g of CH4? Percent by Mass* Oxygen Carbon Hydrogen. Calcium Phosphorus Potassium Sulfur Chlorine 65 18 10 3 1.6 1.2 0.2 0.2 0.2 0.2 Element Sodium Magnesium Iron Cobalt Copper Zinc Joury explains the law of the element in grams present in a 100-g sample. Dalton's theory explains the law of multiple proportions quite simply: Different compounds made up of the same elements differ in the number of atoms of each kind that combine. The Chemistry in Action essay on p. Calculate the number of liters of carbon dioxidet the number of atoms of each kind that combine. gas released if its density is 1.81 g/L. Normally, pound is the unit for mass. In addition, the media-rich E-book for Chemistry integrates relevant animations and videos into the textbook content for a true multimedia learning experience. Express this person's height in meters and weight in kilograms. But atoms are extremely small particles—even the smallest speck of dust that our unaided eyes can detect contains as many as 1 3 1016 atoms! Clearly we cannot weigh a single atom, but it is possible to determine the mass of one atom relative to another experimentally. 43 Mass number (A), p. For the future, scientists have begun to explore the prospect of "molecular computing," that is, replacing silicon with molecules. The measured value of an intensive property does not depend on how much matter is being considered. (b) Is a troy ounce heavier or lighter than an ounce? The masses of the cylinder before and after the addition of the mineral oil are 124.966 g and 159.446 g, respectively. A metal is a good conductor of heat and electricity while a nonmetal is usually a poor conductor of heat and electricity. The Periodic Table Review Questions 2.19 What is the periodic table, and what is its significance in the study of chemistry? 1.22 The density of ethanol, a colorless liquid that is commonly known as grain alcohol, is 0.798 g/mL. Copyright © 2010 by The McGraw-Hill Companies, Inc For every success story, however, there are hundreds of cases in which scientists have spent years working on projects that ultimately led to a dead end, and in which positive achievements came only after many wrong turns and at such a slow pace that they went unheralded. Ball-and-stick models show the three-dimensional arrangement of atoms clearly, and they are fairly easy to construct. The hydrogen molecule, symbolized as H2, is called a diatomic molecule because it contains only two atoms. 66 Periods, p. Access to your book, access to all books! The Presentation Center library includes thousands of assets from many McGraw-Hill titles. Austin State University Bruce Moy College of Lake County Richard Nafshun Oregon State University Jim Neilan Volunteer State Community College Glenn S. Key Equations d5 m V (1.1) ?°C 5 1°F 2 32°F 3 ?°F 5 Equation for density 5°C 9°F 9°F 3 1°C2 1 32°F 5°C ? At this stage of investigation, scientists perceived the atom as follows: The mass of a nucleus constitutes most of the mass of the entire atom, but the nucleus occupies only about 1/1013 of the volume of the atom. His most famous work, now known as Avogadro's law (see Chapter 5), was largely ignored during his lifetime, although it became the basis for determining atomic masses in the late nineteenth century. A hot poker changes ice into water and steam. (Hint: Consider the electrostatic attraction between protons and electrons.) 2.72 (a) Describe Rutherford's experiment and how it led to the structure of the atom. (Continued) 3.5 Percent Composition of Compounds 91 Try to convert to whole numbers by dividing all the subscripts by the smallest subscript (3.406): C: 3.407 (Assume that the volume of inhaled air is equal to that of exhaled air.) 1.70 (a) Referring to Problem 1.69, calculate the total volume (in liters) of air an adult breathes in a day. Examples of ions formed by the loss or gain of more than one electron are Mg21, Fe31, S22, and N32. This research led to the discovery of three such particles—electrons, protons, and neutrons. What is in store for the near future? The key to success in problem solving is practice. In addition to having access to all student digital learning objects, ARIS enables instructors to build assignments and track student progress, and provides more flexibility. 1 2 3 4 5 6 7 8 9 0 DOW/DOW 0 9 ISBN 978-0-07-351109-2 MHID 0-07-351109-9 Publisher: Thomas D. (b) Poor accuracy and good precision. A major disadvantage of burning fossil fuels is that they give off carbon dioxide, which result in acid rain and smog. (e) Uranium is a radioactive element. Basically, this assignment calls for us to find n. What this law means is that an increase in the mass or in the acceleration of an object will always increase its force proportionally, and a decrease in mass or acceleration will always decrease in the following molecular formulas? It is gratifying to know that at times an undergraduate can assist in winning a Nobel Prize. How does one estimate the pressure in a carbonated soft drink bottle before removing the cap? In fact, each Na1 ion is equally held by six surrounding Cl2 ions and vice versa. Of the 83 elements that are found in nature, 12 make up 99.7 percent of Earth's crust by mass. (Sodium fluoride is 45.0 percent fluorine by mass. Thus, the absence of a prefix for the first element usually means there is only one atom of that element present in the molecule. 15 Weight, p. The names of anions in which one or more but not all the hydrogen ions have been removed must indicate the number of H ions present. 1.5 (a) 26.76 L, (b) 4.4 g, (c) 1.6 3 107 dm2, (d) 0.0756 g/mL, (e) 6.69 3 104 m. 438 m. 448 it was pointed out that mass and energy are alternate aspects of a single entity called mass-energy. An atom consists of a very dense central nucleus at a relatively large distance from it. Strategy We are given grams of helium and asked to solve for moles of helium. One is the conversion of sunlight directly to electricity using devices called photovoltaic cells. 2.2 The Structure of the Atom Figure 2.8 (a) Rutherford's experimental design for measuring the scattering of a particles by a piece of gold foil. The molar mass of a compound (in grams) is numerically equal to its molecular mass (in amu). 25 26 Chemistry: The Study of Change Solution In addition and subtraction, the number of decimal places in the answer is determined by the number of decimal places. Because H3PO3 has one fewer O atom, it is called phosphorous acid. Metal cations take their names from the elements. Review of Concepts An ice cube is placed in a closed container Optical computers also would have much greater storage capacity than electronic computers. (b) Abundance of elements in the human body in percent by mass. 2.58 Name these compounds: (a) KClO, (b) Ag2CO3, (c) FeCl2, (d) KMnO4, (e) CsClO3, (f) HIO, (g) FeO, (h) Fe2O3, (i) TiCl4, (j) NaH, (k) Li3N, (l) Na2O2, (m) FeCl3 ? Millikan Ernest Rutherford, James Chadwick. Hydrogen gas, for example, is a pure element, but it consists of molecules made up of two H atoms each. Hypotheses that survive many experimental tests of their validity may evolve into theories. 2.80 Of the 117 elements known, only two are liquids at room temperature (25°C). Organic compounds contain carbon, usually in combination with elements such as hydrogen, oxygen, nitrogen, and sulfur. Zeros to the left of the first nonzero digit are not significant. One of Becquerel's students, Marie Curie, ‡ suggested the name radioactivity to describe this spontaneous emission of particles and/or radiation. Photos are used to help students become familiar with chemicals and understand how chemical reactions appear in reality. We know these negatively charged particles? Surrounding the core is a layer called the mantle, which consists of hot fluid containing iron, carbon, silicon, and sulfur. The substances that make up matter have unique physical properties that can be observed without changing their identity of the Chapter Summary 4. Worked Examples along with the accompanying Practice Exercise is a very important tool for learning and mastering chemistry. Geiger's work focused on the structure of the atomic nucleus and on radioactivity. — Added a new Chemistry is an ancient science, its modern foundation was laid in the nineteenth century, when intellectual and technological advances enabled scientists to break down substances into ever smaller components and consequently to explain many of their physical and chemical characteristics. In a solid, molecules are held close together in an orderly fashion with little freedom of motion. The zinc cation Zn21 and the iodine anion I2 combine to form zinc iodide. For example, consider the anionset and chemical characteristics. derived from phosphoric acid: H3PO4 phosphoric acid H2PO2 dihydrogen phosphate 4 PO32 phosp between moles and number of atoms (Figure 3.2). Go to www.mhhe.com/physsci/chemistry/chang and click on the appropriate cover to explore animations, download content to your Media Player, do your homework electronically, and more. The atomic number (Z) is the number of protons in the nucleus of each atom of an element. In multiplication and division, the number of significant figures in the final product or quotient is determined by the original number that has the smallest number of significant figures. These techniques can be applied to many different farm products, not only for improved yields, but also for better frequency, that is, more crops every year. Problems 2.43 Write the formulas for the following ionic compounds: (a) sodium oxide, (b) iron sulfide (containing the Fe21 ion), (c) cobalt sulfate (containing the Fe21 ion), (c) coba mass of the oppositely charged electron. When significant figures are used, the last digit is understood to be uncertain. (b) The cation is K1 and the anion is H2PO2 4 (dihydrogen phosphate). In a gas, the molecules are separated by distances that are large compared with the size of the molecules. Note that the properties of water are unique among common substances in that the molecules in the liquid state are more closely packed than those in the solid state. Further experiments are devised to test the validity of the hypothesis in as many ways as possible, and the process begins anew. nonmetals. The potassium cation K1 and the bromine anion Br2 combine to form the ionic compound potassium bromide. In our discussion of molecules, each example was given with its molecular formula in parentheses. The tenth edition tools for Chemistry are designed to enable you to do well in your general chemistry course. 1.104 A chemist mixes two liquids A and B to form a homogeneous mixture. Solution We are given the mass and volume and asked to calculate the density. Strategy We refer to Table 2.4 for prefixes. There is a powerful suite of built-in tools that enable detailed searching, highlighting, note taking, and student-to-student note sharing. Dalton's third hypothesis supports another important law, the law of multiple proportions. Section 2.8 gives a brief introduction to organic compounds. Examples are "electronic," "quantum leap," "catalyst," "chain reaction," and "critical mass." Moreover, if you cook, then you are a practicing chemist! From experience gained in the kitchen, you know that oil and water do not mix and that boiling water left on the stove will evaporate. For example, N2O4 may be called dimensional analysis (also called the factor-label method). Mathematically, the percent composition of an element in a compound is expressed as percent compound, p. Therefore, the formula is Cs2S. Calculate the average atomic mass of copper. How are allotropes different from isotopes? This means that when we measure the atomic mass of an element, we must generally settle for the average mass of the naturally occurring mixture of isotopes. The ratio of hydrogen to oxygen atoms in this molecule is 2:2 or 1:1. For example, an improperly calibrated meterstick or a faulty balance may give precise readings that are in error. 11. Chemical analyses show that in one sample of ethane, 2.65 g of carbon are combined with 0.383 g of hydrogen. Condensing the vapor will give us back the water component. Questions and Problems 1.18 Write the numbers represented by the following prefixes: (a) mega-, (b) kilo-, (c) deci-, (d) centi-, (e) milli-, (f) micro-, (g) nano-, (h) pico-. We cannot convert directly from grams to atoms of sulfur. By composition we mean not only the elements present but also the ratios in which the atoms are combined. Atoms of a given element do not all have the same mass. Using computers and special microscopes, for example, chemistry is based—and design new substances with specific properties, such as drugs and environmentally friendly consumer products. No part of this publication may be reproduced or distributed in any form or by any means, or stored in a database or retrieval system, without the prior written consent of The McGraw-Hill Companies, Inc., including, but not limited to, in any network or other electronic storage or transmission, or broadcast for distance learning. Calculate the speed in (a) in/s, (b) m/min, (c) km/h. In addition to the atomic theory, he also formulated several gas laws and gave the first detailed description of color blindness, from which he suffered. One liter of volume is equal to 1000 cm3 5 1 dm3 1 cm 10 cm = 1 dm Volume: 1 cm3; 1 mL and one milliliter is equal to one cubic centimeter: 1 cm 1 mL = 1 cm3 Figure 1.10 Comparison of two volumes, 1 mL and 1000 mL. Answers to the Practice Exercises are listed at the end of the chapter problems. No names have yet been assigned to elements 112-116, and 118. Because gas densities are often very low, we express them in units of grams per liter (g/L): 1 g/cm3 5 1 g/mL 5 1000 kg/m3 1 g/L 5 0.001 g/mL Table 1.4 lists the densities of several substances. Example 1.4 shows the determination of significant figures. The three states of matter can be interconverted without changing the composition of the substance. Thus, the radiation should be the same in any direction that we observe. xxviii Visuals: Understand the chemical principles though the various styles of visual aids and breakdown of important concepts. What conversion factor do we need to convert between grams and moles? 9 The three levels of studying chemistry and their relationships. By the early 1900s, two features of atoms had become clear: they contain electrons, and they are electrically neutral. Dalton's fourth hypothesis is studying chemistry and their relationships. another way of stating the law of conservation of mass, which is that matter can be neither created nor destroyed. The atomic masses of its two stable isotopes, 63 29Cu (30.91 percent) and 65 29Cu (30.91 percent), are 62.93 amu and 64.9278 amu, respectively. (b) An autumn leaf gravitates toward the ground because there is an attractive force between the leaf and Earth. 86) and in Chem Matters, October 1988. The atomic masses of many elements have been accurately determined to five or six significant figures. Consequently, of course, many plant-eating animals perished, and then, in turn, meateating animals began to starve. A certain solder has a melting point of 224°C. Every year Earth's surface receives about 10 times as much energy from sunlight as is contained in all of the known reserves of coal, oil, natural gas, and uranium combined. The percent by mass of each of the elements in H3PO4 4(16.00 g) O and uranium combined. The percent by mass of each of the elements in H3PO4 4(16.00 g) O and uranium combined. The percent by mass of each of the elements in H3PO4 4(16.00 g) O and uranium combined. % S 5 3 100% 5 65.31% 97.99 g H3PO4 % H 5 Similar problem: 3.40. However, chemical formulas are written with whole numbers. 2.34 Give two examples of each of the following: (a) a diatomic molecule containing atoms of the same element, (b) a diatomic molecule containing atoms of the same element, (b) a diatomic molecule containing atoms of the same element, (b) a diatomic molecule containing atoms of the same element, (b) a diatomic molecule containing atoms of the same element, (b) a diatomic molecule containing atoms of the same element, (c) a polyatomic molecule containing atoms of the same element, (b) a diatomic molecule containing atoms of the same element, (b) a diatomic molecule containing atoms of the same element, (b) a diatomic molecule containing atoms of the same element, (c) a polyatomic molecule containing atoms of the same element, (b) a diatomic molecule containing atoms of the same element, (c) a polyatomic molecule containing atoms of the same element, (b) a diatomic molecule containing atoms of the same element, (c) a polyatomic molecule containing atoms of the same element, (b) a diatomic molecule containing atoms of the same element, (b) a diatomic molecule containing atoms of the same element, (b) a diatomic molecule containing atoms of the same element, (b) a diatomic molecule containing atoms of the same element, (b) a diatomic molecule containing atoms of the same element, (b) a diatomic molecule containing atoms of the same element, (b) a diatomic molecule containing atoms of the same element, (b) a diatomic molecule containing atoms of the same element, (b) a diatomic molecule containing atoms of the same element, (b) a diatomic molecule containing atoms of the same element, (b) a diatomic molecule containing atoms of the same element, (b) a diatomic molecule containing atoms of the same element, (b) a diatomic molecule containing atoms of the same element, (b) a diatomic molecule containing atoms of the same element, (b) a diatomic molecule containing atoms diatomic molecule containi of the same element, (d) a polyatomic molecule containing atoms of different elements. They are, in decreasing order of natural abundance, oxygen (O), silicon (Si), aluminum (Al), iron (Fe), calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), titanium (Ti), hydrogen (H), phosphorus (P), and manganese (Mn). A chemical reaction involves only the separation, combination, or rearrangement of atoms; it does not result in their creation or destruction. This problem can be expressed as ? (c) A silicon wafer being processed. Thus, we can use the following equation to convert degrees Celsius to kelvin: ? Every day we observe such changes without thinking about their chemical nature. 2 3 Convert the density to g/cm3. We cannot know which is correct without more information. Representation is a scientific shorthand for describing an experiment in symbols and chemical equations. Without ample sunlight most plants could not grow, and the fossil record confirms that many types of plants did indeed die out at this time. Why, then, do chemists bother with empirical formulas? Isotopes are atoms of the same element having a different number of neutrons. Classification and Properties of Matter Review Questions 1.5 Give an example for each of the following terms: (a) matter, (b) substance, (c) mixture. 2.2 CHCl3. For binary compounds, the first element named is the metal cation, followed by the nonmetallic anion. Lindmark Indiana University Northwest Teh Yun Ling, NUS High School of Maths and Science Arthur Low Tarleton State University Jeanette Madea Broward Community College Steve Malinak Washington Jefferson College Diana Malone Clarke College C. Mixtures are either homogeneous or heterogeneous. 2.53 Give an example each for a binary compound and a ternary compound. Regardless of their magnitude, all numbers can be expressed in the form N × 10n where N is a positive or negative integer (whole number). 4 Compound, p. The manual also includes a detailed discussion of different types of problems and approaches to solving chemical problems: 1.35, 1.36. Key Words Acid, p. Similar problems: 1.21, 1.22. (d) The ignition temperature of paper is 451°F. Mass number is always greater than atomic number. Molecules and Ions Review Questions 2.27 What is the difference between an atom and a molecule? Therefore, the answer is reasonable. 1.96 The average time it takes for a molecule? Therefore, the answer is reasonable. 1.96 The average time it takes for a molecule? energy is lost in the form of heat between the power station and our homes. 450 Key Equations 452 Summary of Facts and Concepts 452 Key Words 453 ix x Contents Intermolecular Forces 463 11.3 Properties of Liquids 469 CHEMISTRY in Action Why Do Lakes Freeze from the Top Down? The solutions to all of the end-of-chapter problems are given in the manual. Example 2.1 shows how to calculate the number of protons, neutrons, and electrons using atomic numbers and mass numbers. — The Special Problem section contains more challenging problems that are suitable for group projects. What is this temperature in degrees Celsius? Radiation may strip a helium atom of one electron, but not always both. carbon-12 is determined experimentally. (See Table 1.1 and the inside front cover.) 1.15 Classify each of the following substances as an element or a compound: (a) hydrogen (b) water, (c) gold, (d) sugar. Predict what would happen. About 50 million tons of SO2 are released to the atmosphere every year. The hydrogen can then be fed into a fuel cell to generate electricity. J. For example, it is known that a certain bacterium produces a protein molecule that is toxic to leaf-eating caterpillars. Their findings enabled them to map out which species existed on 38 Earth during specific geologic periods. 20 Chemistry: The Study of Change Figure 1.11 Comparison of the three temperature scales: Celsius, and Fahrenheit, and the absolute (Kelvin) scales. Note that the combined mass of a Na atom and a Cl atom. 1.55 In 2008, about 95.0 billion lb of sulfuric acid were produced in the United States. Classify each of the following statements as a hypothesis, a law, or a theory. 46 Alpha (a) rays, p. Calculate the percent composition by mass of H, P, and O in this compound. (The mass of Earth is 5.9 3 1021 tons. The procedure used in the example can be reversed if necessary. For greater accuracy, we might use a graduated cylinder that has finer divisions, so that the volume we measure is now uncertain by only 0.1 mL. A chemical equation must be balanced so that we have the same number and type of atoms for the reactants, the starting materials, and the products, the substances formed at the end of the reaction. Figure 1.11 compares the three temperature scales. — Revised the treatment of orientation factor in Chapter 13. In this particular case, we can express the number 400 as 4 × 102 for two significant figures, or 4.00 × 102 for two significant figures. dimensional analysis, the units are carried through the entire sequence of calculations. Measurements that we will utilize frequently in our study of chemistry include time, mass, volume, density, and temperature. (2.2) • We will learn the following ways to identify atoms. As you can see in Figure 2.13, no Na1 ion in NaCl is associated with just one particular Cl2 ion. The masses of molecules can be determined in a similar manner by the mass spectrometer. A helium atom, on the other hand, has two electrons. Finally, the Special Problems section contains more challenging problems. Assume gold costs \$948 per ounce. This investigation led to the hypothesis that the extinction of dinosaurs occurred as follows. Röntgen called them X rays because their nature was not known. What is the volume occupied by 1.20 3 103 g of lithium? Chemistry is an experimental science and many of the problems are quantitative in nature. For relaxation, Professor Change maintains a forest garden; plays tennis, Ping-Pong, and the harmonica; and practices the violin. 4H2O barium chloride dihydrate lithium chloride and the unknown quantity. 1.19 What units do chemists normally use for density of liquids and solids? We can use the preceding result to determine the relationship between atomic mass units and grams. Answers to the Review of Concepts can be found in the Student Solution Manual and online in the accompanying ARIS companion website. (1.9) Classifications of Matter Physical and Chemical Properties of Matter Handling Numbers Dimensional Analysis in Solving Problems End of Chapter Problems End of Chapter Problems Student Interactive Activity Media Player Chapter Student Interactive Activity Media Player Chapter Problems End of Cha with an overview of concepts that will be presented in the chapter. Practice Exercise Write chemical formulas for the following molecular 1026 m3. 1.16 Classify each of the following as an element, a compound, a homogeneous mixture; (a) seawater, (b) helium gas, (c) sodium chloride (table salt), (d) a bottle of soft drink, (e) a milkshake, (f) air in a bottle, (g) concrete. Name the types of radiation known to be emitted by radioactive elements. Practice Exercise Name the following compounds: (a) PbO and (b) Li2SO3. (3.1 and 3.2) • Our discussion of atomic mass leads to molecular mass, which is the sum of the masses of the constituent atoms present. 9 Liter, p. The following examples illustrate this rule: 2.8 3 4.5039 5 12.61092 - round off to 13 6.85 5 0.0611388789 - round off to 0.0611 112.04 3. We will begin our study of chemistry at the macroscopic level, where we can see and measure the materials of which our world is made. Lin Coker III Campbell University Dawn De Carlo University Dawn De Carlo University Erin Dahlke Loras College Gary DeBoer LeTourneau University Dawn De Carlo University Dawn De Carlo University Dawn De Carlo University Erin Dahlke Loras College Gary DeBoer LeTourneau University Dawn De Carlo University Dawn De Carlo University Dawn De Carlo University Erin Dahlke Loras College Gary DeBoer LeTourneau University Dawn De Carlo Univer State University-Fullerton Gregg Dieckman University of Texas at Dallas Michael Doughty Southeastern Louisiana University Eanna C. formula is CS2. Keep in mind that exact numbers of objects can be considered to have an infinite number of significant figures. Cruickshank (Northern Arizona University) and Raymond Chang. Cation Anion Formula Name Magnesium bicarbonate SrCl2 Fe 31 NO2 2 Manganese(II) chlorate SnBr4 Co 21 Hg21 2 PO32 4 I2 Cu2CO3 Lithium nitride Al 31 22 S 2.95 Some compounds are better known by their common names than by their systematic chemical names. EXAMPLE 1.6 A person's average daily intake of glucose (a form of sugar) is 0.0833 pound (lb). Gradebook functionality enables full course management including: — Dropping the lowest grades — Weighting grades/manually adjusting grades/manually adjusting grades — Exporting you to track student progress through multiple reports Offers More Flexibility • • Sharing Course Materials with Colleagues— Instructors can create and share course materials and assignments with colleagues with a few clicks of the mouse, allowing for multiple section courses with many instructors (and TAs) to continually be in sync if desired. Although the ratio of carbon to hydrogen to oxygen atoms in C2H4O2 is the same as that in C6H12O6 (1:2:1), C2H4O2 is not the simplest formula because its subscripts are not in the smallest whole number ratio. The atom's positive charges, Rutherford proposed, are all concentrated in the nucleus, which is a dense central core within the atom. • Tables Every table that appears in the text has been saved in electronic form for use in classroom presentations and/or quizzes. Calculate the density of lead. Handling Numbers Review Questions 1.27 What is the advantage of using scientific notation over decimal notation? Pesterfield Western Kentucky University Richard Petersen University Edward Quitevis Texas Tech University Fast Lansing William Quintana New Mexico State University Edward Quitevis Texas Tech University Preface Jeff Rack Ohio University Lisa Reece Ozarks Technical Community College Michelle Richards-Babb West Virginia University Jim D. Although retaining an additional digit past the number of significant figures for intermediate steps helps to eliminate errors from rounding, this procedure is not necessary for most calculations because the difference between the answers is usually quite small. For example, a solid sample of sodium chloride (NaCl) consists of equal numbers of Na1 and Cl2 ions arranged in a three-dimensional network (Figure 2.13). 1.103 You are given a liquid. Proust's law of definite proportions states that different samples of the same compound always contain its constituent elements in the same proportion by mass. Because density is an intensive property and does not depend on the quantity of mass present, for a given substance the ratio of mass to volume always remains the same; in other 10. 16 Mass, p. Each section under a topic heading begins with Review Questions followed by Problems. Indeed, the microwave signals recorded by astronomers are independent of direction. The relationship between these two physical quantities is Einstein's famous equation, E 5 mc2, where E is energy, m is mass, and c is the speed of light. Convert this number to micrograms per milliliter (mg/mL). Beta (b) rays, or b particles, are electrons and are deflected by the negatively charged plate. File loading please wait... Special Problems 1.99 A bank teller is asked to assemble "one-dollar" sets of coins for his clients. Practice Exercise Calculate the percent composition by mass of each of the elements in sulfuric acid (H2SO4). 3. Many molecular compounds are binary compounds. In other words, chemists often see one thing (in the macroscopic world) and think another (in the macroscopic world). (1.8) • Finally, we learn that dimensional analysis is useful in chemical calculations. Dimensional analysis is often needed to carry out conversions. These ions, as well as Na1 and Cl2, are called monatomic ions because they contain only one atom. To a scientist there is a distinction between 1.9 Dimensional Analysis in Solving Problems 10 10 10 30 30 60 60 60 100 100 (a) (b) (c) 27 Figure 1.13 The distribution of darts on a dart board shows the difference between precise and accurate. com if assigned by your instructor as electronic homework. One likely possibility is room-temperature superconductors. Their units are °F (degrees Fahrenheit), °C (degrees Fahrenheit), °C (degrees Fahrenheit), and K (kelvin). Many NEW end-of-chapter problems with graphical representation of molecules have been added to test the conceptual comprehension and critical thinking skills of the student. Therefore, for all practical purposes mass is conserved. In the helium nucleus there is only one proton and no neutrons; therefore, the ratio is 4:1. The molar masses of H2O2, H, and O are 34.02 g, 1.008 g, and 16.00 g, respectively. (e) Four, because the number is greater than one so all the zeros written to the right of the decimal point count as significant figures. Describe any general trend 75 Questions and Problems 2.82 2.83 2.84 2.85 2.86 2.87 2.88 2.89 2.90 2.91 2.92 you discover in the way this ratio changes with increasing atomic number. Some ancillaries, including electronic and print components, may not be available to customers outside the United States. Similar problem: 1.51. Howell Tyler Junior College Lee Kim Hun, NUS High School of Math and Science Tara Hurt East Mississippi Community College Wendy Innis-Whitehouse University of Texas at Pan American Jongho Jun, Konkuk University Jeffrey Keaffaber University of Florida Michael Keck Emporia State University MyungHoon Kim Georgia Perimeter College Bette A. Even the excessive use of fertilizers is harmful to the land, water, and air. 53 Allotrope, p. (c) Water boils below 100°C on top of a mountain. EXAMPLE 1.2 The density of mercury, the only metal that is a liquid at room temperature, is 13.6 g/mL. 2.26 Group the following elements in pairs that you would expect to show similar chemical properties: K, F, P, Na, Cl, and N. 2.35 Give the number of protons and electrons in each of the following common ions: Na1, Ca21, Al31, Fe21, I2, F2, S22, O22, and N32. 51 Molecular formula, p. Like X rays, g rays have no charge and are not affected by an external field. What would this thermometer read at 25°C? This technique was pioneered by Benjamin Franklin three centuries ago. Because elements in the same periodic group have similar chemical properties, we might expect to find some radium sulfate (RaSO4) mixed with barytes since radium is the last member of Group 2A. 1.90 Chlorine is used to disinfect swimming pools. Each end-of-chapter problem in ARIS is noted in the Electronic Homework Problem section. 2.4 (a) Cr2(SO4)3, (b) TiO2. Solar energy promises to be a viable source of energy for the future. Measurement Review Questions 1.17 Name the SI base units that are important in chemistry. Table 2.3 lists alphabetically the names of a number of common cations and anions. TABLE 2.7 Common Name Systematic Name H2O NH3 CO2 NaCl N2O CaCO3 CaO Ca(OH)2 NaHCO3 Na2CO3 ? Temperature Scales Three temperature scales are currently in use. A concentration of 1 ppm of fluorine is sufficient for the purpose. If carbon atoms could be examined individually, we would find either an atom of atomic mass 12.00000 amu or one of 13.00335 amu, but never one of 12.01 amu. Thus, 8.727 rounds off to 0.425 rounds off to 0.43. Then, by comparing the result to the percent composition obtained experimentally for our sample, we could determine the purity of the sample. (b) Prolonged exposure to mercury (Hg) vapor 37 can cause neurological disorders and respiratory problems. This manual is online in the text's ARIS website. negatively charged. What is the total worth of this quantity of gold? Oberbroeckling Manager: Todd L. The cation is Al31 and the oxygen anion is O22. This can be expressed as 1 mol He 5 4.003 g He From this equality, we can write two conversion factors 1 mol He 5 4.003 g He and A scientific research helium balloon. For example, manganese (Mn) atoms can assume several different positive charges: Mn21: MnO2 manganese-two oxide," "manganese-two oxide," and "manganese-two oxide," using the Stock system, we denote the ferrous ion and the Alfred E. 1.41 The average speed of helium at 25°C is 1255 m/s. Note that all three quantities (atomic number, number of neutrons, and mass number) must be positive integers, or whole numbers. accuracy and precision. In such a compound there is a 1:1 ratio of cations to anions so that the compound is electrically neutral. For numbers that do not contain decimal points, the trailing zeros (that is, zeros after the last nonzero digit) may or may not be significant. 3.5 Percent Compounds As we have seen, the formula of a compound tells us the numbers of atoms of each element in a unit of the compound. However, they can also be studied individually. Practice Exercise Calculate the number of grams of lead (Pb) in 12.4 moles of lead. If the first digit following the point of rounding off is equal to or greater than 5, we add 1 to the preceding digit. We rearrange Equation (1.1) to give m5d3V g 3 5.50 mL 5 74.8 g Mercury. Volume, defined as length cubed, is another extensive property. Each chapter has truefalse questions and a self-test, with all answers provided at the end of the chapter. 1.20 Describe the three temperature scale, and the Kelvin scale. The atomic number of carbon is 6, so there are 14 2 6 5 8 neutrons. In water and hydrogen sulfide, H is written first, whereas it appears last in the other compounds. 53 Monatomic ion, p. If the mixture is made of 41.37 percent A and 58.63 percent B by volume, what is the density of the metal? In 2007 it was discovered that the alloy has mysteriously lost about 50 mg! 18 Chemistry: The Study of Change Volume: 1000 cm3; 1000 mL; 1 dm3; 1L Volume The SI unit of length is the meter (m), and the SI-derived unit for volume is the cubic meter (m3). In chemistry, however, the smaller gram (g) is more convenient: 1 kg = 1000 g = 1 × 103 g Figure 1.9 The prototype kilogram is made of a platinumiridium alloy. The mass number is 17, so there are 17 2 8 5 9 neutrons. 2.6 (a) Rb2SO4, (b) BaH2. Therefore, 5 L of blood would be equal to 5 3 1023 m3, which is close to the answer. Polyatomic ions such as OH2 (hydroxide ion), CN2 (cyanide ion), and NH14 (ammonium ion) are ions containing more than one atom. Problems 2.7 2.8 The diameter of a helium atom is about 1 3 102 pm. 59 Oxoacid, p. What is its mass in pounds? This unit is awkwardly large for most chemical applications. Although the protons are confined to the nucleus of the atom, the electrons are conceived of as being spread out about the nucleus at some distance from it. There is only one correct solution.* 1 2 3 4 Horizontal 1-2: Two-letter symbol for a metal used in ancient times 3-4: Two-letter symbol for a metal used in an is found in Group 5A Vertical 1-3: Two-letter symbol for a metalloid 2-4: Two-letter symbol for a metalloid symbol for a metal used with Zr to make wires for superconducting magnets *Reproduced with permission of S. You can appreciate the relative sizes of a sports stadium, the volume of its nucleus would be comparable to that of a small marble. To make the charges add up to zero we multiply the 21 charge of the anion by 2 and add the subscript "2" to the symbol for iodine. The idea of a unit to denote a particular number of objects is not new. (Hint: See Figure 2.11.) 2.45 What are the empirical formulas of the following compounds? A molecule may contain atoms of the same element or atoms of two or more elements joined in a fixed ratio, in accordance with the law of definite proportions stated in Section 2.1. Thus, a molecule is not necessarily a compound, which, by definition, is made up of two or more elements (see Section 1.4). 1.51 Aluminum is a lightweight metal (density 5 2.70 g/cm3) used in aircraft construction, high-voltage transmission lines, beverage cans, and foils. Solution Refer to the labels (also see back endpapers). Many of the names were derived from their physical appearance, properties, origin, or application-for example, milk of magnesia, laughing gas, limestone, caustic soda, lye, washing soda. But note that as long as a substance yields hydroxide ions when dissolved in water, it need not contain hydroxide ions in its structure to be considered a base. At this rate, how long would it take to run a 1500-m race? One atomic mass of one carbon-12 atom. Molecular formulas are the true formulas of molecules. In general, do you think it would be more difficult to prove that it is an element or a compound? How do elements and compounds differ? • Chemical Mystery poses a mystery case to the student. The first is the Student Interactive Activity found in the opening pages of every chapter. Calculate the annual production of carbon dioxide in kilograms if there are 40 million cars in the United States and each car covers a distance of 5000 mi at a consumption rate of 20 miles per gallon. • Aluminum Oxide. The reason for the difference is that most naturally occurring elements (including carbon) have more than one isotope. At first some students find it confusing that their chemistry instructor and textbook seem to be continually shifting back and forth between the macroscopic and microscopic worlds. (d) The mass of the metal decreases. Some familiar examples are air, soft drinks, milk, and cement. A piece of gold ingot with a mass of 301 g has a volume of 15.6 cm3. We will discuss the uses of these measuring devices in Chapter 4. (b) A flashlight beam slowly gets dimmer and finally goes out. Write the molecular formulas for and names of the following compounds. Polish-born chemist and physicist. (b) Rainwater in industrialized regions tends to be acidic. 1.24 (a) Normally the human body can endure a temperature of 105°F for only short periods of time without permanent damage to the brain and other vital organs. Therefore, the huge dinosaurs, the largest of which might have weighed as much as 30 tons, vanished due to lack of food. Practice Exercise The density of the lightest metal, lithium (Li), is 5.34 3 10 kg/m. 373 K 100°C 310 K 37°C 298 K 25°C Room temperature 77°F 273 K 0°C Freezing point of water 32°F Kelvin Boiling 98.6°F Fahrenheit The following equation is used to convert degrees Celsius to degrees Fahrenheit: ?°F 5 9°F 3 (°C) 1 32°F 5°C (1.3) Both the Celsius and the Kelvin scales have units of equal magnitude; that is, one degree Celsius is equivalent to one kelvin. (c) Mercury, the only metal that exists as a liquid at room temperature, melts at 238.9°C. • xxiii Assign algorithmic questions providing students with multiple chances to practice and gain skill at problem solving on the same concept. This ever-growing resource gives instructors the power to utilize assets specific to an adopted textbook as well as content from all other books in the library. SI units are used to express physical quantities in all sciences, including chemistry. Because 1 mol CH4 5 16.04 g CH4 (Continued) 3.3 Molecular Mass 87 the conversion factor we need should have grams in the denominator so that the unit g will cancel, leaving the unit mol in the numerator: 1 mol CH4 5 16.04 g CH4 We now write 6.07 g CH4 3 1 mol CH4 5 0.378 mol CH4 16.04 g CH4 Thus, there is 0.378 mole of CH4 in 6.07 g of CH4. German physicist. Thereafter, in a series of experiments carried out between 1908 and 1917, R. - α Lead block y β + Radioactive substance Animation Alpha, Beta, and Gamma Rays Positive charge spread over the entire sphere The Proton and the Nucleus - - - - Figure 2.7 Not long after Röntgen's discovery Antoine Becquerel, † a professor of physics in Paris, began to study the fluorescent properties of substances. Practice Exercise Calculate the number of moles of chloroform. 33 1.30 Express the following numbers as decimals: (a) 1.52 3 1022, (b) 7.78 3 1028. German physicist who received the Nobel Prize in Physics in Paris, began to study the fluorescent properties of substances. Practice Exercise Calculate the number of moles of chloroform. 1901 for the discovery of X rays. It stands to reason, then, that if the ratio of the masses of different elements in a given compound is fixed, the ratio of the atoms of elements X and Y. Round off your answer to an integer.) 1.87 One gallon of gasoline in an automobile's engine produces on the average 9.5 kg of carbon dioxide, which is a greenhouse gas, that is, it promotes the warming of Earth's atmosphere. 1 1A 18 8A 2 2A 13 3A Li+ 17 7A C4- N3- O2- F- P3- S2- Cl- Se2- Br- Te2- I- 8 9 8B 10 11 1B 12 2B Cr 2+ Cr 3+ Mn2+ Mn3+ Fe2+ Fe3+ Co2+ Co3+ Ni2+ Ni3+ Cu+ Cu2+ Zn2+ Sr2+ Ag+ Cd2+ Sn2+ Sn4+ Ba2+ Au+ Au3+ Hg2+ 2 Hg2+ Pb2+ Pb4+ K+ Ca2+ Rb+ Cs+ Figure 2.11 two atoms. 1.3 The Scientific Method Figure 1.3 Observation Representation Interpretation After a large amount of data has been collected, it is often desirable to summarize the information in a concise way, as a law. When it is dissolved in water, the molecules break up into H1 and Cl2 ions; in this state, the substance is called hydrochloric acid. Later experiments showed that the rays actually consisted of a third type of subatomic particles, which Chadwick named neutrons, because they proved to be electrically neutral particles having a mass slightly greater than that of protons. Mastering these rules now will prove beneficial almost immediately as we proceed with our study of chemistry. (1 troy ounce 5 31.103 g.) (a) A gold coin weighs 2.41 troy ounce 5 31.103 g.) (a) A gold coin weighs 2.41 troy ounce 5 31.103 g.) any other, it would be the computer. (b) The atomic number is the same as that in (a), or 11. (c) Ice is less dense than water. 10H2O MgSO4 ? Suppose that we could line up helium atoms side by side in contact with one another. 1.95 Pheromones are compounds secreted by females of many insect species to attract mates. Perhaps it was the sight of those wooden balls that provided him with the idea of the atomic theory. Intelligent Tutors can be accessed through the ARIS book site. By using scientific notation, however, we avoid this ambiguity. 2.25 Consult a handbook of chemical and physical data (ask your instructor where you can locate a copy of the handbook) to find (a) two metals less dense than water, (b) two metals more dense than mercury, (c) the densest known solid metallic element. (d) the densest known solid nonmetallic element. He invented a device for measuring radiation that is now commonly called the Geiger counter. (b) 4.5 billion years (roughly the age of Earth) to seconds. They observed that the majority of particles penetrated the foil either undeflected or with only a slight deflection. Matter is anything that occupies space and has mass. The encouraging feedback I have received from instructors and students has convinced me that this approach is effective. Sodium metal reacting with chlorine gas to form sodium chloride. Professor Chang has served on the American Chemical Society Examination Committee, the National Chemistry Olympiad Examination Committee, and the Graduate Record Examinations (GRE) Committee, the National Chemistry Olympiad Examination Committee, and the Graduate Record Examination Committee, the National Chemistry Olympiad Examination Committee, and the Graduate Record Examination Committee, the National Chemistry Olympiad Examination Committee, and the Graduate Record Examination Committee, the National Chemistry Olympiad Examination protons in the nucleus of an atom remains the same during ordinary chemical compounds, we must first distinguish between inorganic compounds. Detecting screen Accelerating plates Electron beam Sample gas Filament Ion beam Magnet 89 3.5 Percent Composition of Compounds Figure 3.4 The mass spectrum of the three isotopes of neon. The molar masses of the elements are given on the inside front cover of the book. (a) Na and H, (b) B and O, (c) Na and S, (d) Al and F, (e) F and O, (f) Sr and Cl. Identify each of the following elements: (a) a halogen whose anion contains 36 electrons, (b) a radioactive noble gas with 86 protons, (c) a Group 4A cation that contains 80 electrons. He has also coauthored books on the Chinese language, children's picture books, and a novel for young readers. The density of the liquid at its boiling point (2196°C or 77 K) is 0.808 g/cm3. (f) 234 94 Protons 5 Neutrons 5 Neutron compounds? From these data calculate the density of silver. A measured quantity is usually written as a number with an appropriate unit. As Table 1.2 shows, the kelvin is the SI base unit of temperature: it is the absolute temperature: it is the absolute temperature scale. Occasionally an a particle was turned back. 2.8 (a) SF4, (b) N2O5. Thus, the scientific notation for 74.6 is 7.46 × 10 and not 7.46 × 101. How is electrical neutrality maintained in an ionic compound? What CH4 conversion factor do we need to convert between grams and moles? For example, 0.08 L contains three significant figures, and so on. Therefore, if the equation is set up correctly, then all the units will cancel except the desired one. Convert this temperature to degrees Celsius. The formula is KBr. • Zinc Iodide. HCl H3O+ Cl- When dissolved in water, the HCl molecule is converted to the H1 and Cl2 ions. Instructor's Resources ARIS (Assessment, Review, and Instruction System) The Assessment, Review, and Instruction System. electronic homework and course management system designed for greater flexibility, power, and ease of use than any other system. When the experiments have been recorded, the next step in the scientific method is interpretation, meaning that the scientific method is interpretation. 2.7 (a) Nitrogen trifluoride, (b) dichlorine heptoxide. The first mass spectrometer, developed in the 1920s by the English physicist F. These facts provide the basis for most methods of obtaining pure elements from their compounds, as we will see in later chapters. The hydrocarbons are used as fuels for domestic and industrial heating, for generating electricity and powering internal combustion engines, and as starting materials for the chemical industry. Based on the data that were gathered, the researcher formulates a hypothesis, a tentative explanation for a set of observations. 1.57 Calculate the mass of each of the following: (a) a sphere of gold with a radius of 10.0 cm [the volume of a sphere] with a radius r is V 5 (4y3)pr3; the density of gold 5 19.3 g/cm3], (b) a cube of platinum of edge length 0.040 mm (the density of platinum 5 21.4 g/cm3), (c) 50.0 mL of ethanol 5 0.798 g/mL). Hydrates Hydrates are compounds that have a specific number of water molecules attached to them. CH4, NaBr, BaF2, CCl4, ICl, CsCl, NF3 Naming Inorganic Compounds Review Questions 2.51 What is the difference between inorganic compounds and organic compounds? Appendix 1 gives the origin of the elements. The second hypothesis states that atoms of one element are different from atoms of all other elements. the two atomic symbols represents a chemical bond. These instruments provide measurements of macroscopic properties, which can be determined directly. Read the question carefully. The hypotheses about the nature of matter on which Dalton's atomic theory is based can be summarized as follows: 1. The relative abundances are given in parentheses. Why Do Lakes Freeze from the Top Down? Note that because there are more 63 29Cu than 29Cu isotopes, the average atomic mass is closer to 62.93 amu than to 64.9278 amu. Density usually decreases with temperature to °C and °F. Chapter Outline 3.1 3.2 Atomic Mass 3.3 3.4 Molecular Mass 3.5 Percent Composition of Compounds 3.6 Experimental Determination of Empirical Formulas 3.7 Chemical Reactions and Chemical Equations 3.8 Amounts of Reactants and Products 3.9 3.10 Limiting Reagents A Look Ahead • We begin by studying the mass of an atom, which is based on the carbon-12 isotope scale. It has been estimated that 8.0 3 104 tons of gold (Au) have been mined. If we know the molecular formula, we also know the empirical formula, but the reverse is not true. The molar mass of exactly 12 grams and contains an Avogadro's number (6.022 3 1023) of atoms. Molecular models help to visualize the three-dimensional arrangement of atoms in a molecule. Thus, the formula is Ca3(PO4)2. It is the responsibility of the textbook author to assist both instructors and their students in their pursuit of this objective by presenting a broad range of topics in a logical manner. ‡ Robert Andrews Millikan (1868-1953). Calculate the volume of water in the ocean in liters. To divide using scientific notation, we divide N1 and N2 as usual and subtract the exponents. (b) Explain why a helium nucleus containing no neutrons is likely to be unstable. Recall that 1 kg 5 1000 g and 1 cm 5 1 3 1022 m. (Hint: The Einstein equation can be used to calculate the change in mass as a result of the change in mass student to solve a chemical problem that a chemist would solve. This type of mixture is called a heterogeneous mixture because the composition of the bronze is 79.42 percent Cu and 20.58 percent Sn and the densities of Cu and Sn are 8.94 g/cm3 and 7.31 g/cm3, respectively. Explain. Therefore, instead of converting one pound of force to 4.45 N, the scientists treated it as 1 N. Note that a chemical reaction or creation. Calculate the corresponding mass change in this process and comment on whether the law of conservation of mass holds for ordinary chemical processes. 1.62 The experiment described in Problem 1.61 is a crude but convenient way to determine the density of some solids. Space-filling models are more accurate because they show the variation in atomic size. animations • interactives • Media Player downloads of selected content Intelligent Tutors, provides real-time personal tutoring help for struggling and advanced students with step-by-step feedback and detailed instruction based on the student's own work. A simple technique requiring little memorization, dimensional analysis is based on the relationship between different units that express the same physical quantity. Give the chemical formulas of the following substances: (a) dry ice, (b) table salt, (c) laughing gas, (d) marble (chalk, limestone), (e) quicklime, (f) slaked lime, (g) baking soda, (h) washing soda, (i) gypsum, (j) milk of magnesia. In Chemistry, flow charts show the thought process of a concept and graphs present data to comprehend the concept. Thus, it is properly classified as a base. And they will save money. One atomic mass unit is also called one dalton. Example 1.5 shows how significant figures are handled in arithmetic operations. (b) Here we have (2452°F 2 32°F) 3 5°C 5 2269°C 9°F (c) The melting point of mercury in kelvins is given by (238.9°C 1 273.15°C) 3 1K 5 234.3 K 1°C Similar problems: 1.24, 1.25, 1.26. The results in inches are X (31.5, 31.6, 31.4); Y (32.8, 32.3, 32,7); Z (31.9, 32.2, 32.1). † Joseph Louis Proust (1754–1826). For each section of a chapter, the author provides study objectives and a summary of the corresponding text. British physicist who received the Nobel Prize in Physics in 1906 for discovering the electron. 2.14 Calculate the number of protons and the number of neutrons in the nucleus: 25 48 79 195 3 4 24 2He, 2He, 12Mg, 12Mg, 22Ti, 35Br, 78Pt 2.16 Indicate the number of protons, neutrons, and electrons in each of the following species: 15 33 63 84 130 186 202 7N, 16S, 29Cu, 38Sr, 56Ba, 74W, 80Hg 2.17 Write the appropriate symbol for each of the following isotopes: (a) Z 5 11, A 5 23; (b) Z 5 28, A 5 64. 7H2O Sr(NO3)2 ? Alpha (a) rays consist of positively charged particles, called a particles, and therefore are deflected by the positively charged plate. Analogies are used where appropriate to help foster understanding of abstract chemical concepts. In chain calculations, that is, calculations involving more than one step, we can get a different answer depending on how we round off. This book is printed on acid-free paper • • • NEW to the chapters is Review of Concepts. Includes index. EXAMPLE 3.4 Sulfur (S) is a nonmetallic element that is present in coal. What mass of S would contain Avogadro's number of atoms? Figure 2.10 shows that the 1 1A 1 H 18 8A 2 2A 13 3A 14 4A 15 5A 16 6A 17 7A 2 He 3 4 5 6 7 8 9 10 Li Be B C N O F Ne 13 14 15 16 17 18 Al Si P S Cl Ar 11 12 Na Mg 3 3B 4 4B 5 5B 6 6B 7 7B 8 9 8B 10 11 1B 12 2B 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 K Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br Kr 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 Rb Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te I Xe 55 56 57 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 Cs Ba La Hf Ta W Re Os Ir Pt Au Hg Tl Pb Bi Po At Rn 112 113 114 115 116 (117) 118 87 88 89 104 105 106 107 108 109 110 111 Fr Ra Ac Rf Db Sg Bh Hs Mt Ds Rg Metals 58 59 60 61 62 63 64 65 66 67 68 69 70 71 Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb Lu Metalloids 90 91 92 93 94 95 96 97 98 99 100 101 102 103 Th Pa U Np Pu Am Cm Bk Cf Es Fm Md No Lr Nonmetals Figure 2.10 The modern periodic table. grams of urea \rightarrow moles of H \rightarrow atoms 3 3 60.06 g (NH2) 2CO 1 mol (NH2) 2CO formula HCl can represent two different chemical systems. Note that the order of elements in the formula is the same as in its name. Note that the charges on the cation and anion are not shown in the formula for an ionic compound. It freezes at 211.5°C. Strategy Our guide for writing formulas for ionic compounds is electrical neutrality; that is, the total charge on the cation(s) must be equal to the total charge on the anion(s). Recognition of periodic table, a chart in which elements having similar chemical and physical properties are grouped together. To work with the more convenient scale of grams, we use the molar mass. To carry out such a procedure, a doctor must have a sound knowledge of the chemical properties of the molecular components involved. grams per milliliter (g/mL), are more commonly used for solid and liquid densities. (e) A stitch in time saves nine. Keeping track of the number of significant figures in a measurement such as mass ensures that calculations involving the data will reflect the precision of the measurement. Compare the properties of the following: a particles, cathode rays, protons, neutrons, electrons. The questions and problems at the end of the chapter are organized by section. EXAMPLE 3.6 Methane (CH4) is the principal component of natural gas. 1.42 How many seconds are there in a solar year (365.24 days)? Electrostatic potential maps illustrate the electron density distribution in molecules. When the puzzle is complete, the four spaces below will contain the overlapping symbols of 10 elements. Chemists study matter and the iron filings remain separate (Figure 1.4). Nomura Georgia Perimeter College Frazier Nyasulu Ohio University MaryKay Orgil University of Nevada-Las Vegas Jason Overby College of Charleston M. H C Methanol Similar problems: 2.47, 2.48. The color codes are: black (carbon), red (oxygen), and gray (hydrogen). (1 lb 5 453.6 g.) Strategy The problem can be stated as Conversion factors for some of the English system units commonly used in the United States for nonscientific measurements (for example, pounds and inches) are provided inside the back cover of this book. NEW are powerful connections to electronic homework. Instructor's Solution Manual is written by Brandon J. The mass of mercury needed to fill the tube is 105.5 g. The measured value of an extensive property depends on how much matter is being considered. In everyday conversations we hear words that have a chemical connection, although they may not be used in the scientifically correct sense. Practice Exercise Determine the number of significant figures in each of the following measurements: (a) 24 mL, (b) 3001 g, (c) 0.0320 m3, (d) 6.4 × 104 molecules, (e) 560 kg. ? What is the volume of blood in m3? 4.003 g He 1 mol He (Continued) 83 84 Mass Relationships in Chemical Reactions The conversion factor on the left of the first nonzero digit do not count as significant figures. 1.102 Bronze is an alloy made of copper (Cu) and tin (Sn). The problems are broken into various types: — By chapter section. The test bank contains over 2000 multiple-choice and short-answer questions. They also revealed no dinosaur skeletons in rocks formed immediately after the Cretaceous period, which dates back some 65 million years. 54 Neutron, p. Does your result support Rutherford's model of an atom? Energy production and energy utilization are closely tied to the quality of our environment. According to electromagnetic fields through which it passes. Copper. Explain what is happening to the sample. EXAMPLE 2.1 Give the number of protons, neutrons, and electrons in each of the following species: 22 17 (a) 20 O, and (d) carbon-14. In the SI system the mole (mol) is the amount of a substance that contains as many elementary entities (atoms, molecules, or other particles) as there are atoms in exactly 12 g (or 0.012 kg) of the carbon-12 isotope. Solution First the percents are converted to fractions: 69.09 percent to 69.09/100 or 0.6909 and 30.91 percent to 30.91/100 or 0.3091. 10. Whenever an a particle came close to a nucleus in the scattering experiment, it experienced a large repulsive force and therefore a large repulsive force hydroxide (OH2) and cyanide (CN2). Do your results support Rutherford's model of an atom? Give an example of a case in which two molecules have different molecular formulas but the same technique is used on a larger scale to separate iron and steel from nonmagnetic objects such as aluminum, glass, and plastics. For convenience, some carbon-containing compounds, such as carbon monoxide (CO2), carbon disulfide (CO2), problem. This density decrease is the result of which of the following? Figure 2.14 summarizes the steps for naming ionic and binary molecular formulas based on the molecular formula C2H6O. How should molar mass and Avogadro's number be used in this calculation? 2.30 Give an example of each of the following: (a) a monatomic cation, (b) a monatomic cation, (c) a polyatomic anion. Great discoveries are usually given to only one individual. Solution The conversion factor needed to convert between moles and grams is the molar mass. (Hint: See Appendix 1.) Name the only country that is named after an element. Figure 2.15 summarizes the nomenclature for the oxoacids and oxoanions, and Table 2.6 gives the names of the oxoacids and oxoanions that contain chlorine. Naming Bases A base can be described as a substance that yields hydroxide ions (OH2) when dissolved in water. The electrons are embedded in a uniform, positively charged sphere. 46 Anion, p. Because of technical difficulties, scientists have not been able to study the inner portions of Earth as easily as the crust. Mass Relationships in Chemical Reactions Sulfur burning in oxygen to form sulfur dioxide. Molecular Models Molecular Models Molecular Models are too small for us to observe directly. These and a number of other such ionic substances are called ternary compounds, meaning compounds, meaning compounds (1) gallon 5 3.79 L; density of liquids 5 1.0 g/mL.) 1.91 The world's total petroleum reserve is estimated at 2.0 3 1022 J (joule is the unit of energy where 1 J 5 1 kg m2/s2). The test can be published automatically online to your course and course management system, or you can print them for paper-based tests. Similar problem: 1.50(d). Student Resources Designed to help students maximize their learning experience in chemistry—we offer the following options to students: ARIS (Assessment, Review, and Instruction System) is an electronic study system that offers students a digital portal of knowledge. Elements and Compounds Substances can be either elements or compounds. In fact, when ammonia dissolves in water, NH3 reacts partially with water to yield NH41 and OH2 ions. Student Solutions Manual The Student Solutions Manual The Student Solutions Manual is written by Brandon J. Schiesl Senior Production Supervisor: Kara Kudronowicz Lead Media Project Manager: Judi David Senior Designer: David W. Modern measurement techniques indicate that one atom of carbon combines with one atoms of oxygen in carbon monoxide and with two atoms of oxygen in carbon dioxide. The balls are proportional in size to atoms. † Antoine Henri Becquerel (1852-1908). EXAMPLE 2.6 Write chemical formulas for the following compounds: (a) mercury(I) nitrite, (b) cesium sulfide, and (c) calcium phosphate. Example 1.3 illustrates these conversions. Because this particular quasar is more than 10 billion light-years away (a light-years ago. (d) When a glass of water is left out in the sun, the water gradually disappears. CHEMISTRY in Action Primordial Helium and the Big Bang Theory W here did we come from? Problems 2.57 Name these compounds: (a) Na2CrO4, (b) K2HPO4, (c) HBr (jas), (d) HBr (jas) problem in order to become proficient in this problem type. Numbers expressed in scientific notation have the form N 3 10n, where N is between 1 and 10, and n is a positive or negative integer. Since then, any element that spontaneously emits radiation is said to be radioactive. Three types of rays are produced by the decay, or breakdown, of radioactive substances such as uranium. Engineers at Lockheed Martin Corporation who built the spacecraft specified its thrust in pounds, which is an English unit. Elements are composed of extremely small particles called atoms. It is obtained mostly from seawater, which is an English unit. following properties are intensive and which are extensive? Mufeed Basti North Carolina A&T Ken Goldsby Florida State University John Hagen California Polytechnic University John Hagen California Polyt University of Arizona William Quintana New Mexico State University Troy Wood University of Buffalo Kim Woodrum University of Kentucky I would also like to thank Dr. Enrique PeacockLopez and Desire Gijima for the computer-generated molecular orbital diagrams in Chapter 10. Molecular and structural formulas and molecular models of four common molecules. This dust amounted to about 0.02 g/cm2 of Earth's surface. What is the speed limit in kilometers per hour? The atomic mass of carbon-13 has been determined to be 13.00335 amu. This example illustrates how very important experimental accuracy is to a quantitative science like chemistry. Chemists generally use standardized symbols and equations in recording their measurements and observations. 1.6 Physical and Chemical Properties of Matter For example, we can measure the melting point of ice by heating a block of ice and recording the temperature at which the ice is converted to water. Chemists are interested primarily in mass, which can be determined readily with a balance; the process of measuring mass, oddly, is called weighing. By imagining the expansion running backward, like a movie in reverse, astronomers have a red color. (The heavier elements, like carbon, nitrogen, and oxygen, are thought to have originated later via nuclear reactions involving hydrogen and helium in the center of stars.) If so, a diffuse gas of hydrogen and helium would have spread through the same mass, which is about 1840 times greater than the mass of an electron. unseen and partially imagined microscopic world of atoms and molecules. 2.10 Why do all atoms of an element have the same atomic numbers? The idea here is to round off the numbers? The idea here is to round off the numbers? The idea here is to round off the numbers? Jerome Rosenberg (Michigan State University) and Lawrence Epstein (University of Pittsburgh) provides students with hundreds of solved and supplementary problems for the general chemistry course. Key Words 31 Check Because 1 m3 5 1 3 106 cm3, we would expect much more mass in 1 m3 than in 1 cm3. Typically, 1.0 3 1028 g of a pheromone

is sufficient to reach all targeted males within a radius of 0.50 mi. When a spoonful of sugar dissolves in water we obtain a homogeneous mixture is the same throughout. 632 14.5 Factors That Affect Chemical Equilibrium 638 CHEMISTRY in Action Life at High Altitudes and Hemoglobin Production 645 CHEMISTRY in Action The Haber Process 646 Key Equations 646 Summary of Facts and Concepts 646 Key Words 647 Questions and Problems 648 xi xii Contents Acids and Bases 660 15.8 15.9 15.10 15.11 15.12 Diprotic and Polyprotic Acids 681 The Acid-Base Properties of Water 66 pH—A Measure of Acidity 663 Strength of Acids and Bases 666 Weak Acids and Constants 670 Weak Bases and Base Ionization Constants 678 The Relationship Between the Ionization Constants 678 The Relation Constants 678 The Relation Constants 678 The Relation Constants Properties of Oxides and Hydroxides 695 Lewis Acids and Bases 697 CHEMISTRY in Action Antacids and the pH Balance in Your Stomach 698 Key Equations 702 CHEMICAL Mystery Decaying Papers 710 Acid-Base Equilibria and Solubility Equilibria 712 16.1 Homogeneous versus Heterogeneous Solution Equilibria 714 16.2 The Common Ion Effect 714 16.3 Buffer Solutions 723 Acid-Base Titrations 723 Acid-Base Indicators 732 Solubility Equilibria 735 Separation of Ions by Fractional Precipitation 742 The Common Ion Effect and Solubility 744 pH and Solubility 749 CHEMISTRY in Action How an Eggshell Is Formed 753 Contents 16.11 Application of the Solubility 749 CHEMISTRY in Action How an Eggshell Is Formed 757 Questions and Problems 757 Contents 16.11 Application of the Solubility 749 CHEMISTRY in Action How an Eggshell Is Formed 758 Contents 16.11 Application of the Solubility 749 CHEMISTRY in Action How an Eggshell Is Formed 758 Contents 16.11 Application of the Solubility 749 CHEMISTRY in Action How an Eggshell Is Formed 758 Contents 16.11 Application of the Solubility 749 CHEMISTRY in Action How an Eggshell Is Formed 758 Contents 16.11 Application of the Solubility 749 CHEMISTRY in Action How an Eggshell Is Formed 759 Contents 16.11 Application of the Solubility 749 CHEMISTRY in Action How an Eggshell Is Formed 759 Contents 16.11 Application of the Solubility 749 CHEMISTRY in Action How an Eggshell Is Formed 759 Contents 16.11 Application of the Solubility 749 CHEMISTRY in Action How an Eggshell Is Formed 759 Contents 16.11 Application of the Solubility 749 CHEMISTRY in Action How an Eggshell Is Formed 759 Contents 16.11 Application of the Solubility 749 CHEMISTRY in Action How an Eggshell Is Formed 759 Contents 16.11 Application of the Solubility 749 CHEMISTRY in Action How an Eggshell Is Formed 759 Contents 16.11 Application of the Solubility 749 CHEMISTRY in Action How an Eggshell Is Formed 759 Contents 16.11 Application of the Solubility 749 CHEMISTRY in Action How an Eggshell Is Formed 759 Contents 16.11 Application Is a first formed 759 Chemistry of Factor How an Eggshell Is Formed 759 Chemistry of Factor How an Eggshell Is Formed 759 Chemistry of Factor How an Eggshell Is Formed 759 Chemistry of Factor How an Eggshell Is Formed 759 Chemistry of Factor How an Eggshell Is Formed 759 Chemistry of Factor How an Eggshell Is Formed 759 Chemistry of Factor How an Eggshell Is Formed 759 Chemistry of Factor How an Eggshell Is Formed 759 Chemistry of Factor How an Eggshell Is Formed 759 Chemistry of Factor How a CHEMICAL Mystery A Hard-Boiled Snack 766 Chemistry in the Atmosphere 773 Depletion of Ozone in the Stratosphere 775 Volcanoes 780 The Greenhouse Effect 781 Acid Rain 785 Photochemical Smog 789 Indoor Pollution 793 Summary of Facts and Concepts 794 Key Words 794 Entropy, Free Energy, and Equilibrium 800 18.1 18.2 18.3 18.4 The Three Laws of Thermodynamics 802 Entropy 803 The Second Law of Thermodynamics 808 CHEMISTRY in Action The Efficiency of Heat Engines 814 18.5 Gibbs Free Energy 814 18.6 Free Energy and Chemical Equilibrium 821 CHEMISTRY in Action The Thermodynamics of a Rubber Band 826 18.7 Thermodynamics in Living Systems 825 Key Words 828 Ouestions and Problems 829 xiii xiv Contents Electrochemistry 836 19.1 19.2 19.3 19.4 19.5 19.6 Redox Reactions 838 Galvanic Cells 841 Standard Reduction Potentials 843 Thermodynamics of Redox Reactions 849 The Effect of Concentration of Cell Emf 852 Batteries 857 CHEMISTRY in Action Bacteria Power 861 19.7 Corrosion 862 19.8 Electrolysis 866 CHEMISTRY in Action Bacteria Power 861 19.7 Corrosion 862 19.8 Electrolysis 866 CHEMISTRY in Action Bacteria Power 861 19.7 Corrosion 862 19.8 Electrolysis 866 CHEMISTRY in Action Bacteria Power 861 19.7 Corrosion 862 19.8 Electrolysis 866 CHEMISTRY in Action Bacteria Power 861 19.7 Corrosion 862 19.8 Electrolysis 866 CHEMISTRY in Action Bacteria Power 861 19.7 Corrosion 862 19.8 Electrolysis 866 CHEMISTRY in Action Bacteria Power 861 19.7 Corrosion 862 19.8 Electrolysis 866 CHEMISTRY in Action Bacteria Power 861 19.7 Corrosion 862 19.8 Electrolysis 866 CHEMISTRY in Action Bacteria Power 861 19.7 Corrosion 862 19.8 Electrolysis 866 CHEMISTRY in Action Bacteria Power 861 19.7 Corrosion 862 19.8 Electrolysis 866 CHEMISTRY in Action Bacteria Power 861 19.7 Corrosion 862 19.8 Electrolysis 866 CHEMISTRY in Action Bacteria Power 861 19.7 Corrosion 862 19.8 Electrolysis 866 CHEMISTRY in Action Bacteria Power 861 19.7 Corrosion 862 19.8 Electrolysis 866 CHEMISTRY in Action Bacteria Power 861 19.7 Corrosion 862 19.8 Electrolysis 866 CHEMISTRY in Action Bacteria Power 861 19.7 Corrosion 862 19.8 Electrolysis 866 CHEMISTRY in Action Bacteria Power 861 19.7 Corrosion 862 19.8 Electrolysis 866 CHEMISTRY in Action Bacteria Power 861 19.7 Corrosion 862 19.8 Electrolysis 866 CHEMISTRY in Action Bacteria Power 861 19.7 Corrosion 862 19.8 Electrolysis 866 CHEMISTRY in Action Bacteria Power 861 19.7 Corrosion 862 19.8 Electrolysis 866 CHEMISTRY in Action Bacteria Power 861 19.7 Corrosion 862 19.8 Electrolysis 866 CHEMISTRY in Action Bacteria Power 861 19.7 Corrosion 862 19.8 Electrolysis 866 CHEMISTRY in Action Bacteria Power 861 19.7 Corrosion 862 19.8 Electrolysis 866 CHEMISTRY in 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Coordination Compounds 959 Structure of Coordination Compounds 959 Structure of Coordination Compounds 964 Bonding in Coordin Compounds 974 CHEMISTRY in Action Coordination Compounds in Living Systems 976 CHEMISTRY in Action Cisplatin—The Anticancer Drug 978 Key Equation 976 CHEMISTRY in Action Concepts 976 Key Words 978 Questions and Problems 979 CHEMISTRY in Action Concepts 976 Key Words 978 Questions and Problems 979 CHEMISTRY in Action Compounds in Living Systems 976 CHEMI 23.2 23.3 23.4 23.5 The Nature of Nuclear Reactions 988 Nuclear Stability 990 Natural Radioactivity 995 Nuclear Fusion 1007 23.7 Uses of Isotopes 1010 23.8 Biological Effects of Radiation 1012 CHEMISTRY in Action Food Irradiation 1014 CHEMISTRY in Action Boron Neutron Capture Therapy 1015 Key Equations 1015 Summary of Facts and Concepts 1016 Key Words 1016 CHEMICAL Mystery The Art Forgery of the Twentieth Century 1022 Organic Chemistry 1024 24.1 Classes of Organic Compounds 1026 24.2 Aliphatic Hydrocarbons 1026 CHEMISTRY in Action Ice That Burns 1038 24.3 Aromatic Hydrocarbons 1039 24.4 Chemistry of the Functional Groups 1051 Key Words 1051 Questions and Problems 1052 CHEMICAL Mystery The Disappearing Fingerprints 1058 Contents Synthetic and Natural Organic Polymers 1069 25.1 Properties of Polymers 1062 25.2 Synthetic Organic Polymers 1062 25.3 Proteins 1067 CHEMISTRY in Action DNA Fingerprinting 1079 Summary of Facts and Concepts 1080 Key Words 1080 Questions and Problems 1067 CHEMISTRY in Action DNA Fingerprinting 1079 Summary of Facts and Concepts 1080 Key Words 1080 Key 1081 CHEMICAL Mystery A Story That Will Curl Your Hair 1084 APPENDIX 1 Derivation of the Names of Elements A-1 APPENDIX 2 Units for the Gas Constant A-7 APPENDIX 2 Units for the Gas Constant A-7 APPENDIX 3 Thermodynamic Data at 1 atm and 25°C A-8 APPENDIX 4 Mathematical Operations A-13 Glossary G-1 Answers to Even-Numbered Problems AP-1 Credits C-1 Index I-1 xvii The opening sentence of this text is, "Chemistry is an active, evolving science that has vital importance to our world, in both the realm of nature and the realm of nature and the realm of society." Throughout the text, Chemistry is an active, evolving science that has vital importance to our world, in both the realm of nature and the realm 0.006 L, (b) 0.0605 dm, (c) 60.5 mg, (d) 605.5 cm2, (e) 960 3 1023 g, (f) 6 kg, (g) 60 m. Atomic number of protons in a nucleus; atoms of different elements have different elements have different atomic number is the number of protons in a nucleus; atoms of different elements have different el obtain the average atomic mass. Thus, water is a compound, a substance composed of atoms of two or more elements chemically united in fixed proportions. In some instances, an a particle actually bounced back in the direction from which it had come! This was a most surprising finding, for in Thomson's model the positive charge of the atom was so diffuse that the positive a particles should have passed through the foil with very little deflection. 1.48 The "normal" lead content in human blood is about 0.40 g of lead per million (that is, 0.40 g of lead per million grams of blood). 9. The empirical formula of hydrogen peroxide is HO. 1.92 In water conservation, chemists spread a thin film of certain inert material over the surface of water to cut down the rate of evaporation of water in reservoirs. The ray itself is invisible, but the fluorescence of a zinc sulfide coating on the glass causes it to appear green. (a) SO2, (b) S8, (c) Cs, (d) N2O5, (e) O, (f) O2, (g) O3, (h) CH4, (i) KBr, (j) S, (k) P4, (l) LiF 2.69 The following table gives numbers of electrons, protons, and neutrons in atoms or ions of a number of elements. Calculate the total mass of sodium chloride in kilograms and in tons. ‡ Marie (Marya Sklodowska) Curie (1867-1934). (b) Consider the 23Na atom. SO2 Solution To calculate molecular mass, we need to sum all the atomic masses in the molecular mass. concentration of mercury vapor must be under 0.050 mg/m3. 46 Atoms, Molecules, and Ions Figure 2.6 Three types of rays emitted by radioactive elements. (1 mi 5 1609 m.) Venus, the second closest planet to the sun, has a surface temperature of 7.3 3 102 K. [The volume of a sphere of radius r is (4/3)pr3.] 2.73 What is wrong with the name (in parentheses) for each of the following compounds: (a) BaCl2 (barium dichloride), (b) Fe2O3 [iron(II) oxide], (c) CsNO2 (cesium nitrate), (d) Mg(HCO3)2 [magnesium(II) bicarbonate]? Earth's crust extends from the surface to a depth of about 40 km (about 25 mi). Proton Neutron 2.3 Atomic Number, Mass Number, and Isotopes TABLE 2.1 Mass and Charge of Subatomic Particles Charge Particle Mass (g) Coulomb Charge Unit Electron* Proton Neutron 9.10938 3 10224 1.67262 1.67262 1.6726 three or four significant figures, we obtain a different number for E: Method 1 3.66 3 8.45 5 30.9 30.9 3 2.11 5 65.2 Method 2 3.66 3 8.45 5 30.93 30.93 3 2.11 5 65.2 Method 2 3.66 3 8.45 5 30.9 concentration of 8.00 3 102 ppm by volume of carbon monoxide is considered lethal to humans. Therefore, Thomson proposed that an atom could be thought of as a uniform, positive sphere of matter in which electrons are embedded like raisins in a cake (Figure 2.7). 1A 8A 2A 3A 4A 5A 6A 7A 2.94 Fill the blanks in the following table. If we combine them to make a single quantity of water in a larger beakers. Grams will cancel, leaving the unit mol for the answer, that is, 6.46 g He 3 1 mol He 5 1.61 mol He 5 1.61 mol He 4.003 g He Thus, there are 1.61 moles of He atoms in 6.46 g of He. Similar problem: 3.15. An element is a substance that cannot be separated into simpler substances by chemical means. After separation, the components of the mixture will have the same composition and properties as they did to start with. This formula indicates that each hydrogen peroxide molecule consists of two hydrogen atoms. On the other hand, 0°F and 0°C are based on the behavior of an arbitrarily chosen substance, water. The conversion factors are 1 kg 1000 g and 1 cm3 1 3 10 26 m3 Finally, ? How many grams of Cu can be obtained from 5.11 3 103 kg of the ore? Instead, it entered Mars' atmosphere about 100 km (62 mi) lower than planned and was destroyed by heat. (1 ppm means one part per million, or 1 g of fluorine per 1 million g of water.) The compound normally chosen for fluoridation is sodium fluoride, which is also added to some toothpastes. Cyvin of the University of Trondheim (Norway). From left to right across any period, the physical and chemical properties of the elements change gradually from metallic to nonmetallic. Like X rays, the rays from the uranium compound were highly energetic and could not be deflected by a magnet, but they differed from X rays because they arose spontaneously. (b) Write reasonable molecular formulas for these compounds. Empirical Formulas H2O2 The word "empirical" means "derived from experiment." As we will see in Chapter 3, empirical formulas are determined experimentally. At the present rate of consumption, 1.8 3 1020 J/yr, how long would it take to exhaust the supply? Early experiments failed to detect neon-21 because its natural abundance is just 0.257 percent. Water, on the other hand, is a molecular compound that contains hydrogen and oxygen in a ratio of two H atoms and one O atom. In this case, the ratio of the atoms of element X to the atoms of element X to the atoms of CH4, following the procedure in Example 3.5: molar mass of CH4 5 12.01 g 1 4(1.008 g) 5 16.04 g Methane gas burning on a cooking range. It is therefore assumed that the dinosaurs became extinct about 65 million years ago. The answers to the practice exercises 1.98 (a) Carbon monoxide (CO) is a poisonous gas because it binds very strongly to the oxygen carrier hemoglobin in blood. 1.12 Does each of the following describe a physical change or a chemical change? In a neutral atom the number of electrons present in the atom. -ic" acid. (a) The metal expands. Its roots are ancient, but as we will see, chemistry is every bit a modern science. Comment on the precision and the accuracy of each tailor's measurements. Calculate its density (in g/mL) if 586 g of the substance occupies 188 mL. and the neutron are the three fundamental components of the atom that are important in chemistry. Previous editions © 2007, 2005, and 2002. When the liquid is cooled further, it will freeze into the solid form. The relationships among elements, compounds, and other categories of matter are summarized in Figure 1.5. Review of Concepts Which of the following diagrams represent elements and which represent elements are summarized in Figure 1.5. Review of Concepts Which of the following diagrams represent elements are summarized in Figure 1.5. Review of Concepts Which of the following diagrams represent elements are summarized in Figure 1.5. Review of Concepts Which of the following diagrams represent elements are summarized in Figure 1.5. Review of Concepts Which of the following diagrams represent elements are summarized in Figure 1.5. Review of Concepts Which of the following diagrams represent elements are summarized in Figure 1.5. Review of Concepts Which of the following diagrams represent elements are summarized in Figure 1.5. Review of Concepts Which of the following diagrams represent elements are summarized in Figure 1.5. Review of Concepts Which of the following diagrams represent elements are summarized in Figure 1.5. Review of Concepts Which of the following diagrams represent elements are summarized in Figure 1.5. Review of Concepts Which of the following diagrams represent elements are summarized in Figure 1.5. Review of Concepts Which of the following diagrams represent elements are summarized in Figure 1.5. Review of Concepts Which of the following diagrams represent elements are summarized in Figure 1.5. Review of Concepts Which of the following diagrams represent el ions arranged according to their positions in the periodic table. There is some justification for this perception. The atoms of all other elements. An atom can lose or gain more than one electron. 2H2O Water Ammonia Dry ice Table salt Laughing gas Marble, chalk, limestone Quicklime Slaked lime Baking soda Washing soda Epsom salt Milk of magnesia Gypsum Dihydrogen monoxide Calcium hydroxide Sodium chloride Sodium chloride Sodium carbonate decahydrate Magnesium hydroxide Calcium sulfate dihydrate Familiar Inorganic Compounds Some compounds are better known by their common names than by their systematic chemical names. 1.9 Dimensional Analysis in Solving Problems Careful measurements and the proper use of significant figures, along with correct calculations, will yield accurate numerical results. 2.3 for the formulas of cations and anions. Thus, the compounds LiOH and KCN are named lithium hydroxide and potassium cyanide, respectively. Finally, note that for ionic compounds like NaCl and MgO that do not contain discrete molecular units, we use the term formula mass instead. Nevertheless, with diligence you can complete this course successfully, and you might even enjoy it. How did the universe begin? The student can learn about the science of scuba diving and nuclear medicine, among many other interesting cases. Next we will discover how scientists define and characterize matter. 1 lb is the force due to gravitational attraction on an object of that mass. Arrington Colorado School of Mines Mufeed M. - 10th ed. Experimental studies have shown that absolute zero on the Kelvin scale is equivalent to -273.15°C on the Celsius scale. In multiplication and division, the significant number of the answer is determined by the number having the smallest number of significant figures. mass of 1 mole of Zn? Review of Concepts (a) Name the only element having an isotope that contains no neutrons. 1.25 Convert the following temperatures to kelvin: (b) 37°C, the melting point of mercury. Why? One class of hydrocarbons is called the alkanes. Table 2.8 shows the names, formulas, and molecular models and writing molecular models and writing empirical formulas from molecular formulas. The threshold limit is 2.0 3 10211 g per liter of air. (a) The nitrate ion (NO2 3) bears one negative charges. In general, it is fairly easy to determine how many significant figures a number has by following these rules: 1. Intensity of peaks 20 10 Ne(90.92%) 21 10 Ne(0.26%) 19 20 22 10 Ne(8.82%) 21 22 Atomic mass (amu) 23 The percent composition by mass is the percent by mass of each element in a compound. (b) Each sulfide ion bears two negative charges, and each cesium ion bears one positive charges (amu) 23 The percent by mass of each element in a compound. (b) Each sulfide ion bears two negative charges (amu) 23 The percent by mass of each element in a compound. (b) Each sulfide ion bears two negative charges (amu) 23 The percent by mass of each element in a compound. (b) Each sulfide ion bears two negative charges (amu) 23 The percent by mass of each element in a compound. (b) Each sulfide ion bears two negative charges (amu) 23 The percent by mass of each element in a compound. (b) Each sulfide ion bears two negative charges (amu) 23 The percent by mass of each element in a compound. (b) Each sulfide ion bears two negative charges (amu) 23 The percent by mass of each element in a compound. (b) Each sulfide ion bears two negative charges (amu) 24 The percent by mass of each element in a compound. (b) Each sulfide ion bears two negative charges (amu) 24 The percent by mass of each element in a compound. (b) Each sulfide ion bears two negative charges (amu) 24 The percent by mass of each element in a compound. (b) Each sulfide ion bears two negative charges (amu) 24 The percent by mass of each element in a compound. (b) Each sulfide ion bears two negative charges (amu) 24 The percent by mass of each element in a compound. (b) Each sulfide ion bears two negative charges (amu) 24 The percent by mass of each element in a compound. (b) Each sulfide ion bears (amu) 24 The percent by mass of each element in a compound (amu) 24 The percent by mass of each element in a compound (amu) 24 The percent by mass of each element in a compound (amu) 24 The percent by mass of each element in a compound (amu) 24 The percent by mass of each element in a compound (amu) 24 The percent by mass of each element in a compound (amu) 24 The percent by mass of each element in a compound (am nucleus occupies a very small fraction of the volume of the atom. Strategy The problem can be stated as ? The sum of the charges of one Zn21 ion and one I2 ion is 12 1 (21) 5 11. kg/m3 5 0.808 g 3 1 cm 3 1 round off the answers to the appropriate number of significant figures: (a) 26.5862 L 1 0.17 L, (b) 9.1 g 2 4.682 g, (c) 7.1 3 104 dm 3 2.2654 3 102 dm, (d) 6.54 g 4 86.5542 mL, (e) (7.55 3 104 m) 2 (8.62 3 103 m). What assumptions must be made in applying this method? In the periodic table (see inside front cover) we see the molar mass of Zn is 65.39 g. This is a quick knowledge test for the student to gauge his or her understanding of the concept just presented. 2.2 The Structure of the Atom On the basic unit of an element that can enter into chemical combination. (a) Oxygen gas supports combustion. Check Because the given mass (6.46 g) is larger than the molar mass of He, we expect to have more than 1 mole of He. Practice Exercise How many moles of magnesium (Mg) are there in 87.3 g of Mg? The subscript numeral indicates the number of atoms of an element present. 30 Chemistry: The Study of Change As Examples 1.7 and 1.8 illustrate, conversion factors can be squared or cubed in dimensional analysis. But much of this energy is "wasted" because it is reflected back into space. Student Study Guide This valuable ancillary by Kim Woodrum (University of Kentucky) contains material to help the student practice problem-solving skills. Because the mass of every carbon-12 atom is exactly 12 amu, the number of atomic mass units equivalent to 1 gram is amu 12 atom 5 3 gram 1 carbon-12 atom 5 10223 g 23 5 6.022 3 1023 amu and 1 amu 5 1.661 3 10224 g This example shows that Avogadro's number can be used to convert from the atomic mass units to mass in grams and vice versa. K 5 1°C 1 273.15°C 1K 1°C (1.2) (1.3) (1.4) Converting °F to °C Converting °C to K Media Player Summary of Facts and Concepts 1. Let n represent the number of moles of each element so that 1 mol C 5 3.407 mol C 12.01 g C 1 mol H nH 5 4.58 g H 3 5 4.54 mol H 1.008 g H 1 mol O nO 5 54.50 g O 3 5 3.406 mol O 16.00 g O nC 5 40.92 g C 3 Thus, we arrive at the formula C3.407H4.54O3.406, which gives the identity and the mole ratios of atoms present. In a separate experiment, a metal ball bearing of mass 18.713 g is placed in the cylinder and the cylinder is again filled to the 40.00-mL mark with the mineral oil. The cathode rays will strike the end of the tube at A in the presence of a magnetic field, at C in the presence of an electric field and magnetic field and at B when there are no external fields present or when the effects of the electric field and magnetic f problem section. 1A H 2A 8A 3A 4A 5A 6A 7A N O F Cl Br I Elements that exist as diatomic molecules. The vast majority of molecules contain more than two atoms. For simplicity, we will omit the word "average" when we discuss the atomic masses of the elements. 2.12 Explain the meaning of each term in the symbol A Z X. 8(12.01 amu) 1 10(1.008) amu) 1 4(14.01 amu) 1 2(16.00 amu) 5 194.20 amu Practice Exercise What is the molecular mass of methanol (CH4O)? Which of the following statements is true? We use the following five common acids as our references in naming oxoacids: carbonic acid H2CO3 HClO3 chloric acid H3PO4 phosphoric acid H2SO4 sulfuric acid Often two or more oxoacids have the same central atom but a different number of O atoms. Arrange the appropriate conversion factor so that grams cancel and the unit moles is obtained for your answer. Choices include: Color Custom by Chapter For even more flexibility, we offer the Chang Chemistry text in a full-color, custom version that enables instructors to pick the chapters they want. Then we will spend some time learning how to handle numerical results of chemical measurements and solve numerical results of chemical measurements and solve numerical results of chemical measurements and solve numerical problems. By absolute we mean that the zero on the Kelvin scale, denoted by 0 K, is the lowest temperature that can be attained theoretically. In (a) there is only one Si atom so we do not use the prefix "mono." Solution (a) Because there are four chlorine atoms present, the compound is silicon tetrachloride. When the two metal plates are connected to a high-voltage source, the negatively charged plate, called the cathode, emits an invisible ray. For names and symbols of the elements, see front end papers. 51 Nucleus, p. Assuming that each cell is completely filled with water (density 5 1 g/mL), calculate the length of one side of such a cell if it were a cube. A hydrogen atom has only one electron, which is stripped by the light from a quasar in a process known as ionization. In this text, we use the standard U.S. notation for group numbers (1A-8A and 1B-8B). There is a delicate balance in the amounts of these elements in our bodies. What is meant by the term "fundamental particle"? She is one of only three people to have received two Nobel prizes in sciences, including the social sciences, including the social sciences. 1.3 The Scientific Method All sciences, including the social sciences. 2.28 What are allotropes? What assumption should you make in this calculation? To carry out the conversion between pound and newton, we start with 1 lb = 0.4536 kg and from Newton's second law of motion, said: "This is going to be the cautionary tale that will be embedded into introduction to the metric system in elementary school, high school, and college science courses till the end of time." force 5 mass 3 acceleration 5 0.4536 kg 3 9.81 m/s2 5 4.45 kg m/s2 5 4.45 N because 1 newton (N) = 1 kg m/s2 5 4.45 N because 1 newton (N) = 1 kg m/s2 5 4.45 kg m/s2 5 4.45 N because 1 newton (N) = 1 kg m/s2 5 4.45 The small discrepancy from 100 percent is due to the way we rounded off. Recall that 1 L 5 1000 cm3 and 1 cm 5 1 3 1022 m. Thus, H2 is the molecular formula for hydrogen, O2 is oxygen, O3 is ozone, and H2O is water. When eaten, the egg is changed again, by substances in our bodies called enzymes. 2.98 (a) Assuming nuclei are spherical in Chloroform Similar problems: 2.45, 2.46. 51 Periodic table, p. Review of Concepts In viewing the periodic table, do chemical properties change more markedly across a period or down a group? 1.69 A resting adult requires about 240 mL of pure oxygen/min and breathes about 12 times every minute. When both the magnetic and the electric fields are off or when they are both on but balanced so that they cancel each other's influence, the ray strikes point B. The more challenging problems are listed under the Special Problems section. Chemical Mystery will foster a high level of critical thinking using the basic problems are listed under the special Problems are listed under the s locations of (a) alkali metals, (b) alkaline earth metals, (c) the halogens, and (d) the noble gases in the following outline of a periodic table. 8 Significant figures, p. The rounding-off procedure is as follows. 8. We learn the basic SI units and use the SI-derived units for quantities like volume and density. In 1903 she and her French husband, Pierre Curie, were awarded the Nobel Prize in Physics for their work on radioactivity. (b) A magnet separates the iron filings from the mixture. However, a series of investigations that began in the 1850s and extended into the twentieth century clearly demonstrated that atoms actually possess internal structure; that is, they are made up of even smaller particles, which are called subatomic particles. If we know the atomic mass of an element, we also know its molar mass. Thus, if the mass of one carbon12 atom is exactly 12 amu, the atomic mass of one carbon12 atom is exactly 12 amu, the atomic mass of hydrogen must be 0.084 3 12.00 amu or 1.008 amu. The accompanying table lists the essential elements in the human body. What are the formulas for magnesium oxide and strontium oxide? They are usually composed of nonmetallic elements (see Figure 2.10). We will use both models extensively in this text. There are no metal atoms in (c) but there is an ammonium group, which bears a positive charge. 1.6 2.36 lb. A physical property can be measured and observed without changing the composition or identity of a substance. According to Rutherford, most of the atom must be empty space. (1 lb 5 453.6 g; 1 m 5 3.28 ft.) 1.46 The current speed limit in some states in the United States is 55 miles per hour. Note that even the order of writing the elements in the formulas for hydrogen compounds is irregular. Then we combine N1 and N2; the exponents remain the same. Na1 Ion 11 protons 10 electrons. (c) All matter is composed of very small particles called atoms. The periodic table is a handy tool that correlates the properties of the elements in a systematic way and helps us to make predictions about chemical behavior. On a broader scale, improved understanding of the mechanism of aging will lead to a longer and healthier life span for the world's population. Table 2.1 shows the masses and charges of these three elementary particles. • Chapter Outline enables the student to numbers, stoichiometry, and more. Similarly, when we say that helium gas is lighter than air, we are referring to a physical property. Finally, knowing the number of H atoms, we can calculate the number of H atoms using Avogadro's number. Scientists are, after all, human beings, and their modes of thinking and working are very much influenced by their background, training, and personalities. Formula of Ionic Compounds are usually the same as their empirical formulas because ionic compounds are usually the same as their empirical formulas of ionic compounds are usually the same as their empirical formulas because ionic compounds are usually the same as their empirical formulas because ionic compounds are usually the same as their empirical formulas because ionic compounds are usually the same as their empirical formulas because ionic compounds are usually the same as their empirical formulas because ionic compounds are usually the same as their empirical formulas because ionic compounds are usually the same as their empirical formulas because ionic compounds are usually the same as their empirical formulas because ionic compounds are usually the same as their empirical formulas because ionic compounds are usually the same as their empirical formulas because ionic compounds are usually the same as their empirical formulas because ionic compounds are usually the same as their empirical formulas because ionic compounds are usually the same as their empirical formulas because ionic compounds are usually the same as their empirical formulas because ionic compounds are usually the same as their empirical formulas because ionic compounds are usually the same as their empirical formulas because ionic compounds are usually the same as their empirical formulas because ionic compounds are usually the same as their empirical formulas because ionic compounds are usually the same as their empirical formulas because ionic compounds are usually the same as their empirical formulas because ionic compounds are usually the same as their empirical formulas because ionic compounds are usually the same as their empirical formulas notation: (1) Express 568.762 in scientific notation: 568.762 = 5.68762 × 102 Note that the decimal point is moved to the left by two places and n = 2. / Raymond Chang. Same reason as in (c). 5H2O (left) is blue; CuSO4 (right) is white. High-Temperature Superconductors And All for the Want of a Button Hard-Boiling an Egg on a Mountaintop, Pressure Cookers, and Ice Skating Liquid Crystals The Killer Lake Desalination Determining the Age of the Shroud of Turin Femtochemistry Life at High Altitudes and the pH Balance in Your Stomach xviii 10 21 52 108 129 146 158 202 210 239 251 257 288 292 337 355 373 393 424 450 4738 486 488 500 501 526 541 580 593 645 646 698 List of Applications Maintaining the pH of Blood How an Eggshell Is Formed The Efficiency of Heat Engines The Thermodynamics of a Rubber Band Bacteria Power Dental Filling Discomfort Recycling Aluminum Metallic Hydrogen Synthetic Gas from Coal Ammonium Nitrate—The Explosive Fertilizer Coordination Compounds in Living Systems Cisplatin—The Anticancer Drug Nature's Own Fission Reactor Food Irradiation Boron Neutron Capture Therapy Ice That Burns The Petroleum Industry Sickle Cell Anemia—A Molecular Disease DNA Fingerprinting 724 753 814 826 861 871 906 919 923 931 976 978 1006 1014 1015 1038 1048 1075 1079 CHEMICAL Mysteries The Disappearance of the Dinosaurs Who Killed Napoleon? Addition of one O atom to the "-ic" acid: The acid is called "per . It is relatively easy to spot a wrong sign or incorrect units. 15 Chemistry, p. The decoding of the human genome, which comprises all of the genetic material in the human body and plays an essential part in gene therapy, relies largely on chemical techniques. What is the volume in m3? Because copper forms both Cu1 and Cu21 ions, we need to use the Stock system and call the compound copper(II) nitrate. In gene therapy, a selected healthy gene is delivered to a patient's cell to cure or ease such disorders. Assignments can include quiz questions, animations, and videos—anything found on the website. Besides irrigation, farmers rely on fertilizers and pesticides to increase crop yield. The rapid development of increasingly sophisticated technology throughout the twentieth century has given us even greater means to study things that cannot be seen with the naked eye. A metric conversion is then needed to convert grams to milligrams (1 mg 5 1 3 1023 g). (In the examples just discussed, the systems are the group of people the psychologist will study and a mixture of hydrogen and air.) The data obtained in a research study may be both qualitative, consisting of general observations about the system. obtained by various measurements of the system. (d) The growth of plants depends on the sun's energy in a process called photosynthesis. For example, oxygen's abundance is 45.5 percent. 49 Base, p. The atomic number of an element is the number of an element is the number of an element is the number of an element. Exceptions to the use of Greek prefixes are molecular compounds containing hydrogen. 12 Density, p. Some examples are HCl hydrogen bromide 63 2.7 Naming Compounds It is quite common for one pair of elements to form several different compounds. The first step is to assign a value to the mass of one atom of a given element so that it can be used as a standard. Mass and Weight The terms "mass" and "weight" are often used interchangeably, although, strictly speaking, they are different quantities. • PowerPoint Slides For instructors who prefer to create their lectures from scratch, all illustrations, photos, and tables are preinserted by chapter into blank PowerPoint slides. By carrying the units through the entire sequence of calculations, all the units will cancel except the desired one. How many atoms are in 16.3 g of S? Problem Solving The development of problem-solving skills has always been a major objective of this text. Preface Real-Life Relevance Interesting examples of how chemistry applies to life are used throughout the text. The flask was weighed dry and then filled with water. In addition and subtraction, the answer cannot have more digits to the right of the decimal point than either of the original numbers. 2.5 (a) Lead(II) oxide, (b) lithium sulfite. (d) Lead is denser than aluminum. Hodge Director of Development: Kristine Tibbetts Senior Developmental Editor: Shirley R. Isotopes are atoms of the same element with the same number of protons but different numbers of neutrons. 23 24 Chemistry: The Study of Change is somewhere between 5.9 mL and 6.1 mL. Fortunately, it is not necessary to memorize their names. What are they? Franklin found that 0.10 mL of oil could spread over the surface of water of about 40 m2 in area. After the change, the original chemical substance-water. What is this mass in milligrams (mg)? Dalton made no attempt to describe the structure or composition of atoms-he had no idea what will be left is a different chemical substance. an atom is really like. Moreover, an a particle traveling directly toward a nucleus would be completely repelled and its direction would be reversed. Furthermore, some of the concepts are abstract. Write the symbol for this cation. Because there are many more carbon-12 atoms than carbon-13 atoms in naturally occurring carbon, the average atomic mass is much closer to 12 amu than to 13 amu. On the other hand, the statement "Hydrogen gas to form water" describes a chemical change, in this case burning. Likewise, the atomic mass of sodium (Na) is 22.99 amu and its molar mass is 22.99 g; the atomic mass of phosphorus is 30.97 amu and its molar mass is 30.97 g; and so on. Practice Exercise Write the formulas of the following ionic compounds: (a) chromium 41 sulfate (containing the Cr31 and SO22 4 ions) and (b) titanium oxide (containing the Ti and O22 ions). Thus, if we wish to convert a length expressed in inches to centimeters, we multiply the length by the appropriate conversion factor. 56 Families, p. In its earliest moments, the universe occupied a tiny volume and was unimaginably hot. What does Avogadro's number represent? 2.29 Describe the two commonly used molecular models. The third type of radioactive radiation consists of high-energy rays called gamma (g) rays. Therefore, 1 lb is roughly 5 3 105 mg. Proust was the first person to isolate sugar from grapes. Calculate the mass of silicon in kilograms in Earth's crust. (c) Crystals of NaCl. 58 Atoms, Molecules, and Ions Refer to Figure 2.11 for charges of cations and anions. Similar problems: 3.20, 3.21. But he did realize that the different properties shown by elements such as hydrogen and oxygen can be explained by assuming that hydrogen atoms. From this equality, we can write two conversion factors 65.39 g Zn 1 mol Zn and 65.39 g Zn 1 mol Zn and a particular compound are always combined in the same proportions). These elements are necessary for biological functions such as growth, transport of oxygen for metabolism, and defense against disease. 46 Groups, p. The density of water at 20°C is 0.998 g/cm3 and that of ice at 25°C is 0.916 g/cm3. Although the ratio of nitrogen to hydrogen is 1:2 in both the molecular formula (N2H4) and the empirical formula (NH2), only the molecular formula (NH2), only the molecular formula tells us the actual number of N atoms (two) and H atoms (four) present in a hydrazine molecular formula (NH2). McCallum University of the Pacific Lisa McCaw University of Central Oklahoma Danny McGuire Carmeron University Scott E. Animations Limiting Reagent (3.9) Media Player Chapter Problems End of Chapter Problems End of Chapter Problems Scott E. Animations Limiting Reagent (3.9) Media Player Chapter Scott E. Animations Limiting Reagent (3.9) Media Player (3.9) Atomic Mass Section 3.4 describes a method for determining atomic mass. Note that the species in (a) and (b) are chemically similar isotopes of sodium. Some other hydrates are BaCl2 ? The two rows of metals beneath the main body of the table are conventionally set apart to keep the table from being too wide. For the past 30 years, intense research efforts have shown that solar energy can be harnessed effectively in two ways. Recall that the Roman numerals in the Stock system provide useful information about the charges of the cation. Practice Exercise Name the following oxoacid and oxoanion: (a) HBrO and (b) HSO2 4. This part is similar to Example 3.2. The molecular formula of the cation. urea shows there are four moles of H atoms in one mole of urea molecule, so the mole ratio is 4:1. 1.7 1.08 3 105 m3. covalent bonding (9.4) Le Châtelier's principle (14.5) Millikan oil drop (2.2) Nuclear fission (23.5) Neutralization reactions (4.3) Orientation of collisions (13.4) Osmosis (12.6) Oxidation reduction reactions (4.4) Packing spheres (11.4) Polarity of molecules (10.2) Precipitation reactions (4.2) Preparing a solution by dilution (4.5) Radioactive decay (23.3) Resonance (9.8) Sigma and pi bonds (10.5) Strong electrolytes, and nonelectrolytes, and nonelectrolytes (4.1) VSEPR (10.1) F rom the first edition, my aim has been to write a general chemistry text that provides a firm foundation in chemical concepts and principles and to instill in students an appreciation of the vital part chemistry plays in our daily life. 14 Precision, p. 9 Volume, p. Percent compound and multiplying by 100 percent. 1.77 Percent error is often expressed as the absolute value of the difference between the true value 2 experimental value 2 experimental value 2 at rue val pure substance can either be an element or a compound. Together with his associate Hans Geiger‡ and an undergraduate named Ernest Marsden, § Rutherford carried out a series of experiments using very thin foils of gold and other metals as targets for a particles from a radioactive source (Figure 2.8). Because the acid has one more O atom than our reference iodic acid (HIO3), it is called periodic acid. 1.97 A human brain weighs about 1 kg and contains about 1011 cells. 2.75 Fill in the blanks in the following table: (d) 21 54 26Fe Symbol 2.66 What is wrong with or ambiguous about the phrase "four molecules of NaCl"? Experimental evidence from early scientific investigations provided support for the notion of "atomism" and gradually gave rise to the modern definitions of elements and compounds. • • Visualization • • • • Graphs and Flow Charts are important in science. (H1 is equivalent to one proton, and is often referred to that way.) Formulas for acids contain one or more hydrogen atoms as well as an anionic group. 51 Metalloid, p. cm 5 57.8 m By definition, 1 cm 5 1 3 1022 m Because we are conversion as ? The most direct and most accurate method for determining atomic and molecular masses is mass spectrometry, which is depicted in Figure 3.3. In one type of a mass spectrometer, a gaseous sample is bombarded by a stream of high-energy electrons. 2 (c) The cation is NH1 4 (ammonium ion) and the anion is ClO3. Thus, the ratio of oxygen in carbon monoxide to oxygen in carbon dioxide is 1:2. Primis LabBase The Primis LabBase is by Joseph Lagowski (the University of Texas at Austin). (f) This is an ambiguous case. One way to quickly check the answer is to make a "ball-park" estimate. The loss of one or more electrons from a neutral atom results in a cation, an ion with a net positive charge. He received the Nobel Prize in Chemistry in 1908 for his investigations into the structure of the atomic nucleus. H O N HNO3 H O C H2CO3 TABLE 2.5 Some Simple Acids Anion Corresponding Acid F2 (fluoride) Br2 (bromide) I2 (coloride) gas phase. 10H2O. 1.8 Handling Numbers Having surveyed some of the units used in chemistry, we now turn to techniques for handling numbers that are not expressed in scientific notation. Solution (a) The atomic number is 11, so there are 11 protons. Unlike mixtures, compounds can be separated only by chemical means into their pure components. Unlike mass, length, and volume, temperature and other intensive properties are not additive. What is the total mass (in g) of the assembled sets of coins? Quantum Tutor problems are also available at the same site. More matter means more mass. Briefly describe steps you would take to show whether it is a pure substance or a homogeneous mixture. Therefore, Student A (1.972 g and 1.968 g deviate less from 1.971 g), but neither set of results is very accurate. The third hypothesis suggests that, to form a certain compound, we need not only atoms of the right kinds of elements, but specific numbers of these atoms as well. 170 Gases 172 5.1 5.2 5.3 5.4 5.5 5.6 Substances That Exist as Gases 174 Pressure of a Gas 175 The Gas Laws 179 The Ideal Gas Equation 185 Gas Stoichiometry 194 Dalton's Law of Partial Pressures 196 CHEMISTRY in Action Scuba Diving and the Gas Laws 202 5.7 The Kinetic Molecular Theory of Gases 201 CHEMISTRY in Action Super Cold Atoms 215 CHEMICAL Mystery Out of Oxygen 226 Thermochemistry 228 6.1 6.2 6.3 The Nature of Energy and Types of Energy 230 Energy Changes in Chemical Reactions 231 Introduction to Thermodynamics 233 CHEMISTRY in Action Fuel Values of Foods and Other Substances 251 6.6 Standard Enthalpy of Formation and Reaction 252 CHEMISTRY in Action How a Bombardier Beetle Defends Itself 257 6.7 Heat of Solution and Dilution 258 Key Equations 261 vii viii Contents Key Words 262 Questions and Problems 262 CHEMICAL Mystery The Exploding Tire 272 Quantum Theory and the Electronic Structure of Atoms 274 7.1 7.2 7.3 From Classical Physics to Quantum Theory 276 The Photoelectric Effect 280 Bohr's Theory of the Hydrogen Atom 282 CHEMISTRY in Action Laser—The Splendid Light 288 7.4 The Dual Nature of the Electron 288 CHEMISTRY in Action Laser—The Splendid Light 288 7.4 The Dual Nature of the Hydrogen Atom 282 CHEMISTRY in Action Laser—The Splendid Light 288 7.4 The Dual Nature of the Electron 288 CHEMISTRY in Action Electron 288 CHEMISTRY in Action Laser—The Splendid Light 288 7.4 The Dual Nature of the Hydrogen Atom 282 CHEMISTRY in Action Electron 288 CHEMISTRY in Action Laser—The Splendid Light 288 7.4 The Dual Nature of the Electron 288 CHEMISTRY in Action Elec Numbers 294 Atomic Orbitals 297 Electron Configuration 300 The Building-Up Principle 307 Key Equations 311 Summary of Facts and Concepts 311 Key Words 312 CHEMICAL Mystery Discovery of Helium and the Rise and Fall of Coronium 320 Periodic Relationships Among the Elements 322 8.1 8.2 8.3 Development of Facts and Concepts 311 Key Words 312 CHEMICAL Mystery Discovery of Helium and the Rise and Fall of Coronium 320 Periodic Relationships Among the Elements 322 8.1 8.2 8.3 Development of Facts and Concepts 311 Key Words 312 CHEMICAL Mystery Discovery of Helium and the Rise and Fall of Coronium 320 Periodic Relationships Among the Elements 322 8.1 8.2 8.3 Development of Facts and Concepts 311 Key Words 312 CHEMICAL Mystery Discovery of Helium and the Rise and Fall of Coronium 320 Periodic Relationships Among the Elements 322 8.1 8.2 8.3 Development of Facts and Concepts 311 Key Words 312 CHEMICAL Mystery Discovery of Helium and the Rise and Fall of Coronium 320 Periodic Relationships Among the Elements 322 8.1 8.2 8.3 Development of Facts and Concepts 311 Key Words 312 CHEMICAL Mystery Discovery of Helium and the Rise and Fall of Coronium 320 Periodic Relationships Among the Elements 322 8.1 8.2 8.3 Development of Facts and Concepts 311 Key Words 312 CHEMICAL Mystery Discovery of Helium and the Rise and Fall of Coronium 320 Periodic Relationships Among the Elements 322 8.1 8.2 8.3 Development of Facts and Concepts 311 Key Words 312 CHEMICAL Mystery Discovery of Helium and the Rise and Fall of Coronium 320 Periodic Relationships Among the Elements 322 8.1 8.2 8.3 Development of Facts and Fall of Coronium 320 Periodic Relationships Among the Elements 322 8.1 8.2 8.3 Development of Facts and Fall of Coronium 320 Periodic Relationships Among the Elements 322 8.1 8.2 8.3 Development of Facts the Periodic Table 324 Periodic Classification of the Elements 326 Periodic Variation in Physical Properties 330 CHEMISTRY in Action The Third Liquid Element? SI Units For many years, scientists recorded measurements in metric units, which are related decimally, that is, by powers of 10. The new edition of Chemistry continues to strike a balance between theory and application by incorporating real examples and helping students visualize the three-dimensional atomic and molecular structures that are the basis of chemical activity. Do the following statements describe chemical or physical properties? For example, a psychologist who wants to know how noise affects people's ability to learn chemistry and a chemist interested in measuring the heat given off when hydrogen gas burns in air would follow roughly the same procedure in carrying out their investigations. Write the symbol for this anion. Of special interest are the trace elements, such as iron (Fe), copper (Cu), zinc (Zn), iodine (I), and cobalt (Co), which together make up about 0.1 percent of the body's mass. 43 Law of multiple proportions, p. Suppose, for example, that three students are asked to determine the mass of a piece of copper wire. Solution To calculate the number of H atoms, we first must convert grams of urea to moles of urea using the molar mass of urea. 2.65 Determine the molecular and empirical formulas of the compound is potassium dihydrogen phosphate. It is a pleasure to acknowledge the support given to me by the following members of McGraw-Hill's College Division: Tammy Ben, Doug Dinardo, Chad Grall, Kara Kudronowicz, Mary Jane Lampe, Marty Lange, Kent Peterson, and Kurt Strand. 51 2.4 The Periodic Table 2.4 The Periodic we learn how to calculate the percent composition of these species from their chemical formulas. Again, the conversion factor 1 cm/1 3 1022 m contains exact numbers; therefore, it does not affect the number of significant figures. 2.67 The following phosphorus sulfides are known: P4S3, P4S7, and P4S10. Figure 2.10 shows the modern periodic table in which the elements are arranged by atomic number (shown above the element symbol) in horizontal rows called periods and in vertical columns known as groups or families, according to similarities in their chemical properties? Thus, everything in the universe has a "chemical" connection. (3.7) • Building on our knowledge of chemical reactions, the densest element known. However, for convenience, some element groups have been given special names. [The volume of a sphere of radius] r is (4/3)pr3.] 2.102 A monatomic ion has a charge of 12. 49 Questions and Problems Law of conservation of mass, p. Because the subscripts in the formula represent a mole ratio, we need to convert the grams of each element to moles. 53 Nonmetal, p. Thus, nitric acid, HNO3, becomes nitrous acid, HNO2. Elements are often referred to collectively by their periodic table group number (Group 1A, Group 2A, and so on). For example, the inch is defined to be exactly 2.54 centimeters; that is, 1 in 5 2.54 cm Thus, the "2.54" in the equation should not be interpreted as a measured number with three significant figures. If the charges are numerically equal, then no subscripts are necessary. The number of significant figures may be four (7.000 × 103), three (7.00 × 103), two (7.0 × 103 boiling point of ethanol (78.3°C) are taken as 0°S and 100°S, respectively, where S is the symbol for the new temperature scale. Therefore, the Pt atoms in the cube cannot fill all of the available space. (Hint: One element is a familiar metal and the other element), 42He, 20 40 84 132He, 20 40 84 He, 20 4 10Ne, 18Ar, 36Kr, and 54Xe, (a) determine the nucleus of each atom. Strategy We are asked to solve for atoms of hydrogen in 25.6 g of urea. To make the sum of the charges equal zero, we must adjust the numbers of cations and anions: 3(12) 1 2(23) 5 0 Similar problems: 2.59(a), (b), (d), (h), (i). The emphasis is on experimental design, analysis problem solving, and communication. (a) The Roman numeral shows that the mercury ion bears a 11 charge. Most of them occur naturally on Earth. How are these elements distributed on Earth, and which are essential to living systems? Practice Exercise Write the molecular formula of chloroform, which is used as a solvent and a cleansing agent. Now we can write ? We must specify that the distance is 5166 kilometers. Each student measures the volume three times with a graduated cylinder. EXAMPLE 3.7 How many hydrogen atoms are present in 25.6 g of urea [(NH2)2CO], which is used as a fertilizer, in animal feed, and in the manufacture of polymers? § 47 Ernest Marsden (1889-1970). Given the percent compound, we can determine the empirical formula of the compound (Figure 3.5). The same is true in chemistry; units are essential to stating measurements correctly. More the percent composition by mass of a compound, we can determine the empirical formula of the compound (Figure 3.5). often than not, the public learns only of spectacular scientific breakthroughs. Strategy In a chemical formula, the subscripts represent the ratio of the number of moles of each element that combine to form one mole of the compound. Energy is a by-product of many chemical processes, and as the demand for energy continues to increase, both in technologically advanced countries like the United 1.1 Chemistry: A Science for the Twenty-First Century (a) (c) (b) (d) Figure 1.1 (a) The output from an automated DNA sequencing machine. 2.20 State two differences between a metal and a nonmetal. Thus, there are 3.06 3 1023 atoms of S in 16.3 g of S. (1 lb 5 16 oz; 1 lb 5 453.6 g.) 1.76 Osmium (Os) is the densest element known (density 5 22.57 g/cm3). Calculate the volume of the 73Li nucleus. Solution To satisfy electrical neutrality, the following relationship must hold: (12)x 1 (23)y 5 0 Solving, we obtain x/y 5 3/2. The anion is named 1A 8A 2A Li Na Mg K Ca Rb Sr Cs Ba 3A 4A 5A 6A 7A N O F Al S Cl Br I The most reactive metals (green) and the most reactive nonmetals (blue) combine to form ionic compounds. The symbols of some elements are derived from their English names. 13 1.5 The Three States of Matter Matter Separation by physical methods Mixtures Figure 1.5 Heterogeneous mixtures Figure 1.5 Heterogeneous mixtures Pure substances Compounds Separation by chemical methods Elements Classification of matter. particular isotope. Researchers have also found a way to prevent pesky insects from reproducing. As always, I have benefited much from discussions with many instructors here and abroad. In this chapter, we will discuss the scientific method, which provides the framework for research not only in chemistry but in all other sciences as well. Therefore, the ratio of the mass of a helium atom to that of a hydrogen atom should be 2:1. As Figure 1.6 shows, gases differ from liquids and solids in the distances between the molecules. Except for the most common form of hydrogen, which has one proton and no neutrons, all atomic nuclei contain both protons and neutrons. With additional information, it is possible to deduce the molecular formula. As Examples 3.6 and 3.7 show, a knowledge of the molar mass enables us to calculate the numbers of moles and individual atoms in a given quantity of a compound. Precision refers to how closely two or more measurements of the same quantity agree with one another (Figure 1.13). • Many sections have been revised and updated based on the comments from reviewers and users. Solution (a) Three, because each digit is a nonzero digit. There is some justification for this perception; for one thing, chemistry has a very specialized vocabulary. In this tenth edition, as in previous editions, my goal is to create a text that is clear in explaining abstract concepts, concise so that it does not overburden students to move on to the next level of learning. When only the electric field is on, the ray strikes point C. The true volume is 87.0 mL. Chemistry in Action boxes appear in every chapter on a variety of topics, each with its own story of how chemistry: The Study of Change 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 Intermolecular Forces and Liquids and Solids Atoms, Molecules, and Ions 40 Mass Relationships in Chemical Reactions Reactions Reactions Reactions Feriodic Relationships Among the Elements Chemical Bonding I: Basic Concepts 274 322 364 Chemical Bonding II: Molecular Geometry and Hybridization of Atomic Orbitals 408 Physical Properties of Solutions Chemical Kinetics Acids and Bases 460 512 556 Chemical Equilibrium 614 658 Acid-Base Equilibrium 800 836 Metallurgy and the Chemistry of Metals 884 Nonmetallic Elements and Their Compounds 912 Transition Metals Chemistry and Coordination Compounds Nuclear Chemistry 986 Organic Chemistry 986 Thermodynamic Data at 1 atm and 25°C Mathematical Operations A-13 A-8 952 List of Applications xviii List of Animations xx Preface xxi Tools for Success xxviii A Note to the Study of Chemistry: A Science for the Twenty-First Century 4 The Study of Chemistry: The Study of Chemistry: A Science for the Twenty-First Century 4 The Study of Chemistry 7 The Scientific Method 8 CHEMISTRY in Action Primordial Helium and the Big Bang Theory 10 1.4 1.5 1.6 1.7 Classifications of Matter 13 Physical and Chemical Properties of Matter 13 Physical and Chemical Properties of Matter 14 Measurement 16 CHEMISTRY in Action The Importance of Units 21 1.8 1.9 Handling Numbers 22 Dimensional Analysis in Solving Problems 31 Summary of Facts and Concepts 31 Key Words 31 Questions and Problems 32 CHEMICAL Mystery The Disappearance of the Atom 43 Atomic Number, Mass Number, and Isotopes 49 The Periodic Table 51 CHEMISTRY in Action Distribution Distribution and Problems 32 CHEMICAL Mystery The Disappearance of the Atom 43 Atomic Number, Mass Number, and Isotopes 49 The Periodic Table 51 CHEMISTRY in Action Distribution Dist Earth and in Living Systems 52 2.5 2.6 2.7 Molecules and Ions 53 Chemical Formulas 55 Naming Compounds 59 v vi Contents 2.8 Introduction to Organic Compounds 59 v vi Contents 2 Atomic Mass 80 Avogadro's Number and Molar Mass of an Element 81 Molecular Mass 85 The Mass Spectrometer 88 Percent Composition of Compounds 88 Experimental Determination of Empirical Formulas 92 Chemical Reaction Yield 106 CHEMISTRY in Action Chemical Fertilizers 108 Key Equations 109 Summary of Facts and Concepts 109 Key Words 109 Questions and Problems 110 Reactions 122 Precipitation Reactions 124 CHEMISTRY in Action An Undesirable Precipitation Reaction 129 4.3 4.4 Acid-Base Reactions 129 Oxidation-Reduction Reactions 135 CHEMISTRY in Action Breathalyzer 146 4.5 4.6 4.7 4.8 Concentration of Solutions 150 Redox Titrations 156 CHEMISTRY in Action Metal from the Sea 158 Key Equations 159 Summary of Facts and Concepts 159 Contents Key Words 160 Questions and Problems 160 CHEMICAL Mystery Who Killed Napoleon? CHEMICAL Mystery The Disappearance of the Dinosaurs D inosaurs dominated life on Earth for millions of years and then disappearance of the Dinosaurs D inosaurs and the radius and mass of the nucleus are 3.04 3 10215 m and 3.82 3 10223 g, respectively, calculate the density of the nucleus in g/cm3. The rules are accepted worldwide, facilitating communication among chemists and providing a useful way of labeling an overwhelming variety of substances. tastes better than margarine. Zeros between nonzero digits are significant. (a) This conversion is carried out by writing 9°F 3 (224°C) 1 32°F 5 435°F 5°C Solder is used extensively in the construction of electronic circuits. Dividing the subscripts by 6, we obtain the empirical formula CH2O. Figure 1.7 shows the three states of water. Addition and Subtraction To add or subtract using scientific notation, we first write each quantity—say N1 and N2—with the same exponent n. For example, we know the molar mass of carbon-12 is 12.00 g and there are 6.022 3 1023 carbon-12 atoms in 1 mole of the substance; therefore, the mass of one carbon-12 atoms in 1 mole of the substance; therefore, the mass of one carbon-12 atoms in 1 mole of the substance; therefore, the mass of one carbon-12 atoms in 1 mole of the substance; therefore, the mass of one carbon-12 atoms 6.022 atoms 6.022 atoms 6.022 atoms in 1 mole of the substance; therefore, the mass of one carbon-12 atoms 6.022 atoms 6.022 atoms in 1 mole of the substance; therefore atoms 6.022 atoms 6 3 1023 carbon-12 atoms † 5 1.993 3 10223 g Lorenzo Romano Amedeo Carlo Avogadro di Quaregua e di Cerreto (1776-1856). Accuracy and Precision. The following steps will help to improve your skill at solving numerical problems. Writing formulas for molecular compounds is usually straightforward. He was awarded the Nobel Prize in Chemistry in 1922 for developing the mass spectrometer. 55 56 Atoms, Molecules, and Ions fasteners, so that the bonds are not visible. 55 Diatomic molecule, p. According to the law, if two elements can combine to form more than one compound, the masses of one element that combine with a fixed mass of the other element are in ratios of small whole numbers. (The only exception is 11H, where the mass number is equal to the atomic number.) In a case where no subscript is shown, as in parts (c) and (d), the atomic number can be deduced from the element symbol or name. This relationship will enable conversion from pounds to grams. 1.35 Carry out the following operations as if they were calculations of experimental results, and express each answer in the correct units with the correct number of significant figures: (a) 5.6792 m 1 0.6 m 1 4.33 m (b) 3.70 g 2 2.9133 g (c) 4.51 cm 3 3.6666 cm (d) (3 3 104 g 1 6.827 g)y(0.043 cm 3 2 0.021 cm3) 1.36 Carry out the following operations as if they were calculations of experimental results, and express each answer in the correct units with the correct (A, B, and C) are asked to determine the volume of a sample of ethanol. This explains why the majority of a particles passed through the gold foil with little or no deflection. The performance of a microprocessor is judged by the speed with which it carries out mathematical operations, such as addition. 1.100 A graduated cylinder is filled to the 40.00mL mark with a mineral oil. 51 Gamma (g) rays, p. They can be atoms of the same element, as in ozone (O3), which is made up of three atoms of oxygen, or they can be combinations of the following scientists to our knowledge of atomic structure: J. This equivalence enables us to write a conversion factor as follows: 1 in 2.54 cm Because both the numerator and the denominator express the same length, this fraction is equal to 1. If an atom were magnified so that the radius of its nucleus became 2.0 cm, about the size of a marble, what would be the radius of the atom in miles? Available evidence suggests that about 20 percent of the asteroid's mass turned to dust and spread uniformly over Earth after settling out of the upper atmosphere. The visual resources in this collection include: • Art Full-color digital files of all illustrations, exams, or custom-made classroom materials. (Continued) CHEMISTRY in Action The Importance of Units I n December 1998, NASA launched the 125-million dollar Mars Climate Orbiter, intended as the red planet's first weather satellite. Setting x 5 3 and y 5 2, we write When magnesium burns in air, it forms both magnesium oxide and magnesium oxide and magnesium oxide and magnesium oxide and magnesium burns in air, it forms both magnesium oxide and magnesium oxide and magnesium burns in air, it forms both magnesium burns in air, it forms both magnesium oxide and magnesium oxide and magnesium oxide and magnesium burns in air, it forms both magnesium oxide and magnesium burns in air, it forms both magnesium burns in air, it forms both magnesium burns in air, it forms both magnesium oxide and magnesium burns in air, it forms both magnesium burns in air, it forms burns However, the standard way of writing the molecular formula for methanol is CH3OH because it shows how the atoms are joined in the molecule. Table 2.2 shows the "-ide" nomenclature of some common monatomic anions according to their positions in the periodic table. For example, 74.6 × 100 (n = 0) is equivalent to 74.6. Second, the usual practice is to omit the superscript when n = 1. In this chapter, we will use what we have learned about chemical structure and formulas in studying the mass relationships of atoms and molecules. More than 40 general chemistry experiments are available in this database collection of Preface general lab experiments from the Journal of Chemical Education and experiments used by Professor Lagowski at the University of Texas at Austin, enabling instructors to customize their lab manuals. (a) Good accuracy and good precision. The Fahrenheit scale, which is the most commonly used scale in the United States outside the laboratory, defines the normal freezing and boiling points of water to be exactly 32°F and 212°F, respectively, mg 5 0.0833 lb The relationship between pounds and grams is given in the problem. Consider the following examples: CO carbon monoxide SO3 sulfur trioxide prefixes: • The prefix "mono-" may be omitted for the first element. The answers to the Review, and Instruction System) website. (Assume there are appropriate tools for this procedure and that copper atoms are lined up in a straight line, in contact with each other. Problems 1.3 1.4 Classify the following as qualitative or quantitative statements, giving your reasons. With the exception of hydrogen (H), nonmetals appear at the far right of the table. Figure 1.3 summarizes the main steps of the research process. When a summarizes the main steps of the research process. With the exception of hydrogen (H), nonmetals appear at the far right of the table. Review of Concepts Match each of the diagrams shown here with the following ionic compounds: Al2O3, LiH, Na2S, Mg(NO3)2. Is the fact that you can have more than one compound with the same molecular formula consistent with Dalton's atomic theory? H O C N 2.48 Write the molecular formula of ethanol. The following quide explains how to take full advantage of the text, technology, and other tools. An apple that falls from a tree is pulled downward by Earth's gravity. Sometimes solving a problem will involve more than one step, and you may be expected to look up quantities in tables that are not provided in the problem. definite (constant) composition and distinct properties. (b) Atoms are spherical in shape. 53 Electron, p. If we had used the empirical formula HO for the calculation, we would have obtained the same percentages. Chemistry. How many Fe atoms are in 4.9 g of Fe, which is the total amount of iron in the body of an average adult? Thus, the name arsenic trifluoride means that there are three F atoms and one As atom in each molecular formula is AsF3. Thus, if we were to analyze samples of carbon dioxide gas obtained from different sources, we would find in each sample the same ratio by mass of carbon to oxygen. Commenting on the failure of the Mars mission, one scientist Artist's conception of the Martian Climate Orbiter. The density of Pt is 21.45 g/cm3 and the mass of a single Pt atom is 3.240 3 10222 g. (b) The cathode ray is bent downward when a bar magnet is brought toward it. When ingested, it reacts with the gastric juice (hydrochloric acid) in the stomach to give off carbon dioxide gas. (a) Are these results consistent with the law of multiple proportions? 28 Chemistry: The Study of Change which is also equal to 1. • Use the Student Interactive Activity as a guide to review challenging concepts in motion. 48 Atoms. Molecules, and Ions If the size of an atom were expanded to that of this sports stadium, the size of the nucleus would be that of a marble. Electrons are shown as "clouds" around the nucleus. Questions and Problems 1.63 A lead sphere has a mass of 1.20 3 104 g, and its volume is 1.05 3 103 cm3. Mg 2 ≤ N 3 ≥ Mg3 N2 Check The subscripts are reduced to the smallest whole number ratio of the atoms Similar problems: 2.43, 2.44. What unit do we need to convert grams of sulfur to in order to convert to atoms? If the number of neutrons in the nucleus is 1.2 times that of the number of protons, what is the name and symbol of the element? To account for the quantity of iridium found, scientists suggested that a large asteroid several miles in diameter hit Earth about the time the dinosaurs disappeared. Does this violate the law of definite proportion? 1.28 Define significant figure. The small discrepancy from 100 percent is due to the way we rounded off the molar masses of the elements. The animations, media player content, and electronic homework including tutorials are valuable in presenting a concept and enabling the student to manipulate or choose steps so full understanding can happen. 1.2 341 g. The emerging ions are deflected into a circular path by a magnet. Just as a marathon runner cannot prepare for a race by simply reading books on running and a pianist cannot give a successful concert by only memorizing the musical score, you cannot be sure of your understanding 1.9 Dimensional Analysis in Solving Problems 29 of chemistry without solving problems. Figure 2.9 shows the location of the elementary particles (protons, neutrons, and electrons) in an atom. xxxi G eneral chemistry is commonly perceived to be more difficult than most other subjects. For example, the natural abundances of carbon-12 and carbon-13 are 98.90 percent and 1.10 percent, respectively. Calculate the density and radius of the ball bearing. Mass, which is the quantity of matter in a given sample of a substance, is an extensive property. 1.7 Using examples, explain the difference between a physical property. blocked the sunlight for months or perhaps years. Therefore, the measured mass typically will have four significant figures (for example, 0.8642 g) or more (f boiling point of liquid nitrogen, to degrees Celsius. 1.8 How does an intensive property differ from an extensive property? (b) Which are negatively charged? Professor Chang has written books on physical chemistry, and physical science. Chalcopyrite, the principal ore of copper (Cu), contains 34.63 percent Cu by mass. Explain the differences. 16 Mixture, p. Arrange the appropriate conversion factor so that moles cancel and the unit grams are obtained for measuring the atomic mass of the other elements. Chemical reactions usually involve a gain or loss of heat and other forms of energy. • Animations Numerous full-color animations illustrating important processes are also provided. cm 5 57.8 m 3 1 cm 1 3 10 22 m 5 5780 cm 5 5.78 3 103 cm Note that scientific notation is used to indicate that the answer has three significant figures. (1 ton 5 2000 lb; 1 lb 5 453.6 g.) 1.72 Magnesium (Mg) is a valuable metal used in alloys, in batteries, and in the manufacture of chemicals. Also, temperatures expressed in kelvins can never be negative. In any real situation, we deal with macroscopic samples containing enormous numbers of atoms. For example, it is known that each of the two H atoms is bonded to an O atom in the water molecule. He practiced law for many years before he became interested in science. (3.6) • Next, we learn how to write a chemical equation to describe the outcome of a chemical reaction. Even though the liter is not an SI unit, volumes are usually expressed in liters and milliliters. For additional practice, you can turn to similar problems referred to in the margin next to the example. Millikan‡ succeeded in measuring the charge of the electron with great precision. Explain why the chemical formulas of ionic compounds are usually the same as their empirical formulas. Quantum Tutor Problems: 2.43, 2.46, 2.57, 2.58, 2.59, 2.60. (d) Two. This is a tremendous drain on a nation's resources. This puzzle appeared in Chemical & Engineering News, December 14, 1987 (p. Using his knowledge of electrostatics, Millikan found the charge of an electron to be 21.6022 3 10219 C. Chemists can help to device and obtain more significant figures, but in every case, the last digit is always uncertain the amount of this uncertainty depends on the particular measuring device we use. In any compound, the ratio of the numbers of atoms of any two of the elements present is either an integer or a simple fraction. In the periodic table (see inside front cover) we see that the molar mass of He is 4.003 g. Calculate the average atomic mass of boron. R. Which are likely to be molecular? (2.7) The Atomic Theory The Structure of the Atom Atomic Number, and Isotopes 2.4 The Periodic Table 2.5 2.6 2.7 2.8 Molecules and Ions Chemical Formulas Naming Compounds Introduction to Organic Compounds Student Interactive Activity Animations Cathode Ray Tube (2.2) Millikan Oil Drop (2.2) Alpha, Beta, and Gamma Rays (2.2) a-Particle Scattering (2.2) Finally, we will briefly explore the organic world to which we will return in a later chapter. Study of radioactivity helped to advance scientists' knowledge about atomic structure. ‡ According to Albert Einstein, mass and energy are alternate aspects of a single entity called massenergy. The third piece of evidence supporting Gamow's hypothesis is the discovery of primordial helium. Whereas mass is a measure of the amount of matter in an object. (c) The temperature on the surface of the sun is about 6300°C. (Black spheres are carbon and gray spheres are hydrogen.) (a) (b) (c) 2.71 Explain why anions are always larger than the atoms from which they are derived. I. There are other subatomic particles, but the electron, the proton, † James Chadwick (1891–1972). 2.74 What is wrong with the chemical formula for each of the following compounds: (a) (NH3)2CO3 (ammonium carbonate), (b) CaOH (calcium hydroxide), (c) CdSO3 (cadmium sulfide), (d) ZnCrO4 (zinc dichromate)? However, the balls are not proportional to the size of atoms. Unlike the units of length and time, which are based on natural processes that can be repeated by scientists anywhere. the kilogram is defined in terms of a particular object (Figure 1.9). According to Table 2.3, however, the mercury(I) ion is diatomic (that is, Hg21 2) and the nitrite ion is NO2 2. One device used to investigate this phenomenon was a cathode ray tube, the forerunner of the television tube (Figure 2.3). The preceding rounding-off procedure applies to

one-step calculations. (True value: 0.864 g.) The natural abundances of elements in the human body, expressed as percent; calcium (Ca), 1.6 percent; calcium significant figures, 40.062 mL has five significant figures. EXAMPLE 2.4 Write the formulas and empirical formulas. However, there was no convincing evidence for any one hypothesis until 1977. 7. Enhance your learning by utilizing the list of media available for the chapter. An effective means of visualizing them is by the use of molecular models. In (b), we need to convert the anion to its parent acid shown in Table 2.6. Solution (a) We start with our reference acid, phosphoric acid (H3PO4). Keep in mind that the Roman numerals refer to the charges on the metal cations. - Expanded coverage on effective nuclear charge in Chapter 8. Ionized hydrogen atoms cannot absorb any of the quasar's light. There is, of course, an element of luck involved in scientific discoveries, but it has been said that "chance favors the prepared mind." It takes an alert and well-trained person to recognize the significance of an accidental discovery and to take full advantage of it. Like atoms, molecules are electrically neutral. 76 Atoms NaCl 5 22.99 amu 1 35.45 amu 5 58.44 amu and its molar mass is 58.44 g. Do these compounds obey the law of multiple proportions? Donnelley Willard, OH The credits section for this book begins on page C-1 and is considered an extension of the copyright page. 57 2.6 Chemical Formulas EXAMPLE 2.3 Cl H Write the empirical formulas for the following molecules: (a) acetylene (C2H2), which is used in welding torches; (b) glucose (C6H12O6), a substance known as blood sugar; and (c) nitrous oxide (N2O), a gas that is used as an anesthetic gas ("laughing gas") and as an aerosol propellant for whipped creams. (b) Helium has the lowest boiling point of all the elements at 2452°F. Values of the same extensive property can be added together. Because an atom is electrically neutral, the number of protons is equal to the number of electrons in it. Because there is only one carbon atom present. 36 Chemistry: The Study of Change 1.83 A 1.0-mL volume of seawater contains about 4.0 3 102121 g of gold. In degrees Celsius, express the percent error expected from each of these thermometers in measuring a person's body temperature of 38.9°C. 74 Atoms, Molecules, and Ions Additional Problems 2.61 A sample of a uranium compound is found to be losing mass gradually. Despite her great contribution to science, her nomination to the French Academy of Sciences in 1911 was rejected by one vote because she was a woman! Her daughter Irene, and son-in-law Frederic Joliot-Curie, shared the Nobel Prize in Chemistry in 1935. Proving or disproving a theory can take years, even centuries, in part because the necessary technology may not be available. Hydrocarbon is the simplest type of organic compound. • Use prefixes for both elements present (Prefix "mono-" usually omitted for the first element) • Add "-ide" to the root of the second element 65 2.7 Naming Compounds Acids and Bases Naming Acids An acid can be described as a substance that yields hydrogen ions (H1) when dissolved in water. Review of Concepts The atoms of elements A (blue) and B (orange) form two compounds shown here. The following diagram helps us determine the subscripts for the compound formed by the cation and the anion: Al 3
Q2 Al2 O3 Note that in each of the above three examples, the subscripts are in the smallest ratios. After a 416-million mi journey, the spacecraft was supposed to go into Mars' orbit on September 23, 1999. But every now and then an a particle was scattered (or deflected) at a large angle. Blaha Columbus State University Timothy Brewer Eastern Michigan University Michelle M. Integration with BlackBoard or WebCT—once a student is registered in the course, all student activity within McGraw-Hill's ARIS is automatically recorded and available to the instructor through a fully integrated grade book that can be downloaded to Excel, WebCT, or BlackBoard. 5 6 Chemistry: The Study of Change Another potential source of energy is nuclear fission, but because of environmental concerns about the radioactive wastes from fission processes, the future of the nuclear industry in the United States is uncertain. End of Chapter: Test your knowledge in preparation for exams by utilizing these tools: Key Equations, Summary, Key Words, Electronic Homework, Questions and Problems xxx Media Tools Animations: Understand major concepts by viewing animations developed specifically to reinforce the text content. Elements in Group 8A (He, Ne, Ar, Kr, Xe, and Rn) are called noble gases, or rare gases. Using the proper conversion factors we can convert one quantity to another, as Examples 3.2-3.4 show. Cooperative Chemistry Laboratory Manual This innovative guide by Melanie Cooper (Clemson University) features open-ended problems designed to simulate experience in a research that begins with the gathering of information through observation and measurements. Harness the visual impact of concepts in motion by importing these files into classroom presentations or online course materials. Neglect the buoyance of air.) 1.74 The surface area and average depth of the Pacific Ocean are 1.8 3 108 km2 and 3.9 3 103 m, respectively. 65 Oxoanion, p. Assuming that the oil forms a monolayer, that is, a layer that is only one molecule thick, estimate the length of each oil molecule in nanometers. Thus, when energy is lost in a reaction, for example, mass is also lost. m3 5 5.2 L How many conversion factors are needed for this problem? Presentation Center Accessed from your textbook's ARIS website, Presentation Center is an online digital library containing photos, artwork, animations, and other media types that can be used to create customized lectures, visually enhanced tests and quizzes, compelling course websites, or attractive xxiv Preface printed support materials. (1.7) • Chemical calculations often involve very large or very small numbers and a convenient way to deal with these numbers is the scientific notation. (Hint: This country is in South America.) Fluorine reacts with hydrogen (H) and deuterium (D) to form hydrogen fluoride (HF) and deuterium (21H) is an isotope of hydrogen. We place the name of the first element in the formula first, and the second element is named by adding -ide to the root of the element name. Two scientists may start working on a project with exactly the same objective, but will end up taking drastically different approaches. You apply chemical and physical principles when you use baking soda to leaven bread, choose a pressure cooker to shorten the time it takes to prepare soup, add meat tenderizer to a pot roast, squeeze lemon juice over sliced pears to prevent them from turning brown or over fish to minimize its odor, and add vinegar to the water in which you are going to poach eggs. All assets are copyrighted by McGraw-Hill Higher Education, but can be used by instructors for classroom purposes. Instructors: To access ARIS, request registration information from your McGraw-Hill sales representative. The periodic table enables us to classify elements (as metals, metalloids, and nonmetals) and correlate their properties in a systematic way. Using sketches helps student understand the inner workings of a problem. Mixtures do not have constant composition. A chlorine atom (Cl), for instance, can gain an electron to become the chloride ion Cl2: Cl2 Ion 17 protons 18 electrons Sodium chloride (NaCl), ordinary table salt, is called an ionic compound because it is formed from cations and anions. Silicon (Si) is the second most abundant element in Earth's crust (27.2 percent by mass). In these cases, confusion in naming the compounds is avoided by the use of Greek prefixes to denote the number of atoms of each element present (Table 2.4). (b) The mass of water is greatest for the ice cube and least for the steam. The molar masses of other elements are also expressed in grams and contain the same number of atoms. What is the difference between qualitative data and quantitative data? The number 9 is exact and does not determine the number of significant figures. (The area of Earth is 5.1 3 1014 m2; 1 lb 5 453.6 g,) (Source: Consider a Spherical Cow—A Course in Environmental Problem Solving by J. (b) Ethylene glycol is a liquid organic compound that is used as an antifreeze in car radiators. • Attend classes regularly and take careful notes. However, for our purposes we will normally use atomic masses inside the front cover). The purpose of this course is to make you think like a chemist, to look at the macroscopic world—the things we can see, touch, and measure directly—and visualize the particles and events of the microscopic world that we cannot experience without modern technology and our imaginations. 49 50 Atoms, Molecules, and Ions Thus, for the isotopes of hydrogen, we write 1 1H 2 1H 1 1H 2 1H 3 1H hydrogen deuterium tritium 3 1H As another example, consider two common isotopes of uranium with mass numbers of 235 and 238, respectively: 235 92U 238 92U The first isotope is used in nuclear reactors and atomic bombs, whereas the second isotope lacks the properties necessary for these applications. 54 Isotope, p. Our guide for this discussion will be the law of conservation of mass. At first, studying chemistry is like learning a new language. Vincent University of Alabama Thomas Webb Auburn University of Mississippi Wayne Wesolowski University of Hong Kong Troy Wood University of Alabama Thomas Webb Auburn University of Mississippi Wayne Wesolowski University of Alabama Thomas Webb Auburn University of Alabama Thomas Webb Auburn University of Alabama Thomas Webb Auburn University of Alabama genetically engineered and is barely attacked by the worms. One, simply known as hydrogen, has one proton and no neutrons. (1 mi 5 1609 m.) 1.61 A piece of silver (Aq) metal weighing 194.3 g is placed in a graduated cylinder containing 242.0 mL of water. For example, PCl3 is named phosphorus trichloride, not monophosphorus trichloride. This 2.50 Which of the following compounds are likely to be ionic? (3.10) Avogadro's Number and the Molar Mass of an Element The Mass Spectrometer Reaction Yield Student Interactive Activity I n this chapter we will consider the masses of atoms and molecules and what happens to them when chemical changes occur. Student C's results are not only the most precise, but also the most accurate, because the average value is closest to the true value. (b) If it takes 0.304 ft3 of gas to boil a 2.1-L kettle of water? For this reason, it is important to indicate the margin of error in a measurement by clearly indicating the number of significant figures, which are the meaningful digits in a measured or calculated quantity. Mixtures, whether homogeneous, can be separated into pure components by physical means. In 1995, astronomers analyzed A color photo of some distant galaxy, including the position of a quasar. See Problem 1.57 for volume of a sphere. Used with permission.) 39 Atoms, Molecules, and Ions Colored images of the radioactive emission of radium (Ra). Create announcements and utilize full course or individual student communication tools. Solution (a) There are two carbon atoms and two hydrogen atoms in acetylene. The models show elemental sulfur (S8), and oxygen and sulfur dioxide molecules. Currently the major sources of energy are fossil fuels (coal, petroleum, and natural gas). It is used mainly in jewelry, dentistry, and electronic devices. Chapter Outline 1.1 Chemistry: A Science for the Twenty-First Century 1.2 1.3 1.4 The Study of Chemistry 1.5 1.6 The Three States of Matter 1.7 1.8 1.9 Measurement The Scientific Method A Look Ahead • We begin with a brief introduction to the study of chemistry and describe its role in our modern society. 1.23 Convert the following temperatures to degrees Celsius or Fahrenheit: (a) 95°F, the temperature on a hot summer day; (b) 12°F, the temperature on a cold winter day; (c) a 102°F fever; (d) a furnace operating at 1852°F; (e) 2273.15°C (theoretically the lowest attainable temperature). 2.59 Write the formulas for the following compounds: (a) rubidium nitrite, (b) potassium dihydrogen phosphate, (c) sodium hydrogen sulfide, (d) magnesium sulfate, (i) silver perchlorate, (j) boron trichloride. (c) The general test for type II diabetes is that the blood sugar (glucose) level should be below 120 mg per deciliter (mg/dL). (a) Al2Br6, (b) Na2S2O4, (c) N2O5, (d) K2Cr2O7 2.47 Write the molecular formula of glycine, an amino acid present in proteins. We will take a closer look at this keystone of chemistry in Chapter 8. The accepted way to denote the atomic number of an atom of an element (X) is as follows: mass number 8n A ZX Protons and neutrons are collectively called nucleons. Compounds are composed of atoms of more than one element. represented by truncated balls held together by snap Molecular formula Structural formula Hydrogen Water Ammonia Methane H2 H2O NH3 CH4 H±H ±O±H Ball-and-stick model Space-filling model Figure 2.12 See back endpaper for color codes for atoms. In recognition of all the supporting evidence, scientists now refer to Gamow's hypothesis as the Big Bang theory. 1.1 1.2 Explain what is meant by the scientific method. (1 mi 5 1609 m.) 1.47 For a fighter jet to take off from the deck of an aircraft carrier, it must reach a speed of 62 m/s. When coal is burned, sulfur is converted to sulfur dioxide and eventually to sulfur carrier, it must reach a speed of 62 m/s. phenomenon. A liter is the volume occupied by one cubic decimeter. Calculate the density of gold. Thus, NaCl is the empirical formula for sodium chloride. The mass number is Similar problems: 2.15, 2.16. Figure 1.10 compares the relative sizes of two volumes. Strategy We are trying to solve for grams of zinc. Consequently, when working with very large and very small numbers, we use a system called scientific notation. This is a tremendous waste. In the gaseous or pure liquid state, HCl is a molecular compound called hydrogen chloride. We will discuss the nature of chemical bonds in Chapters 9 and 10. Assign questions developed following the problemsolving strategy used within the textual material, enabling students to continue the learning process from the text into their homework assignments in a structured manner. (b) The parent acid is HIO4. K 5 (°C 1 273.15°C) 1K 1°C (1.4) We will frequently find it necessary to convert between degrees Celsius and kelvin. Here are some suggestions to help you form good study habits and master the material in this text. What does P4 signify? Problems 2.31 Which of the following diagrams represent diatomic molecules, molecules, molecules that are not compounds, or an elemental form of the substance? [The volume of a sphere of radius r is (4/3)pr3.] 1.101 A chemist in the nineteenth century prepared an unknown substance. 2.11 What do we call atoms of the same elements with different mass of an atom depends on the number of electrons, protons, and neutrons it contains. It continues the tradition of providing a firm foundation in chemical concepts and principles while presenting a broad range of topics in a clear, concise manner. Review of Concepts enables the student to evaluate whether they understand the concept presented in the section. Dalton's brilliant insight into the nature of matter was the main stimulus for the rapid progress of chemistry during the nineteenth century. Strategy The question asks for atoms of sulfur. A metalloid has properties that are intermediate between those of metals and nonmetals. Determine its empirical formula. 1.5 The Three States of Matter All substances, at least in principle, can exist in three states: solid, liquid, and gas. Moreover, chemists can devise ways to increase the production of fertilizers that are less harmful to the environment and substances that would selectively kill weeds. What are the similarities and differences between 73 Questions and Problems 2.39 2.40 2.41 2.42 the empirical formula of a compound? Definitions of the key words can be studied in context on the pages cited in the end-of-chapter list or in the glossary at the back of the book. — Solution is the process of solving a problem given in a stepwise manner. (c) Because the subscripts in N2O are already the smallest possible whole numbers, the empirical formula for nitrous oxide is the same as its molecular formula. Figure 2.1 is a schematic representation of the last three hypotheses. ARIS Problems: 1.12, 1.16, 1.22, 1.29, 1.31, 1.33, 1.35, 1.36, 1.40, 1.44, 1.45, 1.48, 1.92, 1.93, 1.94, 1.105. At first glance this may seem to be an exception to the definition of a base. Media Player: Learn on the fly by downloading text-specific content to your Media Player. Also residing on your textbook's ARIS website are • PowerPoint Lecture Outlines Ready-made presentations that combine art and lecture notes are provided for each chapter of the text. In science, a law is a concise verbal or mathematical statement of a relationship between percent of the space inside the cube is taken up by Pt atoms, calculate the radius in picometers of a Pt atom. Note that elements 112-116 and 118 have recently been named. Chapter Outline 2.1 2.2 2.3 A Look Ahead • We begin with a historical perspective of the search for the fundamental units of matter 77 Answers to Practice Exercises 2.104 Name the following acids: H S N Cl C O Answers to Practice Exercises 2.1 29 protons, 34 neutrons, and 29 electrons. 27 Qualitative, p. Although the nomenclature of the major classes of organic compounds and their properties in terms of the functional groups will not be discussed until Chapter 24, we will frequently use organic compounds as examples to illustrate chemical bonding, acid-base reactions, and other properties throughout the book. Carbon-12 is the carbon isotope that has six protons and six neutrons. Water is made up of two parts hydrogen and one part oxygen. were disruptions of the food chain and a dramatic change in climate caused by violent volcanic eruptions. Kreuz University of Michigan-Dearborn Jothi V. In other words, only 26 in 10,000 Ne atoms are neon-21. The true length is 32.0 in. (b) Photovoltaic cells. American physicist who was awarded the Nobel Prize in Physics in 1923 for determining the charge of the electron. English chemist, mathematician, and philosopher. German chemist. This number is called Avogadro's number (NA), in honor of the Italian scientist Amedeo Avogadro. The currently accepted value is NA 5 6.0221415 3 1023 In calculations, the units of molar mass are g/mol or kg/mol. 54 Chemical formula, p. Note that the molar mass of carbon-12 (in grams) is numerically equal to its atomic mass in amu. (b) Magnified view of a particles passing through and being deflected by nuclei. Starting with our reference oxoacids whose names all end with "-ic," we use the following rules to name these compounds. After doing postdoctoral research at Washington University and teaching for a year at Hunter College of the City University of New York, he joined the chemistry department at Williams College, where he has taught since 1968. Because the cathode ray is attracted by the plate bearing positive charges and repelled by the plate bearing positive charges and repelled by the plate bearing negative charges and repelled by the plate bearing negative charges. differ from 4P? 2.63 One isotope of a metallic element has mass number 65 and 35 neutrons in the nucleus. Solution The sequence of conversion factors 453.6 g 1 lb and 1 mg 1 3 10 23 g we obtain the answer in one step: ? Suppose that we have two beakers of water at the same temperature. This means that each fluorine atom has 9 protons and 9 electrons. 54 Atoms, Molecules, and Ions Ions An ion is an atom or a group of atoms that has a net positive or negative charge. However, suppose we needed to verify the purity of a compound for use in a laboratory experiment. Use capital letters for each square. 1.66 Vanillin (used to flavor vanilla ice cream and other foods) is the substance whose aroma the human nose detects in the smallest amount. Calculate the density of 40 ft. Understand the information that is given and what you are asked to solve. Use the outline to organize your note taking in class. Solution The conversion factor needed to convert between grams and moles is the molar mass. The book features a straightforward, clear writing style and proven problem-solving strategies. Gold foil α -Particle emitter Slit Detecting screen (a) (b) In 1910 the New Zealand physicist Ernest Rutherford,† who had studied with Thomson at Cambridge University, decided to use a particles to probe the structure of atoms. Review of Concepts tool found after appropriate chapter sections. • For oxides, the ending "a" in the prefix is sometimes omitted. On heating, the ice cube first melts and the water then boils to form steam. 18 Macroscopic property, p. Chemical compounds are either molecular compounds (in which the smallest units are discrete, individual molecules) or ionic compounds, which are made of platinum (Pt) has an edge length of 1.0 cm On the other hand, highly precise measurements do not necessarily guarantee accurate results. H2O MgSO4 ? As another example, consider the compound hydrazine (N2H4), which is used as a rocket fuel. Diane Payne Villa Julie College Lester L. TABLE 2.6 Names of Oxoacids and Oxoanions That Contain Chlorine Acid Anion HClO4 (perchloric acid) HClO3 (chloric acid) HClO2 (chlorous acid) ClO2 4 ClO2 3 ClO2 2 ClO2 2 ClO2 (perchlorate) (chlorate) (chlorate and other properties. (Continued) H3PO4 90 Mass Relationships in Chemical Reactions Solution The molar mass of H3PO4 is 97.99 g. We also learn that, in principle, all matter can exist in one of three states: solid, liquid, and gas. The two major categories of learning are the worked examples and end of chapter problems. Calculate the density of the space occupied by the electrons in the solution and evaporating it to dryness. 11,254.1 g 1 0.1983 g 11,254.2983 g m88 round off to 11,254.3 g 66.59 L 2 3.113 L 63.477 L m88 round off to 63.48 L (c) 8.16 m 3 5.1355 5 41.90568 m m88 round off to 41.9 m 0.0154 kg (d) 5 0.000174405436 kg/mL m88 round off to 0.000174 kg/mL 88.3 mL or 1.74 3 1024 kg/mL 2 (e) First we change 3.27 3 10 cm to 0.327 cm) 3 103. This is called the Stock† system. If the masses of the empty flask and filled flask were 56.12 g and 87.39 g, respectively, and the density of water is 0.9976 g/cm3, calculate the volume of the flask in cm3. Rutherford and others postulated that there must be another type of subatomic particle in the atomic nucleus; the proof was provided by another type of subatomic particle in the atomic nucleus; the proof was provided by another type of subatomic particle in the atomic nucleus; the proof was provided by another type of subatomic particle in the atomic nucleus; the proof was provided by another type of subatomic particle in the atomic nucleus; the proof was provided by another type of subatomic particle in the atomic nucleus; the proof was provided by another type of subatomic particle in the atomic nucleus; the proof was provided by another type of subatomic n matter. Therefore, samples of air collected in different cities would probably differ in composition because of differences in altitude, pollution, and so on. EXAMPLE 3.9 Mass percent Convert to grams and divide by molar mass Moles of each element Divide by the smallest number of moles Mole ratios of elements Change to integer subscripts Empirical formula Figure 3.5 Procedure for calculating the empirical formula of a compound from its percent compositions. Computerized Test Bank Online A comprehensive bank of test questions, revised by Ken Goldsby (Florida State University), is provided within a computerized test bank enabling you to create paper and online tests or quizzes in this easy-to-use program. The radius of a 23Na atom is 186 pm. Quantum Tutor Problems: 1.29, 1.30, 1.33, 1.34. How many times can you divide evenly a piece of 10-cm copper atoms? If the volume of the liquid is now found to be 6.0 mL, we may express the quantity as (6.0; 0.1) mL, and the actual value Any number raised to the power zero is equal to one. The simplest substances in chemistry are elements. We can solve the problem by first calculating the number of S atoms from the number of S atoms of S \rightarrow number of S atoms We can combine these conversions in one step as follows: 1 mol S 6.022 3 1023 S atoms 16.3 g S 3 3 5 3.06 3 1023 S atoms 32.07 g S 1 mol S Elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulfur (S8) consists of eight S atoms 32.07 g S 1 mol S elemental sulf compound's empirical formula. Nothing could be easier! Accessed from the instructor side of your textbook chapter, asset type, or keyword. Dalton was described as an indifferent experimenter, and singularly wanting in the language through the critical thinking necessary for succeeding in chemistry. Review "A Look Ahead" to familiarize yourself with the chapter concepts. 2.2 The Structure of the Atom (a) (b) 45 (c) Figure 2.4 (a) A cathode ray produced in a discharge tube. The interconversion between these states can be effected by changing the temperature. It was then left outdoors overnight, where the average temperature was 25°C. What is the Similar problem: 3.16. A second set of rules specifies how to handle significant figures in calculations. Therefore, the formula is Hq2(NO2)2. 1.4 Classifications of Matter 10 We defined chemistry at the beginning of the chapter as the study of matter and the changes it undergoes. 1.49 Carry out the following conversions: (a) 1.42 lightyears to miles (a light-year is an astronomical measure of distance—the distance traveled by light in a year, or 365 days; the speed of light is 3.00 3 108 m/s), (b) 32.4 yd to centimeters, (c) 3.0 3 1010 cm/s to ft/s. 2.60 Write the formulas for the following compounds: (a) copper(I) cyanide, (b) strontium chlorite, (c) perbromic acid, (d) hydroiodic acid, (e) disodium ammonium phosphate, (f) lead(II) carbonate, (g) tin(II) fluoride, (k) selenium hexafluoride. 43 Atomic number (Z), p. If a theory is disproved by experiment, then it must be discarded or modified so that it becomes consistent with experimental observations. 51 Halogens, p. Density, defined as the mass of an object divided by its volume, is an intensive property. If you follow these suggestions and stay up-to-date with your assignments, you should find that chemistry is challenging, but less difficult and much more interesting than you expected. Solution If we have 100 g of ascorbic acid, then each percentage can be converted directly to grams. The names of many inorganic compounds can be deduced from a set of simple rules. Scientific notation helps us handle very large and very small quantities. Products in Chapter 3. For example, two copper pennies will have a combined mass that is the sum of the length of two tennis courts is the sum of the length of two tennis courts is the sum of the length of two tennis courts is the sum of the length of two tennis courts is the sum of the masses of each penny, and the length of two tennis courts is the sum of the masses of each penny, and the length of two tennis courts is the sum of the masses of each penny, and the length of two tennis courts is the sum of the masses of each penny tennis courts is the sum of the masses of each penny, and the length of two tennis courts is the sum of the masses of each penny, and the length of two tennis courts is the sum of the masses of each penny tennis courts is the sum of the masses of each penny tennis courts is the sum of the masses of each penny tennis courts is the sum of the masses of each penny tennis courts is the sum of the masses of each penny tennis courts is the sum of the masses of each penny tennis courts is the sum of the masses of each penny tennis courts is the sum of the masses of each penny tennis courts is the sum of the masses of each penny tennis courts is the sum of the masses of each penny tennis courts is the sum of the masses of each penny tennis courts is the sum of the masses of each penny tennis courts is the sum of the masses of each penny tennis courts is the sum of the masses of each penny tennis courts is the sum of the masses of each penny tennis courts is the sum of te 1 mole of elemental carbon contains 6.022 3 1023 carbon atoms. Starting with Review Questions to test basic conceptual understanding, followed by Problems to test the student's skill in solving problems to test basic conceptual understanding, followed by Problems to test the student's skill in solving problems to test the student's skill in solving problems for that particular section of the chapter. not only their physical appearance but their chemical makeup as well. (a) (b) 12 Chemistry: The Study of Change TABLE 1.1 Name Aluminum Arsenic Barium Bismuth Bromine Calcium Carbon Chlorine Gold Hydrogen Iodine Iron Lead Magnesium Manganese Mercury Nickel Nitrogen Symbol F Au H I Fe Pb Mg Mn Hg Ni N Name Symbol Oxygen Phosphorus Platinum Potassium Silicon Silver Sodium Sulfur Tin Tungsten Zinc O P Pt K Si Ag Na S Sn W Zn others have been created by scientists via nuclear processes, which are the subject of Chapter 23 of this text. 1.105 Tums is a popular remedy for acid indigestion. Hydrogen burning in air to form water. • End-of-Chapter Problems pose many relevant questions of different charges (see Figure 2.11), we need to use the Stock system. Observation refers to measurements in the macroscopic world; representation involves the use of shorthand notation; interpretations are based on atoms and molecules, which belong to the microscopic world. Stock (1876-1946). Hydrogen gas, for example, burns in oxygen gas to form water, which has properties that are distinctly different from those of the starting materials. Similar problem: 3.26. 1.85 The thin outer layer of Earth, called the crust, contains only 0.50 percent of Earth's total mass and yet is the source of almost all the elements (the atmosphere provides elements such as oxygen, nitrogen, and a few other gases). The H1 ion is associated with one or more water molecules, and is usually represented as H3O1. Thus, 606 m contains three significant figures, 40,501 kg contains five significant figures, and so on. Except for nuclear reactions (see Chapter 23), however, changes of mass in chemical reactions are too small to detect. The Instructor's Manual provides a briefform of the significant figures, 40,501 kg contains five significant figures, 40,5 summary of the contents of each chapter, along with the learning goals, reference to background concepts in earlier chapters, and teaching tips. There are 8 electrons. 15 International System of Units (SI), p. Referring to Problem 1.71, calculate the volume of seawater (in liters) needed to extract 8.0 3 104 tons of Mg, which is roughly the annual production in the United States. Spreer University of the Pacific Shane Street University of Alabama Satoshi Takara University of Hawaii Kimberly Trick University of Hawaii Kimberly Trick University of Alabama Satoshi Takara University of Hawaii Kimberly Trick University Origee Uni † John Dalton (1766-1844). E-books from McGraw-Hill are smart, interactive, searchable, and portable. Convert this quantity to tons. Therefore, the molecular formula is CH4O. Similar problems or studying related subjects in different chapters. (Assume there are 365 days in a year.) (c) 71.2 cm3 to m3. The first letter of a symbol is always capitalized, but any following letters are not. Calculate the mass of 242 mL of the liquid. 1.8 0.534 g/cm3. Also take the time to work through the practice exercise that follows each example to be sure you understand how to solve the type of problem illustrated in the example. 47 Radiation, p. The deuterium isotope contains one proton and two neutrons. In this system, the Roman numeral I indicates one positive charges, and so on. — Problem statement is the reporting of the facts needed to solve the problem based on the question posed. Indeed, it is central to our way of life; without it, we would be living shorter lives in what we would consider primitive conditions, without automobiles, electricity, computers, CDs, and many other everyday conveniences. elements are not evenly distributed throughout Earth' crust, and (2) most elements occur in combined forms. 1.2 The Study of Chemistry Compared with other subjects, chemistry is commonly believed to be more difficult, at least at the introductory level. Convert this speed to miles per hour (mph). 1 gallon 5 3.79 L; 1 year 5 365 days; density of water 5 1.0 g/mL.) 1.94 A gas company in Massachusetts charges \$1.30 for 15.0 ft3 of natural gas. (Green spheres represent cations and red spheres represent anions.) (a) (b) (c) (d) 2.7 Naming Compounds was small, it was possible to memorize their names. . Turner Senior Project Manager: Gloria G. 15 16 Chemistry: The Study of Change 1.7 Measurement The measurements chemists make are often used in calculations to obtain other related quantities. The next 30 years will see high-temperature superconductors being applied on a large scale in magnetic resonance imaging (MRI), levitated trains, and nuclear fusion. 44 Atoms, Molecules, and Ions Figure 2.3 A cathode ray tube with an electric field perpendicular to the direction of the cathode rays and an external magnetic field. Atom or Ion of Element A B C D E F G Number of neutrons 5 5 5 10 7 7 18 19 20 28 30 36 36 35 46 5 5 6 9 9 10 2.70 Identify the elements represented by the following symbols and give the number of protons and neutrons 20 63 182 203 X, (b) 29 X, (c) 107 in each case: (a) 10 47X, (d) 74X, (e) 84X, X. If a number is less than 1, then only the zeros that are between nonzero digits are significant. A very important part of problem solving is being able to judge whether the answer is reasonable. 1.31 Express the answers to the following calculations in scientific notation: (a) 145.75 1 (2.3 3 1021) (b) 79,500 4 (2.5 3 102) (c) (7.0 3 1023) 2 (8.0 3 1024) (d) (1.0 3 104) 3 (9.9 3 105) (d) (3.6 3 1024) (d) (1.0 3 104) 3 (9.9 3 105) (d) (3.6 3 1024) (d) (1.0 3 104) 3 (9.9 3 105) (d) (3.6 3 1024) (d) (1.0 3 104) 3 (9.9 3 105) (d) (3.6 3 1024) (d) (1.0 3 104) 3 (9.9 3 105) (d) (3.6 3 1024) (d) (1.0 3 104) 3 (9.9 3 105) (d) (3.6 3 1024) (d) (1.0 3 104) 3 (9.9 3 105) (d) (3.6 3 1024) (d) (1.0 3 104) 3 (9.9 3 105) (d) (3.6 3 1024) (d) (1.0 3 104) 3 (9.9 3 105) (d) (3.6 3 1024) (d) (1.0 3 104) 3 (9.9 3 105) (d) (3.6 3 1024) (d) (1.0 3 104) 3 (9.9 3 105) (d) (3.6 3 1024) (d) (1.0 3 104) 3 (9.9 3 105) (d) (3.6 3 1024) (d) (1.0 3 104) 3 (9.9 3 105) (d) (3.6 3 1024) (d) (3.6 3 106) 1.33 What is the number of significant figures in each of the following measurements? Therefore, the structural formula of water is H}O}H. This highly energetic radiation penetrated matter, darkened covered photographic plates, and caused a variety of substances to fluoresce. This rule follows from the fact that because the formulas of ionic compounds are usually empirical formulas, the subscripts must always be reduced to the smallest ratios. I also thank my sponsoring editor, Tami Hodge, and publisher, Thomas Timp, for their advice and assistance. Hash Cover/Interior Designer: Jamie E. Molecular Formulas A molecular formula shows the exact number of atoms of each elemen in the smallest unit of a substance. In 1808 an English scientist and school teacher, John Dalton, formulated a precise definition of the indivisible building blocks of matter that we call atoms. 8 Quantitative, p. ferric ion as iron(II), respectively; ferrous chloride becomes iron(II) chloride; and ferric chloride is called iron(III) chloride Library of Congress Cataloging-in-Publication Data Chang, Raymond. Knowledge of an atom's mass is important in laboratory work. Therefore, from Equation (1.1), we write d5 5 m V 301 g Gold bars. 2.36 Give the number of protons and electrons in each of the following common ions: K1, Mg21, Fe31, Br2, Mn21, C42, Cu21. Dalton's concept of an atom was far more detailed and specific than Democritus'. Thus, the empirical formula tells us which elements are present and the simplest whole-number ratio of their atoms, but not necessarily the actual number of atoms in a given molecule. The radius of the path depends on the charge-to-mass ratio (that is, e/m). The empirical formula shows the simplest ratios of the atoms combined in a molecule. (c) Frozen orange juice is reconstituted by adding water to it. Table 1.1 shows the names and symbols of some of the more common elements; a complete list of the elements and their symbols appears inside the front cover of this book. Cruickshank (Northern Arizona University) and Raymond xxve Chang. There are four H atoms, one C atom, and one O atom. Bilicki Pasadena City College John J. To say that the distance between New York and San Francisco by car along a certain route is 5166 is meaningless. 2. French physicist who was awarded the Nobel Prize in Physics in 1903 for discovering radioactivity in uranium. (d) 88.6 m3 to liters. Bugay Kilgore College Maureen Burkhart Georgia Perimeter College William Burns Arkansas State University Ices Butler Louisiana State University Bindu Chakravarty Houston Community College Liwei Chen Ohio University Ices Butler Louisiana State University Ices Barbara Cole University of Maine W. The Practice Exercises are available in the ARIS electronic homework system. An atom of the carbon-12 isotope is assigned a mass of an element is based on the average mass of the stable (nonradioactive) isotopes of the element.] 3.2 Avogadro's Number and the Molar Mass of an Element Atomic mass units provide a relative scale for the masses of the elements. —Raymond Change A hydrogen-filled balloon exploding when heated with a flame. Upon heating, a solid (for example, ice) will melt to form a liquid (water). Molecular art appears in various formats to serve different needs. Furthermore, the sticks greatly exaggerate the space between atoms in a molecule. For example, by definition 1 in 5 2.54 cm (exactly). Would a given amount of fluorine react with different masses of the two hydrogen isotopes? The anion derived from the isotope has 54 electrons. The percent by mass of each element (H, P, and O) is given by the combined molar mass of the atoms of the element in 1 mole of H3PO4, then multiplied by 100 percent. The hydrogen gas reacts with oxygen in air to form water vapor. To quote Rutherford's initial reaction when told of this discovery: "It was as incredible as if you had fired a 15-inch shell at a piece of tissue paper and it came back and hit you." Rutherford was later able to explain the results of the a-scattering experiment in terms of a new model for the atom. 1.52 The density of ammonia gas under certain conditions is 0.625 g/L. Thus, the ferric ion is Fe31, but the cation of copper named cupric has the formula Cu21. Calculate the mass of a bronze cylinder of radius 6.44 cm and length 44.37 cm. Modern chemistry began with Dalton's atomic theory, which states that all matter is composed of tiny, indivisible particles called atoms; that all atoms of the same element are identical; that compounds contain atoms of different elements combined in whole-number ratios; and that atoms are neither created nor destroyed in chemical reactions (the law of conservation of mass). Assume that seawater contains 3.1 percent sodium chloride by mass and that its density is 1.03 g/mL. 53 Alkaline earth metals, p. Molecules in a liquid are close together but are not held so rigidly in position and can move past one another. Nevertheless, it is believed that there is a solid core consisting mostly of iron at the center of Earth. m is the molar mass (g/mol) of the element and NA is Avogadro's number. The enormity of Avogadro's number is difficult to imagine. A theory is a unifying principle that explains a body of facts and/or those laws that are based on them. Because these rays could not be deflected by a magnet, they could not contain charged particles as cathode rays do. In a combustion experiment, it was found that 12.096 g of hydrogen molecules combined with 96.000 g of oxygen molecules to form water and released 1.715 3 103 kJ of heat. 46 Structural formula, p. But because atoms have such small masses, no usable scale can be devised to weigh them in calibrated units of atomic mass units. The models show hydrogen, oxygen, and water molecules. (b) There are four phosphorus atoms and ten oxygen atoms present, so the compound is tetraphosphorus decoxide. Since the 1950s, treatment for crops suffering from pest infestations has sometimes been the indiscriminate application of potent chemicals. xxix Problems at the end of each chapter. Their drawbacks are that they are time-consuming to put together and they do not show the three-dimensional positions of atoms very well. Average Atomic mass 13 12 C 98.90% C 1.10% Natural abundances of C-12 and C-13 isotopes. Whatever your reasons for taking general chemistry, a good knowledge of the subject will better enable you to appreciate its impact on society and on you as an individual. For example, experiments have shown that, on average, a hydrogen atom is only 8.400 percent as massive as the carbon-12 atom. When this occurs, the resulting compound is CuSO4, which is sometimes called anhydrous copper(II) sulfate; "anhydrous" means that the compound no longer has water molecules associated with it (Figure 2.16). In keeping with modern practice, we will favor the Stock system of naming compounds in this textbook. because the chemical formula of an ionic compound is usually its empirical formula. Title. Whether you are looking for a preplanned course or one you can customize to fit your course needs, ARIS is your solution. In 1960, however, the General Conference of Weights and Measures, the international authority on units, proposed a revised metric system called the International System of Units (abbreviated SI, from the French Système International authority on units, proposed a revised metric system called the International System of Units (abbreviated SI, from the French Système International authority on units, proposed a revised metric system called the International System of Units (abbreviated SI, from the French Système International System called the International System of Units (abbreviated SI, from the French Système International System called the International System called the International System of Units (abbreviated SI, from the French Système International System called the International System of Units (abbreviated SI, from the French Système International System called the International System called the International System of Units (abbreviated SI, from the French Système International System called the International System c when a unit is raised to a power, any conversion factor you use must also be raised to that power. In 1911, she again received the Nobel prize, this time in chemistry, for her work on the radioactive elements radium and polonium. Identify a nonmetal whose name also ends with ium. Any digit that is not zero is significant. Then within the chapter are icons letting the student and instructor know that an animation is available for a specific topic. Figure 2.11 shows the charges of a number of grams of Zn is 0.356 mol Zn 3 65.39 g Zn 5 23.3 g Zn 1 mol Zn Thus, there are 23.3 g of Zn in 0.356 mole of Zn. Check Does a mass of 23.3 g for 0.356 mole of Zn seem reasonable? 15 Heterogeneous mixture, p. Designed for the two-semester general chemistry course, Chang's best-selling textbook continues to take a traditional approach and is often considered a student and teacher favorite. It is kept in a vault at the International Bureau of Weights and Measures in Sèvres, France. The molecular mass (sometimes called molecular masses (in amu) in the sum of the atomic masses (in amu) in the same chemical formula. For example, spreading 6.022 3 1023 oranges over the entire surface of Earth would produce a layer 9 mi into space! Because atoms (and molecules) are so tiny, we need a huge number to study them in manageable quantities. To solve the mystery, paleontologists studied fossils and skeletons found in rocks in various layers of Earth's crust. ISBN 978-0-07-351109-2 — ISBN 0-07-351109-9 (hard copy : acid-free paper) 1. Their purpose is to indicate the placement of the decimal point. Timp Senior Sponsoring Editor: Tamara L. A typical atomic molecule can contain atoms of different elements. 2.3 C4H5N2O. Review of Concepts Explain the fact that for carbon. A single-pan Guidelines for Using Significant Figures We must always be careful in scientific work to write the proper number of significant figures. Although our understanding of the scientific process of converting solar energy to electricity has advanced, the technology has not yet improved to the point where we can produce electricity has advanced, the technology has not yet improved to the point where we can produce electricity has advanced. to Shirley Oberbroeckling, the developmental editor, for her care and enthusiasm for the project, and supervision at every stage of the writing of this edition. 1.58 A cylindrical glass tube 12.7 cm in length is filled with mercury. Calculate its density in g/cm3. Knowing the molar mass and Avogadro's number, we can calculate the mass of a single atom in grams. The results of two successive weighings by each student are Average value Student A 1.964 g 1.978 g 1.971 g Student B 1.972 g 1.968 g 1.970 g Student C 2.000 g. To convert degrees Fahrenheit to degrees Fahrenheit to degrees Celsius, we write ?°C 5 (°F 2 32°F) 3 5°C 9°F (1.2) Note that the Kelvin scale does not have the degree sign. New Zealand physicist. Too much or too little over an extended period of time can lead to serious illness, retardation, or even death. Rounding off 0.0833 lb to 0.1 lb, we get 5 3 104 mg, which is close to the preceding quantity. Figure 1.6 Microscopic views of a solid, a liquid, and a gas. Acknowledgements I would like to thank the following reviewers and symposium participants whose comments were of great help to me in preparing this revision: Michael Adams Xavier University of Louisiana Elizabeth Aerndt Community College of Rhode Island Francois Amar University of Maine Taweechai Amornsakchai, Mahidol University Dale E. The formulas of oxoacids are usually written with the H first, followed by the central element and then O. Similarly, we can write the conversion factor as 2.54 cm 1 in Dimensional analysis might also have led Einstein to his famous mass-energy equation E 5 mc2. Simply browse, select, and download the files you need to build engaging course materials. Practice Exercise The volume of a room is 1.08 3 108 dm3. All atoms of a given elements are identical, but they are different from atoms of all other compounds are classified as inorganic compounds. 56 Ternary compound, p. Scientists at NASA's Jet Propulsion Laboratory, on the other hand, had assumed that thrust data they received were expressed in metric units, as newtons. What is an ionic compound? (a) There are two O atoms and one S atom in SO2, so that molecular mass of SO2 5 32.07 amu 1 2(16.00 amu) 5 64.07 amu (b) There are eight C atoms, ten H atoms, four N atoms, and two O atoms in caffeine, so the molecular mass of C8H10N4O2 is given by Similar problems: 3.23, 3.24. The Figure 1.4 (a) The mixture contains iron filings and sand. Nevertheless, it provided indisputable evidence of the existence of isotopes—neon-20 (atomic mass 19.9924 amu and natural abundance 90.92 percent) and neon-22 (atomic mass 21.9914 amu and natural abundance 8.82 percent). Arrange the appropriate conversion factors so that pounds and grams cancel and the unit milligrams is obtained in your answer. By identifying and synthesizing pheromones used in mating, it is possible to interfere with the normal reproductive cycle of common pests; for example, by inducing insects to mate too soon or tricking female insects into mating with sterile males. How many grams of lead are contained in 6.0 3 103 g of blood (the amount in an average adult) if the lead content is 0.62 ppm? The formula unit of NaCl consists of one Na1 ion and one Cl2 ion. H O C 2.49 Which of the following compounds are likely to be ionic? (a) 11H and 11H1, (b) 147N and 147N32, (c) 126C and 136C. Lawson University Neocles Leontis Bowling Green State University Alan F. (b) Which metallic elements are most likely to form cations with different charges? (a) (b) (c) 2.32 Which of the following diagrams represent diatomic molecules, molecules that are not compounds, or an elemental form of the substance? The Additional Problems section provides more problems not organized by sections. Therefore, it is convenient to have a special unit to describe a very large number of atoms. Chemistry— Textbooks. Empirical formulas to the smallest possible whole numbers. The number of electrons is the same as the number of protons; that is, 11. Example 3.1 shows how to calculate the average atomic mass of an element. EXAMPLE 2.7 Name the following molecular compounds: (a) SiCl4 and (b) P4O10. What percent of the sodium fluoride is "wasted" if each person uses only 6.0 L of water a day for drinking and cooking? Examples include: Why do swimming coaches sometimes place a drop of alcohol in a swimmer's ear to draw out water? 10 Microscopic property, p. A. Strategy We are given grams of CH4 and asked to solve for moles of CH4. Setting the Stage On the two-page opening spread for each chapter the chapter outline, Student Interactive Activity, and A Look Ahead appear. For ionic compounds to be electrically neutral, the sum of the charges on the cation and anion in each formula unit must be zero. The Celsius scale was formerly called the centigrade scale. Note that the "a" is omitted in "deca." Practice Exercise Name the following molecular compounds: (a) NF3 and (b) Cl2O7. The moon's smaller gravity enabled astronauts to jump about rather freely on its surface despite their bulky suits and equipment. 52 describes the distribution of the elements on Earth and in the human body. A chemical equation enables us to use the mole method to predict the amount of product(s) formed, knowing how much the reactant(s) was used. We learn that the most direct way to determine atomic and molecular mass is by the use of a mass spectrometer. 3.2 Avogadro's Number and the Molar Mass of an Element 81 EXAMPLE 3.1 Copper, a metal known since ancient times, is used in electrical cables and pennies, among other things. m3 5 5.2 L 3 1 3 1022 m 3 1000 cm3 3a b 5 5.2 L 3 1 3 1022 m 3 1000 cm3 a b 5 5.2 L 3 1 3 1022 m 3 1000 cm3 a b 5 5.2 L 3 1 3 1000 cm3 a b 5 5.2 L 3 1 3 1000 cm3 a b 5 5.2 L 3 1 3 1000 cm3 a b 5 5.2 L 3 1 0 0 cm3 a b 5 5.2 L 3 1 0 cm3 a b 5 5.2 L 3 1 0 cm3 a b 5 5.2 4867 mi (b) 56 mL (c) 60,104 ton (d) 2900 g (e) 40.2 g/cm3 (f) 0.0000003 cm (g) 0.7 min (h) 4.6 3 1019 atoms 1.34 How many significant figures are there in each of the following? Finally, there is the macroscopic-to-microscopic art, helping students understand processes at the molecular level. Check Do the percentages add to 100 percent? This means that in a 100-g sample of Earth's crust there are, on the element oxygen. Proponents of Gamow's explanation rejoiced at the detection of helium in the far reaches of the universe. 1.2 The Study of Chemistry Food and Agriculture How can the world's rapidly increasing population be fed? EXAMPLE 2.2 Write the molecular formula of methanol, an organic solvent and antifreeze, from its ball-and-stick model, shown in the margin. O The molecular formula of hydrogen peroxide, a substance used as an antiseptic and hair, is H2O2. Because potassium only forms one type of ion (K1), there is no need to use potassium(I) in the name. Compound Ionic Molecular Cation: metal or NH+4 Anion: monatomic or polyatomic • Binary compounds of nonmetals Naming Cation has more than one charge • Other metal cations • Ag+, Al3+, Cd2+, Zn2+ Cation has more than one charge • Other metal cations • Ag+, Al3+, Cd2+, Zn2+ Cation has more than one charge • Other metal cations • Alkaline earth metal cations • Ag+, Al3+, Cd2+, Zn2+ Cation has more than one charge • Other metal cations • Ag+, Al3+, Cd2+, Zn2+ Cation has more than one charge • Other metal cations • Ag+, Al3+, Cd2+, Zn2+ Cation has more than one charge • Other metal cations • Ag+, Al3+, Cd2+, Zn2+ Cation has more than one charge • Other metal cations • Ag+, Al3+, Cd2+, Zn2+ Cation has more than one charge • Other metal cations • Ag+, Al3+, Cd2+, Zn2+ Cation has more than one charge • Other metal cations • Ag+, Al3+, Cd2+, Zn2+ Cation has more than one charge • Other metal cations • Ag+, Al3+, Cd2+, Zn2+ Cation has more than one charge • Other metal cations • Ag+, Al3+, Cd2+, Zn2+ Cation has more than one charge • Other metal cations • Ag+, Al3+, Cd2+, Zn2+ Cation has more than one charge • Other metal cations • Ag+, Al3+, Cd2+, Zn2+ Cation has more than one charge • Other metal cations • Ag+, Al3+, Cd2+, Zn2+ Cation has more than one charge • Other metal cations • Ag+, Al3+, Cd2+, Zn2+ Cation has more than one charge • Other metal cations • Ag+, Al3+, Cd2+, Zn2+ Cation has more than one charge • Other metal cations • Ag+, Al3+, Cd2+, Zn2+ Cation has more than one charge • Other metal cations • Ag+, Al3+, Cd2+, Zn2+ Cation has more than one charge • Other metal cations • Ag+, Al3+, Cd2+, Zn2+, Cd2+, Z "-ide" to the root of the element name • If polyatomic anion, use name of anion (see Table 2.3) Figure 2.14 • Name metal first • Specify charge of metal cation with Roman numeral in parentheses • If monatomic anion, add "-ide" to the root of the element name • If polyatomic anion, use name of anion (see Table 2.3) Steps for naming ionic and binary molecular compounds. List five elements each that are (a) named after places, (b) named after people, (c) named after a color. Given that the diffusion coefficient of glucose is 5.7 3 1027 cm2/s, calculate the time it would take for a glucose molecule to diffuse 10 mm, which is roughly the size of a cell. In discussing the natural abundance of the Mantle Crust Essential Elements in the Human Body Element Core 2900 km 3480 km Structure of Earth's interior. Note that there are 100 divisions, or 180 degrees, between the same two temperature limits on the Fahrenheit scale. All measurable properties of matter fall into one of two additional categories: extensive properties. For example, in its normal state, each unit of copper(II) sulfate has five water molecules associated with it. Ascorbic acid (vitamin C) cures scurvy. A hallmark of the 10th anniversary edition is the integration of many tools designed to inspire both students and instructors. The formula for calcium oxide is CaO. If the cells are spread out in a thin layer that is a single cell thick, what is the surface area in square meters? 1 ton 5 2000 lb; 1 lb 5 453.6 g.) 1.86 The radius of a copper (Cu) atom is roughly 1.3 3 10210 m. This system was developed using time-tested in-chapter and endof-chapter problems from Chang 10th edition. (True value: 0.798 g/mL.) (b) The mass of gold in an earring is analyzed to be 0.837 g. The densities of the liquids are 2.0514 g/mL for B. 72 Atoms, Molecules, and Ions 2.18 Write the appropriate symbol for each of the following isotopes: (a) Z 5 74, A 5 186; (b) Z 5 80; A 5 201. EXAMPLE 1.3 (a) Solder is an alloy made of tin and lead that is used in electronic circuits. Note that all the names end with -ane. 54 Ionic compound, p. These devices are not drawn to scale relative to one another. Over the years chemists have devised a clear system for naming chemical substances. 54 Polyatomic molecule, p. The combined mass of the ball bearing and mineral oil is 50.952 g. (3.8 and 3.9) • We will learn that the actual yield of a reaction is almost always less than that predicted from the equation, called the theoretical yield, because of various complications. The mission controllers said the loss of the spacecraft was due to the failure to convert English measurement units into metric units in the navigation software. Water differs from ice only in appearance, not in composition, so this is a physical change; we can freeze the water to recover the original ice. Therefore, it has become increasingly common to designate different cations with Roman numerals. Because the charges on the Mg21 and N32 ions are not equal, we know the formula cannot be MgN. Tools to Use for Studying Useful aids for studying are plentiful in Chemistry and should be used constantly to reinforce the comprehension of chemical and physical properties in a chart called the periodic table. (b) Three, because zeros between nonzero digits are significant. Molecular Compounds Unlike ionic compounds, molecular compounds contain discrete molecular units. Study Aids • • • • Marginal Notes are used to provide hints and feedback to enhance the knowledge base for the student. All of the practice exercises for the Worked Examples in all chapters are now found within the ARIS (Assessment, Review, and Instruction System) electronic homework system. Can this procedure be used in general to determine the densities of solids? xxi xxii • Preface End-of-Chapter problems are organized in various ways. Consider the following examples: (7.4 3 103) 1 (2.1 3 103) 5 9.5 3 103 (4.31 3 104) 1 (3.9 3 103) 5 (4.31 3 104) 1 (0.39 3 104) 5 4.70 3 104 22 23 (2.22 3 10) 2 (4.10 3 10) 5 (2.22 3 10 22) 2 (0.41 3 10 22) 5 1.81 3 10 22) 5 1.81 3 10 22) 5 (4.31 3 10 22) 5 1.81 3 10 22) 5 (4.31 3 10 22) 5 (4.31 3 10 22) 5 (4.31 3 10 22) 5 (4.31 3 10 ion that has a net positive or net negative charge. (a) Natural abundance of the elements in percent by mass. Naming binary molecular compounds is similar to naming binary molecular compounds. Calculate its mass in grams. In another 50 years, nuclear fusion will likely be a significant source of energy. If the volume is found to be 6 mL, then the actual volume is in the range of 5 mL to 7 mL. In calculations or measurements, every quantity must show the proper number of significant figures, which are the meaningful digits. In particular, I would like to mention Gloria Schiesl for supervising the production, David Hash for the book design, John Leland for photo research, Daryl Bruflodt and Judi David for the media, and Todd Turner, the marketing manager for his suggestions and encouragement. (c) Poor accuracy and poor precision. Figure 2.4 shows the effect of a bar magnet on the cathode ray. 1.64 Lithium is the least dense metal known (density: 0.53 g/cm3). Thomson's model of the atom, sometimes described as the "plum-pudding" model, after a traditional English dessert containing raisins. Key Words Accuracy, p. The black dots show the positions of the darts. xxxii • • • • • At the end of each chapter, you will find a summary of facts and concepts, the key equations, and a list of key words, all of which will help you review for exams. 1.50 Carry out the following conversions: (a) 185 nm to meters. Calculate the speed in miles per hour (mph). 15 Element, p. Actually, cerium (Ce) should follow lanthanum (La), and thorium (Th) should come right after actinium (Ac). Removal of one O atom from the "-ic" acid: 1.54 Which of the following statements describe physical properties and which describe chemical properties? b rays consist of negatively charged particles (electrons) and are therefore attracted by the positively charged plate. 1.43 How many minutes does it take light from the sun to reach Earth? Media Player Rutherford's Experiment (2.2) Formation of an Ionic Compound (2.7) Chapter Summary ARIS Example Practice Problems End of Chapter Problems Quantum Tutors End of Chapter Problems 41 42 Atoms, Molecules, and Ions 2.1 The Atomic Theory In the fifth century b.c. the Greek philosopher Democritus expressed the belief that all matter consists of very small, indivisible particles, which he named atomos (meaning uncuttable or indivisible). If the decimal point has to be moved to the left, then n is a positive integer: if it has to be moved to the right, n is a negative integer. Because the Big Bang would have filled the entire universe. Removal of two O atoms from the "-ic" acid: The acid is called "hypo... Strategy Each isotope contributes to the average atomic mass based on its relative abundance. 46 Beta (b) rays, p. This method of naming ions has some distinct limitations. 19 Law, p. Before plunging into the study of matter and its transformation, let us consider some of the frontiers that chemists are currently exploring (Figure 1.1). Imagine being able to create and access your test or quiz anywhere, at any time. This form of representation not only simplifies the process of keeping records, but also provides a common basis for communication with other chemists. Superconductors are materials that have no electrical resistance and can therefore conduct electricity with no energy loss. The proton has a positive charge, the electron has a negative charge, and the neutron has no charge. This result is consistent with the law of multiple proportions (Figure 2.2). Convert its melting point to kelvins. If this is not the case, then an error must have been made somewhere, and it can usually be spotted by reviewing the solution. Most matter is composed of molecules or ions formed by atoms. (1.1 and 1.2) • Next, we become familiar with the scientific method, p. In 1935 he received the Nobel Prize in Physics for proving the existence of neutrons. We also become familiar with the three temperature scales: Celsius, Fahrenheit, and Kelvin. An older nomenclature system that is still in limited use assigns the ending "-ic" to the cation with more positive charges: Fe21 ferrous ion Fe31 ferric ion The names of the compounds that these iron ions form with chlorine would thus be FeCl2 ferrous chloride FeCl3 ferric chloride from 33.871 kg of guarters, 10.432 kg of nickels, and 7.990 kg of dimes? The formulas can be written from the names of the compound 60 Atoms, Molecules, and Ions TABLE 2.2 The "-ide" Nomenclature of Some Common Monatomic Anions According to Their Positions in the Periodic Table Group 4A Group 5A Group 6A Group 6A Group 7A C carbide (C42)* Si silicide (Si42) N nitride (N32) P phosphide (P32) O oxide (C22) S sulfide (Si42) N nitride (Si42) S sulfide (Si42) S sulfide (Si42) S sulfide (Si42) N nitride (Si42) N nitride (Si42) S sulfide (Si42) S sul 480 11.6 Types of Crystals 482 CHEMISTRY in Action High-Temperature Superconductors 486 11.7 Amorphous Solids 486 CHEMISTRY in Action Hard-Boiling an Egg on a Mountaintop, Pressure Cookers, and Ice Skating 500 CHEMISTRY in Action Hard-Boiling an Egg on a Mountaintop, Pressure Cookers, and Ice Skating 500 CHEMISTRY in Action Hard-Boiling an Egg on a Mountaintop, Pressure Cookers, and Ice Skating 500 CHEMISTRY in Action Hard-Boiling an Egg on a Mountaintop, Pressure Cookers, and Ice Skating 500 CHEMISTRY in Action Hard-Boiling an Egg on a Mountaintop, Pressure Cookers, and Ice Skating 500 CHEMISTRY in Action Hard-Boiling an Egg on a Mountaintop, Pressure Cookers, and Ice Skating 500 CHEMISTRY in Action Hard-Boiling an Egg on a Mountaintop, Pressure Cookers, and Ice Skating 500 CHEMISTRY in Action Hard-Boiling an Egg on a Mountaintop, Pressure Cookers, and Ice Skating 500 CHEMISTRY in Action Hard-Boiling an Egg on a Mountaintop, Pressure Cookers, and Ice Skating 500 CHEMISTRY in Action Hard-Boiling an Egg on a Mountaintop, Pressure Cookers, and Ice Skating 500 CHEMISTRY in Action Hard-Boiling an Egg on a Mountaintop, Pressure Cookers, and Ice Skating 500 CHEMISTRY in Action Hard-Boiling an Egg on a Mountaintop, Pressure Cookers, and Ice Skating 500 CHEMISTRY in Action Hard-Boiling an Egg on a Mountaintop, Pressure Cookers, and Ice Skating 500 CHEMISTRY in Action Hard-Boiling an Egg on a Mountaintop, Pressure Cookers, and Ice Skating 500 CHEMISTRY in Action Hard-Boiling an Egg on a Mountaintop, Pressure Cookers, and Ice Skating 500 CHEMISTRY in Action Hard-Boiling an Egg on a Mountaintop, Pressure Cookers, and Ice Skating 500 CHEMISTRY in Action Hard-Boiling an Egg on a Mountaintop, Pressure Cookers, and Ice Skating 500 CHEMISTRY in Action Hard-Boiling 500 CHEM Action Liquid Crystals 501 Key Equations 503 Summary of Facts and Concepts 503 Key Words 504 Questions and Problems 504 Physical Properties of Solutions 512 12.1 12.2 12.3 12.4 12.5 Types of Solutions 512 12.1 12.2 12.3 12.4 12.5 Types of Solutions 514 A Molecular View of the Solution Process 515 Concentration Units 517 The Effect of Pressure on the Solubility of Gases 524 CHEMISTRY in Action The Killer Lake 526 12.6 Colligative Properties of Nonelectrolyte Solutions 545 Questions and Problems 546 CHEMICAL Mystery The Wrong Knife 554 Chemical Kinetics 556 13.1 The Rate of a Reaction 558 13.2 The Rate Law 565 13.3 The Relation Determining the Age of the Shroud of Turin 580 13.4 Activation Energy and Temperature Dependence of Rate Constants 582 13.5 Reaction Mechanisms 588 CHEMISTRY in Action Femtochemistry 593 13.6 Catalysis 594 Key Equations 601 Summary of Facts and Concepts 602 Key Words 602 Questions and Problems 602 Chemical Equilibrium Constant Expressions 618 14.3 The Relationship Between Chemical Kinetics and Chemical Equilibrium 630 14.4 What Does the Equilibrium Constant Tell Us? With so much gold out there, why hasn't someone become rich by mining gold from the ocean? The asteroid very likely had a density of about 2 g/cm3. Some metallic elements can assume three or more different positive charges in compounds. The molecular formula conveys the specific number and type of atoms combined in each molecule or compound. 1.71 The total volume of seawater is 1.5 3 1021 L. From the molecular mass we can determine the molecular mass of a molecule or compound. language of chemistry. • Do not hesitate to ask your instructor or your teaching assistant for help. For example, in 1 mole of hydrogen peroxide (H2O2) there are 2 moles of H atoms and 2 moles of O atoms. (d) The leaf on the left was taken from a tobacco plant that was not genetically engineered but was exposed to tobacco horn worms. For example carbon forms two stable compounds with oxygen, namely, carbon monoxide and carbon dioxide. Electricity is carried by copper cables, which are not perfect conductors. Scientists believe that helium and hydrogen (the lightest elements) were the first elements) were the first elements formed in the early stages of cosmic evolution. Health and Medicine Three major advances in the past century have enabled us to prevent and treat diseases. Examples are water, ammonia, table sugar (sucrose), gold, and oxygen. The molar mass of urea is 60.06 g. The impact of the asteroid on Earth's surface must have been so tremendous that it literally vaporized a large quantity of surrounding rocks, soils, and other objects. What conversion factor do we need to convert between moles and grams? Solution In Example 1.7 we saw that 1 cm3 5 1 3 1026 m3. cm. Calculate the total amount of gold (in grams) that is present in seawater, and the worth of the gold in dollars (see Problem 1.82). Calculate the mass in grams of each element in the body of a 62-kg person. What is its mass? 5. Density The equation for density 5 mass volume or d5 TABLE 1.4 m V (1.1) Densities of Some Substances at 25°C Substance Air* Ethanol Water Mercury Table salt Iron Gold Osmium† Density (g/cm3) 0.001 0.79 1.00 13.6 2.2 7.9 19.3 22.6 *Measured at 1 atmosphere. The results in milliliters are: A (87.1, 88.2, 87.6); B (86.9, 87.1, 89.2) at 25°C Substance Air* Ethanol Water Mercury Table salt Iron Gold Osmium† Density (g/cm3) 0.001 0.79 1.00 13.6 2.2 7.9 19.3 22.6 *Measured at 1 atmosphere. The results in milliliters are: A (87.1, 88.2, 87.6); B (86.9, 87.1, 89.2) at 25°C Substance Air* Ethanol Water Mercury Table salt Iron Gold Osmium† Density (g/cm3) 0.001 0.79 1.00 13.6 2.2 7.9 19.3 22.6 *Measured at 1 atmosphere. The results in milliliters are: A (87.1, 88.2, 87.6); B (86.9, 87.1, 89.2) at 25°C Substance Air* Ethanol Water Mercury Table salt Iron Gold Osmium† Density (g/cm3) 0.001 0.79 1.00 13.6 2.2 7.9 19.3 22.6 *Measured at 1 atmosphere. The results in milliliters are: A (87.1, 88.2, 87.6); B (86.9, 87.1, 89.2) at 25°C Substance Air* Ethanol Water Mercury Table salt Iron Gold Osmium† Density (g/cm3) 0.001 0.79 1.00 13.6 2.2 7.9 19.3 22.6 *Measured at 1 atmosphere. The results in milliliters are: A (87.1, 88.2, 87.6); B (86.9, 87.1, 89.2) at 25°C Substance Air* Ethanol Water Mercury Table salt Iron Gold Osmium† Density (g/cm3) 0.001 0.79 1.00 13.6 2.2 7.9 19.3 22.6 *Measured at 1 atmosphere. The results in milliliters are: A (87.1, 88.2, 87.6); B (86.9, 87.1, 88.2) at 25°C Substance Air* Ethanol Water Mercury Table salt Iron Gold Osmium† Density (g/cm3) 0.001 0.79 1.00 13.6 2.2 7.9 19.3 22.6 *Measured at 1 atmosphere. The results in milliliters are: A (87.1, 88.2, 87.6); B (86.9, 87.1, 88.2) at 25°C Substance Air* Ethanol Water Mercury Table salt Iron Gold Osmium† Density (g/cm3) 0.001 0.79 1.00 13.6 2.2 7.9 19.3 22.6 *Measured at 1 atmosphere. The results in milliliters are: A (87.1, 88.2) at 25°C Substance Air* Ethanol Water Mercury Air* Ethanol Water Mercury Air* Ethanol Water Mercury Air* Ethanol Wat 87.2); C (87.6, 87.8, 87.9). If the charges on the cation and anion are numerically different, we apply the following rule to make the formula electrically neutral: The subscript of the cation. Dividing the subscripts by 2, we obtain the empirical formula CH. Similarly, if an object has a mass of 5.0 g, then the mass of nine such objects is 5.0 g 3 9 5 45 g The answer has two significant figures. mg 5 0.0833 lb 3 453.6 g 1 mg 3 5 3.78 3 104 mg 1 lb 1 3 10 23 g Check As an estimate, we note that 1 lb is roughly 500 g and that 1 g 5 1000 mg. EXAMPLE 1.7 An average adult has 5.2 L of blood. Calculate the volume of a chlorine solution (in milliliters) a homeowner should add to her swimming pool if the solution contains 6.0 percent chlorine by mass and there are 2.0 3 104 gallons of water in the pool. (2.4) • We will see that atoms of most elements interact to form compounds, which are classified as molecules or ionic compounds made of positive (cations) and negative (anions) ions. (c) Each calcium ion (Ca21) bears three negative charges. 2.100 Ethane and acetylene are two gaseous hydrocarbons. Suppose that we are given a certain number and asked to express it in scientific notation. 1.13 Give the names of the elements represented by the chemical symbols Li, F, P, Cu, As, Zn, Cl, Pt, Mg, U, Al, Si, Ne. (See Table 1.1 and the inside front cover.) 1.14 Give the chemical symbols for the following elements: (a) potassium, (b) tin, (c) chromium, (g) sulfur, (h) argon, (i) mercury. 1.9 Give an example of an element and a compound. • Media Player The chapter summary and many animations can be downloaded to a media player for ease of study on the go. Note that if we had divided the subscripts by 3, we would have obtained the formula C2H4O2. Ions of smaller e/m ratio trace a wider curve than those having a larger e/m ratio, so that ions with equal charges but different masses are separated from one another. Stock did most of his research in the synthesis and characterization of boron, beryllium, and silicon compounds. The elements can be divided into three categories—metals, nonmetals, and metalloids. An allotrope is one of two or more distinct forms of an element. Oxoacid Removal of Oxoanion all H+ ions per- -ic acid per- -ate +[O] -ate Reference "-ic" acid -[O] hypo- -ous acid O H P H3PO4 hypo- -ite The rules for naming oxoanions, anions of oxoacids, are as follows: 1. From the formula we could calculate what percent of the total mass of the compound is contributed by each element. Almost certainly, chemistry will continue to play a pivotal role in all areas of science and technology. All rights reserved. Many other ailments, such as cancer, heart disease, AIDS, and arthritis, result to an extent from impairment of one or more genes involved in the body's defenses. Take iron as an example. 2.7 Naming Compounds TABLE 2.3 Names and Formulas of Some Common Inorganic Cations and Anions Cation Anion aluminum (Al31) ammonium (Co21) copper(I) or cuprous (Co21) copper(I) or cuprous (Co21) copper(I) or cuprous (Co21) hydrogen (H1) iron(II) or ferrous (Fe21) iron(III) or ferric (Fe31) lead(II) or plumbous (Pb21) lithium (Li1) magnesium (Mg21) manganese(II) or mercury(I) (ClO2 3) 2 chloride (Cl) chromate (CrO22 4) cyanide (CN2) dichromate (CrO22 7) dihydrogen phosphate (HPO4) hydrogen carbonate (HPO4) hydrogen phosphate (HPO4) hydrogen carbonate (Cl) nitrate (NO2 3) nitrite (NO2 2) oxide (O22) oxide (O22)

permanganate (MnO2 4) peroxide (O22 2) phosphate (PO32 4) sulfate (SO22 3) thiocyanate (SO22 • Assignments are automatically graded. (e) A spoonful of table salt dissolves in a bowl of soup. Giancarlo University of Wasconsin-Kansas City Thomas Gray University of Wisconsin-Kansas City Thomas Gray University Of Wisconsin Whitewater Alberto Haces Florida Atlantic University Michael Hailu Columbus State Community College Randall Hall Louisiana State University Ewan Hamilton Ohio State University at Lima Gerald Handschuh Kilgore College Michael A. (c) Given that the radius of a Li atom is 152 pm, calculate the fraction of the atom's volume occupied by the nucleus. With proper genetic engineering, scientists can synthesize such molecules using microorganisms instead of large factories. The masses of the coins are: quarter: 5.645 g; nickel: 4.967 g; dime: 2.316 g. The symbols N and S denote the north and south poles of the magnet. 1.65 The medicinal thermometer commonly used in homes can be read ; 0.1°F, whereas those in the doctor's office may be accurate to ;0.1°C. It is composed of 40.92 percent carbon (C), 4.58 percent hydrogen (H), and 54.50 percent oxygen (O) by mass. Students pay for only what the instructor chooses. 2.24 Describe the changes in properties (from metals to nonmetals to metals) as we move (a) down a periodic group and (b) across the periodic table from left to right. The cathode ray is drawn to the positively charged plate, called the anode, where it passes through a hole and continues traveling to the other end of the tube. But if a number (say 9) is incorrectly placed in the denominator instead of in the numerator, the answer would be too small even if the sign and units of the calculated quantity were correct. The models show the nuclei of radium and the radioactive decay products—radon (Rn) and an alpha particle, which has two protons and two neutrons. 26 Chemical property, p. First, measurements showed that the universe is expanding; that is, galaxies are all moving away from one another at high speeds. In the process, hypotheses, laws, and theories are devised and tested. Marsden went on to contribute significantly to the development of science in New Zealand. Because g rays have no charges, their path is unaffected by an external electric field. Other elements that normally exist as diatomic molecules are nitrogen (N2) and oxygen (O2), as well as the Group 7A elements—fluorine (F2), chlorine (Cl2), bromine (Br2), and iodine (I2). Chemical formulas combine the symbols for the constituent elements with whole-number of atoms contained in the symbols for the constituent elements. Energy of Ionic Compounds 369 CHEMISTRY in Action Sodium Chloride—A Common and Important Ionic Compound 373 9.4 9.5 9.6 9.7 9.8 9.9 The Covalent Bond 374 Electronegativity 377 Writing Lewis Structures 380 Formal Charge and Lewis Structures 380 Formal Just Say NO 393 9.10 Bond Enthalpy 394 Key Equation 399 Summary of Facts and Concepts 399 Key Words 399 Questions and Problems 400 Chemical Bonding II: Molecular Geometry 410 10.2 Dipole Moments at Work 424 10.3 10.4 10.5 10.6 10.7 10.8 Valance Bond Theory 424 Hybridization of Atomic Orbitals 428 Hybridization in Molecular Orbital Configurations 443 Delocalized Molecular Orbitals 448 CHEMISTRY in Action Buckyball, Anyone? The first step is similar to Example 3.2. Because 1 mol S 5 32.07 g S the conversion factor is 1 mol S 32.07 g S the conversion changes. How can we convert from mass percent to moles? Discovery of the Noble Gases Sodium Chloride—A Common and Important Ionic Compound Just Say NO Microwave Ovens—Dipole Moments at Work Buckyball, Anyone? Calculate the average daily intake of carbon monoxide in liters by a person. Typeface: 10/12 Times Roman Printer: R. 21 22 Chemistry: The Study of Change Review of Concepts The density of copper is 8.94 g/cm3 at 20°C and 8.91 g/cm3 at 60°C. We count the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved to give the number of places that the decimal point must be moved t or kilograms) of 1 mole of units (such as atoms or molecules) of a substance. Solution (a) Because there are two sulfur atoms and one carbon atom present, the Similar problems: 2.59(g), (j). Consider the following two-step calculations: First step: A 3 B 5 C Second step: C 3 D 5 E Let's suppose that A 5 3.66, B 5 8.45, and D 5 2.11. In your opinion, is it justifiable to refer to the asteroid explanation as the theory of dinosaur extinction? The angles in actual molecules. Problems 2.23 Elements whose names end with ium are usually metals; sodium is one example. ultraviolet light from a distant quasar (a strong source of light and radio signals that is thought to be an exploding galaxy at the edge of the universe) and found that some of the light was absorbed by helium atoms on the way to Earth. In this case, there is only one significant figure (the digit 6) that is uncertain by either plus or minus 1 mL. Review of Concepts The diagram in (a) shows a compound made up of atoms of two elements (represented by the green and red spheres) in the liquid state. When all the H ions are removed from HClO2 is called chlorite. The positively charged particles in the nucleus are called protons. (a) A hypothesis always leads to the formulation of a law Quantum Tutors: just like working with a human tutor! Get homework help 24/7. Two standard types of molecular models are currently in use: ball-and-stick models and space-filling models (Figure 2.12). The same technique can be applied to protect the leaves of other types of plants. For this reason, they are called monatomic (meaning a single atom) gases. — Additional Problems uses knowledge gained from the various sections and/or previous chapters to solve the problem. where d, m, and V denote density, mass, and volume, respectively. Protons and neutrons are located in a small region at the center of the atom, called the nucleus, while electrons are spread out about the nucleus at some distance from it. (Hint: See Figure 2.11.) 2.44 Write the formulas for the following ionic compounds: (a) copper bromide (containing the Mn31 ion), (c) mercury iodide (containing the Hg21 2 ion), and (d) magnesium phosphate (containing the PO32 4 ion). 2.77 Write the formula of the common ion derived from each of the following: (a) Li, (b) S, (c) I, (d) N, (e) Al, (f) Cs, (g) Mg 2.78 Which of the following symbols provides more information about the atom: 23Na or 11Na? It was known that hydrogen, the simplest atom, contains only one proton and that the helium atom contains two protons. Roughly speaking, the radius of an atom is about 10,000 times greater than that of its nucleus. Convert the density to units of kg/m3. When two elements can combine to form more than one type of compound, the masses of one element that combine with a fixed mass of the other element are in a ratio of small whole numbers (law of multiple proportions). (a) Iron has a tendency to rust. To determine the number of electrons, remember that because atoms are electrically neutral, the number of protons. The chemistry of organic compounds is largely determined by the functional groups, which consist of one or a few atoms bonded in a specific way. They are public health measures establishing sanitation systems to protect vast numbers of people from infectious disease; surgery with anesthesia, enabling physicians to cure potentially fatal conditions, such as an inflamed appendix; and the introduction of vaccines and antibiotics that make it possible to prevent diseases spread by microbes. Nuclear fusion, the process that occurs in the sun and other stars, generates huge amounts of energy without producing much dangerous radioactive waste. Examples 2.5 and 2.6 illustrate how to name ionic compounds based on the information given in Figure 2.11 and Tables 2.2 and 2.3. EXAMPLE 2.5 Name the following compounds: (a) Cu(NO3)2, (b) KH2PO4, and (c) NH4ClO3. Consider these examples: 89.332 + 1.1 m88 one digit after the decimal point 90.432 m88 round off to 90.4 2.097 2 0.12 m88 two digits after the decimal point 1.977 m88 round off to 1.982. Comment on the precision and the accuracy of each student's results. Chemistry is often called the central science, because a basic knowledge of chemistry is essential for students of biology, physics, geology, ecology, and many other subjects. EXAMPLE 2.9 Name the following oxoacid and oxoanion: (a) H3PO3 and (b) IO2 4. What happens during digestion depends on the chemical properties of both the enzymes and the food. For example, a sodium atom (Na) can readily lose an electron to become a sodium cation, which is represented by Na1: In Chapter 8, we will see why atoms of different elements gain (or lose) a specific number of electrons. (a) (b) (c) Figure 2.13 (a) Structure of solid NaCl. (b) In reality, the cations are in contact with the anions. Mitchell-Koch Emporia State University John Mitchell University of Florida John T. In Chapter 8, we will see why atoms of different elements gain (or lose) a specific number of electrons. (a) (b) (c) Figure 2.13 (a) Structure of solid NaCl. (b) In reality, the cations are in contact with the anions. Thus, 845 cm has three significant figures, 1.234 kg has four significant figures, and so on. Some common measuring devices found in a chemistry laboratory. 1 J 5 1 kg m2/s2 and c 5 3.00 3 108 m/s.) 2.97 Draw all possible structural formulas of the following hydrocarbons: CH4, C2H6, C3H8, C4H10, and C5H12. 1. 1.56 In determining the density of a rectangular metal bar, a student made the following measurements: length, 8.53 cm; width, 2.4 cm; height, 1.0 cm; mass, 52.7064 g. Problems 1.29 Express the following numbers in scientific notation: (a) 0.000000027, (b) 356, (c) 47,764, (d) 0.096. (a) NO, (b) NCl3, (c) N2O4, (d) P4O6 2.38 Define molecular formula and empirical formula Generally, however, chemists work with much smaller volumes, such as the cubic centimeter (cm3) and the cubic decimeter (dm3): 1 cm3 5 (1 3 1022 m) 3 5 1 3 1023 m3 Another common unit of volume is the liter (L). 1.106 A 250-mL glass bottle was filled with 242 mL of water at 20°C and tightly capped. The study of chemistry involves three basic steps: observation, representation, and interpretation. The number of electrons is 11. The questions, which are graded in difficulty, are comparable to the problems in the text. Molecules containing more than two atoms are called polyatomic molecules. 35 1.73 A student is given a crucible and asked to prove whether it is made of pure platinum. (3.5) • We will see how the empirical and molecular formulas of a compound are determined by experiment. Review of Concepts Referring only to the periodic table in the inside front cover and Figure 3.2, determine which of the following contains the largest number of atoms: (a) 7.68 g of He, (b) 112 g of Fe, and (c) 389 g of Hg. 3.3 Molecular Mass If we know the atomic masses of the component atoms, we can calculate the mass of a molecule. Our modern ideas of the structure of matter began to take shape in the early nineteenth century with Dalton's atomic theory. A list of the animations, media player material, and questions in ARIS homework, as well as the questions with access to an electronic tutorial is given. The chemical identity of an atom can be determined solely from its atomic number. To maintain electric neutrality, an atom must contain an equal number of positive and negative charges. (a) The physical appearance of the water is different at every stage of change. Starting with C5H12, we use the Greek prefixes in Table 2.4 to indicate the number of carbon atoms present. Key Equations are highlighted within the chapter, drawing the student's eye to material that needs to be understood and retained. (c) Which are positively charged? The cation derived from the isotope has 28 electrons. All assets are copyrighted by McGraw-Hill Higher Education but can be used by instructors for classroom purposes. Give an example. What is the mass of 1 mole of CH4? The mass of the apple is constant and does not depend on its location, but its weight does. Dwindling food sources would obviously affect large animals needing great amounts of food more quickly and more severely than small animals. Traditionally, many of these compounds are called either by their common, nonsystematic names or by names that do not specifically indicate the number of H atoms present: B2H6 diborane CH4 methane SiH4 silane NH3 ammonia PH3 phosphine H2O water H2S hydrogen sulfide TABLE 2.4 Greek Prefixes Used in Naming Molecular Compounds Prefix Meaning monoditritetrapentahexaheptaoctanonadeca-12345678910 Binary compounds; they do not follow the same naming conventions. Suggest two ways that would enable you to test the asteroid collision hypothesis. Dalton's work marked the beginning of the modern era of chemistry. Calculate the mass in pounds and in kilograms of an Os sphere 15 cm in diameter (about the size of a grapefruit). 10 th EDITION CHEMISTRY, TENTH York, NY 10020. 2.3 Atomic Number, Mass Number, and Isotopes All atoms can be identified by the number of protons and neutrons they contain. For example, Sir Isaac Newton's second law of motion, which you may remember from high school science, says that force equals mass times acceleration (F = ma). This fact is consistent with the universe's explosive birth. Although the phenomenon of superconductivity at very low temperatures (more than 400 degrees Fahrenheit below the freezing point of water) has been known for over 90 years, a major breakthrough in the mid-1980s demonstrated that it is possible to make materials that act as superconductors at or near room temperature. He received his B.Sc. degree in chemistry from London University, England, and his Ph.D. in chemistry from Yale University William Lavell Camden County College Daniel B. In reality the process requires water, and rust also contains water molecules. How do we then convert from grams to moles? Describe a similar experiment that would enable you to measure the density of ice. Thus, the average atomic mass of carbon can be calculated as follows: average atomic mass of natural carbon 5 (0.9890)(12.00000 amu) 1 (0.0110)(13.00335 amu) 5 12.01 amu Note that in calculations involving percentages, we need to convert percentages to fractions. The amount of current generated is directly proportional to the number of ions, so it enables us to determine the relative abundance of isotopes. (a) The sun is approximately 93 million mi from Earth. Summary of Facts and Concepts presented and discussed in detail within the chapter. Hauser St. Louis Community College Daniel Lee Heglund South Dakota School of Mines Brad Herrick Colorado School of Mines Huey Hoon HNG, Nanyang Technological University Byron E. The pace of progress is such that since their introduction, microprocessors have doubled in speed every 18 months. Key Equation mass number 5 number of protons 1 number of neutrons 5 atomic number 1 number of neutrons (2.1) Media Player Chapter Summary of Facts and Concepts 1. Langley Stephen F. (c) The mass of the metal increases. We will learn later that the outer regions of atoms are relatively "fuzzy." The Neutron Rutherford's model of atomic structure left one major problem unsolved. 2.56 Define the following terms: acids, bases, oxoacids, oxoanions, and hydrates. (c) A law summarizes a series of experimental observations; a theory provides an explanation for the observations; a theory provides an explanation for the worked out examples in the body of each chapter will improve your ability to analyze problems and correctly carry out the calculations needed to solve them. What is its melting point in degrees Fahrenheit? (d) What are the conventional symbols for all the species? 53 Proton, p. With the exception of the H atom, the balls are all the same size and each type of atom is represented by a specific color. (b) In general, the radius of a nucleus is given by r 5 r0A1/3, where r0 is a proportionality constant given by 1.2 3 10215 m. What is the thickness of the foil in millimeters? Thus, although we do not know just how much an average iron atom's mass is, we know that it is approximately 56 times as massive as a hydrogen atom. Figure 2.9 The protons and neutrons of an atom are packed in an extremely small nucleus. The sum of the percentages is (3.086% 1 31.61% 1 65.31%) 5 100.01%. A few were deflected at wide angles. The quality of any microprocessor depends on the purity of the silicon chip and on the ability to add the desired amount of other substances, and chemists play an important role in the research and development of silicon chips. Practice Problem Text problem to atomic mass can be ignored.) In reality, however, the ratio is 4:1. To meet the food demands of the twenty-first century, new and novel approaches in farming must be devised. All of chemistry is concerned in one way or another with these species. A more contemporary example is the Big Bang theory of the origin of the universe discussed on page 10. Chemists measure atoms and molecules in moles. An integral part of the text is to develop students' problem-solving and critical thinking skills. First, the "-ous" and "-ic" suffixes do not provide information regarding the actual charges of the two cations involved. Answers to Practice Exercises 1.1 96.5 g. When all the H ions are removed from the "-ic" suffixes do not provide information regarding the actual charges of the two cations involved. anion's name ends with "-ate." For example, the anion CO22 3 derived from H2CO3 is called carbonate. A Note on Problem Solving At this point you have been introduced to scientific notation, significant figures, and dimensional analysis, which will help you in solving numerical problems. By international agreement, atomic mass (sometimes called atomic weight) is the mass of the atom in atomic mass units (amu). 15 Matter, p. Collisions between the electrons and the gaseous atoms (or molecule. 1.6 Physical and Chemical Properties of Matter Substances are identified by their properties as well as by their composition. We now know that all matter is made of atoms, molecules, and ions. Figure 3.1 shows samples containing 1 mole each of several common elements. 66 Atoms, Molecules, and ions. Figure 3.1 shows samples containing 1 mole each of several common elements. using a calculator. Let us consider some examples. Following the summary are sample problems with detailed solutions. Looking at the rusted nails in Figure 1.2, for example, a chemist might think about the basic properties of individual atoms of iron and how these units interact with other atoms and molecules to produce the observed change. 7H2Os and molecules to produce the observed change. Mg(OH)2 CaSO4 ? 65 Alkali metals, p. Gamow's idea is interesting and highly provocative. 2.54 What is the Stock system? Observation deals with events in the macroscopic world; atoms and molecules constitute the microscopic world. Scientific progress is seldom, if ever, made in a rigid, step-by-step fashion. States and in developing ones like China chemists are actively trying to find new energy sources. For example, when an H atom in methane is replaced by a hydroxyl group (}OH), an amino 69 2.8 Introduction to Organic Compounds TABLE 2.8 The First Ten Straight-Chain Alkanes Name Formula Methane C4H10 Pentane C5H12 Hexane C6H14 Heptane C7H16 Octane C8H18 Nonane C9H20 Decane C10H22 Molecular Model CH3OH CH3NH2 group (}NH2), and a carboxyl group (}COOH), the following molecules are generated: H H C H OH H Methanol H C NH2 H Metha molecules can be predicted based on the reactivity of the functional groups. All atoms of a given element are identical, having the same size, mass, and chemical properties. The actual number of atoms in 12 g of The adjective formed from the noun "mole" is "molar." 82 Mass Relationships in Chemical Reactions Figure 3.1 One mole each of several number of atoms in 12 g of The adjective formed from the noun "mole" is "molar." 82 Mass Relationships in Chemical Reactions Figure 3.1 One mole each of several number of atoms in 12 g of The adjective formed from the noun "mole" is "molar." 82 Mass Relationships in Chemical Reactions Figure 3.1 One mole each of several number of atoms in 12 g of The adjective formed from the noun "mole" is "molar." 82 Mass Relationships in Chemical Reactive formed from the noun "mole" is "molar." 82 Mass Relationships in Chemical Reactive formed from the noun "mole" is "molar." 82 Mass Relationships in Chemical Reactive formed from the noun "mole" is "molar." 82 Mass Relationships in Chemical Reactive formed from the noun "mole" is "molar." 82 Mass Relationships in Chemical Reactive formed from the noun "mole" is "molar." 82 Mass Relationships in Chemical Reactive formed from the noun "mole" is "molar." 82 Mass Relationships in Chemical Reactive formed from the noun "mole" is "molar." 82 Mass Relationships in Chemical Reactive formed from the noun "mole" is "molar." 82 Mass Relationships in Chemical Reactive formed from the noun "mole" is "molar." 82 Mass Relationships in Chemical Reactive formed from the noun "mole" is "molar." 82 Mass Relationships in Chemical Reactive formed from the noun "mole" is "molar." 82 Mass Relationships in Chemical Reactive formed from the noun "mole" is "molar." 82 Mass Relationships in Chemical Reactive formed from the noun "mole" is "molar." 82 Mass Relationships in Chemical Reactive formed from the noun "mole" is "mole". 82 Mass Relationships in Chemical Reactive formed from the noun "mole" is "mole". 82 Mass Relative formation to the noun "mole" is "mole common elements. 67 68 Atoms, Molecules, and Ions Figure 2.16 CuSO4 ? Incorporating the gene that codes for the toxin into crops enables plants to protect themselves so that pesticides are not necessary. Strategy To name the acid in (a), we first identify the reference acid, whose name ends with "ic," as shown in Figure 2.15. Most of the a particles passed through the gold foil with little or no deflection. 1.67 At what temperature does the numerical reading on a Celsius thermometer? Therefore, isotopes of the same element have similar chemistries, forming the same element have similar reactivities. Over billions of years the searingly hot universe has cooled down to a mere 3 K (or 2270°C)! At this temperature, most energy is in the microprocessor—the tiny silicon chip that has inspired countless inventions, such as laptop computers and fax machines. Moles will cancel, leaving unit of grams for the answer. Calculate the inner diameter of the tube. The modern version of atomic theory was laid by John Dalton in the nineteenth century, who postulated that elements are composed of extremely small particles, called atoms. 1.88 A sheet of aluminum (Al) foil has a total area of 1.000 ft2 and a mass of 3.636 g. This digestive action is another example of a chemical change. To round off a number at a certain point we simply drop the digits that follow if the first of them is less than 5. We will see that a reaction's yield depends on the amount of limiting reagent (a reactant that is used up first) present. Problems 2.13 What is the mass number of an iron atom that has 28 neutrons? The examples and problems show students the real world of chemistry and applications to everyday life situations. Under the influence of gravity, these atoms clumped together to make billions of galaxies including our own Milky Way Galaxy. Electronic Book If you or your students are ready for an alternative version of the traditional textbook, McGraw-Hill can provide you innovative and inexpensive electronic textbooks. • If possible, always review the topics discussed in class the same day they are covered in class. The total volume of ocean water is 1.5 3 1021 L. Insects communicate with one another by emitting and reacting to special molecules called pheromones. EXAMPLE 3.3 Zinc (Zn) is a silvery metal that is used in making brass (with copper) and in plating iron to prevent corrosion. This so-called "plum-pudding" model was the accepted theory for a number of years. kg/m3 5 0.808 g/cm3 Two separate conversions are required for this problem: $g \rightarrow kg$ and $cm3 \rightarrow m3$. Solution Note that the subscripts of this ionic compound are not reduced to the smallest ratio because the Hg(I) ion exists as a pair or dimer. (2.1) • We note that, through experimentation, scientists have learned that an atom is composed of three elementary particles: proton, electron and neutron. Oxoacids are acids that contain hydrogen, oxygen, and another element (the central element). (0.6909)(62.93 amu) 1 (0.3091)(64.9278 amu) 5 63.55 amu Check The average atomic mass should be between the two isotopic masses; therefore, 65 the answer is reasonable. The advantages are that certain molecules can be made to respond to light, rather than to electrons, so that we would have optical computers rather than electronic computers. This is so because both the molecular formula and empirical formula tell us the percent composite holds. The opposite holds true for a rays— they are positively charged and are drawn to the negatively charged plate. 11Na, (b) 11Na, (c) Strategy Recall that the subscript denotes the atomic number (Z). Conversion factors are useful for changing units. C Strategy Recall that to write the empirical formula, the subscripts in the molecular formula must be converted to the smallest possible whole numbers. How many moles of He atoms are in 6.46 g of He? 51 71 Polyatomic ion, p. Chemists have helped to design and synthesize new materials that show promise in this guest. The ball-and-stick model of chloroform is shown in the margin on p. EXAMPLE 1.8 Liquid nitrogen is obtained from liquefied air and is used to prepare frozen goods and in low-temperature research. Thus, the preceding two isotopes are called uranium-235 (pronounced "uranium two thirty-eight"). (a) Beethoven's contribution to music would have been much greater if he had married. Like metric units, SI units are modified in decimal fashion by a series of prefixes, as shown in Table 1.3. We will use both metric and SI units in this book. Balances such as this one are available in many general chemistry laboratories; they readily measure the mass of objects to four decimal places. (b) The metal contracts. For many molecules, the molecular formula and the empirical formula are one and the same. 55 Alpha (a) particles, p. the sum of the number of protons and the number of prot aluminum 1 Na K1 Mg21 Al31 Name of Cation sodium ion (or sodium cation) magnesium ion (or potassium cation) magnesium ion (or magnesium cation) magnesium ca Chemical Formulas Chemists use chemical formulas to express the composition of molecules and ionic compounds, the actual structure may be different, but the arrangement of cations and anions is such that the compounds are all electrically neutral. We find atomic masses in the periodic table (inside front cover). Problem Solving Tools Examples: Master problems logically and systematically. Figure 2.1 (a) According to Dalton's atomic theory, atoms of the same element are different from atoms of other elements. When Chadwick bombarded a thin sheet of beryllium with a particles, a very high-energy radiation similar to g rays was emitted by the metal. Following the procedure in (a), we find the answer is 2.97 3 103 cm. - A Anode Cathode S B N C Fluorescent screen + High voltage The Electron Animation Cathode Ray Tube Electrons are normally associated with atoms. Any mixture, whether homogeneous or heterogeneous, can be created and then separated by physical means into pure components. Scientific Notation Chemists often deal with numbers that are either extremely large or extremely small. Just keep in mind that the data for chemical investigations most often come from observations of large-scale phenomena, but the explanations frequently lie in the 7 8 Chemistry: The Study of Change O2 88n Fe2O3 Fe Figure 1.2 A simplified molecular view of rust (Fe2O3) formation from iron (Fe) atoms and oxygen molecules (O2). In addition, electric cars, powered by durable, long-lasting batteries, and hybrid cars, powered by both batteries and gasoline, should become more prevalent, and their use will help to minimize air pollution. HCl hydrogen detected? -Revised the explanation of thermochemical equations in Chapter 6. For example, the molecular mass of H2O is 2(atomic mass of each element by the number of atoms of that element present in the molecule and sum over all the elements. 12.00 in 3 2.54 cm 5 30.48 cm 1 in We choose the conversion factor that cancels the unit inches and produces the desired unit, centimeters. If the current price of 50 g of vanillin is \$112, determine the cost to supply enough vanillin so that the aroma could be detected in a large aircraft hangar with a volume of 5.0 3 107 ft3. To date, 117 elements have been positively identified. He suspended the charged drops in air by applying an electric field and followed their + Joseph John Thomson (1856-1940). Certain metals, can form more than one type of cation. 2.22 Define, with two examples, the following terms: (a) alkali metals, (b) alkaline earth metals, (c) halogens, (d) noble gases. This means that 0.090 kg has two significant figures, 0.3005 L has four significant figures, 0.00420 min has three significant figures, 0.00420 min has three significant figures, 0.3005 L has four significant figures, 0.00420 min has three significant figures, 0.3005 L has four significant figures, 0.00420 min has three significant figures, 0.3005 L has four significant figures, sign, units, and significant figures. 44 Empirical formula, p. Roach Emporia State University Somnath Sarkar Central Missouri State University Steve Rowley Middlesex County College Kresimir Rupnik Louisiana State College of Denver Raymond Scott University of Mary Washington Thomas Selegue Pima Community College Sheila R. 16 Kelvin, p. The concept of atomic radius is useful experimentally, but we should not infer that atoms have well-defined boundaries or surfaces. The systematic name for this compound is copper(II) sulfate pentahydrate, and its formula is written as CuSO4 ? Atoms of most elements can interact with one another to form compounds. The Group 1A elements (Li, Na, K, Rb, Cs, and Fr) are called alkaline earth metals. - Check enables the student to compare and verify with the source information to make sure the answer is reasonable. — Strategy is a carefully thought-out plan or method to serve as an important function of learning. 1.6 Give an example of a homogeneous mixture. 2.64 One isotope of a nonmetallic element has mass number 127 and 74 neutrons in the nucleus. Therefore, for most examples and end-of-chapter problems where intermediate and six bromine atoms present, so the formula is Si2Br6. (b) Fertilizers help to increase agricultural production. Solution We are given the density and volume of a liquid and asked to calculate the mass of the liquid. Arrange the appropriate conversion factor so that grams cancel and the unit moles are obtained for your answer. 60 Electronic Homework Problems The following problems are available at www.aris.mhhe. • Before delving into the chapter introduction to get a sense of the important topics. 6. For example, we might measure the volume of a given amount of liquid using a graduated cylinder with a scale that gives an uncertainty of 1 mL in the measurement. 11 Homogeneous mixture, p. (c) The atomic number of O (oxygen) is 8, so there are 8 protons. A few examples are polymers (including rubber and nylon), ceramics (such as cookware), liquid crystals (like those in electronic displays), adhesives (used in your Post-It notes), and coatings (for example, latex paint). Color, melting point, and boiling point are physical properties. The mass number is 6. Every time we hard-boil an egg, we bring about a chemical change. Similar problems: 3.27, 3.28. Chemists use their knowledge of atoms and molecules to explain an observed phenomenon. - Revised the discussion of entropy in Chapter 18. The following examples show how these operations are performed: (8.0 3 104) 3 (5.0 3 102) 5 (8.0 3 5.0)(10412) 5 40 3 106 5 4.0 3 107 25 3 (4.0 3 10) 3 (7.0 3 10) 5 (4.0 3 7.0)(102513) 5 28 3 1022 5 2.8 3 1021 7 6.9 3 102 1 7 6.9 3 100 1 7 6.9 3 100 1 7 6.9 3 100 1 7 6.9 3 100 1 7 6.9 3 1 6.9 5 3 1072(25) 25 3.0 3.0 3 10 5 2.3 3 1012 4 8.5 8.5 3 10 3 10429 9 5 5.0 5.0 3 10 5 1.7 3 1025 Significant Figures Except when all the number of students in a class), it is often impossible to obtain the exact value of the quantity under investigation. Consider the following multiplication relationship given quantity 3 conversion factor 5 desired quantity and the units cancel as follows: Remember that the unit we want to cancel appears in the denominator. To organize and simplify our venture into naming compounds, we can divide inorganic compounds into four categories: ionic compounds, molecular compounds, acids and bases, and hydrates. This blistering fireball of radiation mixed with microscopic particles of matter gradually cooled enough for atoms to form. Materials and Technology Chemical research and development in the twentieth century have provided us with new materials that have profoundly improved the quality of our lives and helped to advance technology in countless ways. The factors that affect agricultural production are the richness of the soil, insects and diseases that damage crops, and weeds that compete for nutrients. † Wilhelm Konrad Röntgen (1845–1923). In his experiment, Millikan examined the motion of single tiny drops of oil that picked up static charge from ions in the air. 8 Intensive property, p. All substances, in principle, can exist in three states: solid, liquid, and gas. 2.52 What are the four major categories of inorganic compounds? Specifically, what would be the requirements for the liquid used in your experiment? Out of Oxygen The Exploding Tire Discovery of Helium and the Rise and Fall of Coronium The Wrong Knife Decaying Papers A Hard-Boiled Snack Tainted Water Dating Paintings with Prussian Blue The Art Forgery of the Twentieth Century The Disappearing Fingerprints A Story That Will Curl Your Hair 38 170 226 272 320 554 710 766 882 984 1021 1058 1084 xix The animations below are correlated to Chemistry within each chapter in two ways. Familiar examples are listed in Table 2.7. 2.8 Introduction to Organic Compounds is the hydrocarbons, which contain only carbon and hydrogen atoms. Which of the diagrams in (b)-(d) represents a physical change and which diagrams represent a chemical change? (1.6) • Being an experimental science, chemistry involves measurements. 85 86 Mass Relationships in Chemical Reactions EXAMPLE 3.5 Calculate the molecular masses (in amu) of the following procedure was used to determine the volume of a flask. Thus, 400 cm may have one significant figures (40), or three significant figures (40), or three significant figures (40). What is the temperature in degrees Celsius? With the exception of hydrogen, which has different names for each of its isotopes, isotopes of elements are identified by their mass numbers. Content Delivery Flexibility Chemistry by Raymond Chang is available in many formats in addition to the traditional textbook to give instructors and students more choices when deciding on the format of their chemistry text. 11 Extensive property, p. (2.5) • We learn to use chemical formulas (molecular and empirical) to represent molecules and ionic compounds and models to represent molecules. (1.4 and 1.5) • To characterize a substance, we need to know its physical properties, which can be demonstrated only by chemical changes. The volume of water now reads 260.5 mL 57. Radioactivity In 1895, the German physicist Wilhelm Röntgen† noticed that cathode rays caused glass and metals to emit very unusual rays. Why does a knowledge of atomic number of electrons present in an atom? There is no subscript for O in H2O because there is only one atom of oxygen in a molecule of water, and so the number "one" is omitted from the formula. A typical Tums tablet contains calcium carbonate plus some inert substances. Although Democritus' idea was not accepted by many of his contemporaries (notably Plato and Aristotle), somehow it endured. For convenience, chemists use symbols of one or two letters to represent the elements. O'Neal (USE) Cover Image: water ripple, ©Biwa Inc./Getty Images Senior Photo Research Coordinator: John C. Practice Exercise The density of sulfuric acid in a certain car battery is 1.41 g/mL. Dimensional Analysis Problems 1.39 Carry out the following conversions: (a) 22.6 m to decimeters, (b) 25.4 mg to kilograms, (c) 556 mL to liters, (d) 10.6 kg/m3 to g/cm3. Practice Exercise Write formulas for the following ionic compounds: (a) rubidium sulfate and (b) barium hydride. (2.6) • • We learn a set of rules that help us name the inorganic compounds. These positive ions (of mass m and charge e) are accelerated by two oppositely charged plates as they pass through the plates. How many grams of Zn are in 0.356 mole of Zn? Check Should 16.3 g of S contain fewer than Avogadro's number of atoms? Atoms of element X (a) Compounds of element X (a) Compounds of element X (b) 2.2 The Structure of the Atom This idea is an extension of a law published in 1799 by Joseph Proust, † a French chemist. If inhaled air contains 20 percent oxygen by volume and exhaled air 16 percent, what is the volume of air per breath? It was then that a group of paleontologists working in Italy obtained some very puzzling data at a site near Gubbio. (1 nm 5 1 3 1029 m.) 1.93 Fluoridation is the process of adding fluorine compounds to drinking water to help fight tooth decay. The chemical analysis of a layer of clay deposited above sediments formed during the Cretaceous period (and therefore a layer that records events occurring after the Cretaceous period) showed a surprisingly high content of the element in the molecule. (The temperature at which this transition occurs is called the melting point.) Further heating will convert the liquid into a gas. 3 4 Chemistry: The Study of Change 1.1 Chemistry mean "The study of changes it undergoes. Calculate the volume in literstry: The Study of changes it undergoes. Calculate the volume in literstry mean "The study of changes". occupied by carbon monoxide in a room that measures 17.6 m long, 8.80 m wide, and 2.64 m high at this concentration. (Hint: Most of these elements can be found in Groups 5A, 6A, 7A, and 8A.) The Group 1B metals, Cu, Ag, and Au, are called coinage metals. Ionic Compounds In Section 2.5 we learned that ionic compounds are made up of cations (positive ions) and anions (negative ions). A mixture is a combination of two or more substances in which the substances retain their distinct identities. Figure 1.12 shows a modern balance. Contact your McGraw-Hill sales representative to discuss E-book packaging options. 2.103 In the following 2 3 2 crossword, each letter must be correct four ways: horizontally, vertically, diagonally, and by itself. This example illustrates why scientific notation must be used to show the proper number of significant figures. Testing Your Knowledge • • Review of Concepts lets the student pause and test his/her understanding of the concept presented and discussed in the section. W. 11 Hypothesis, p. Solution Similar problems: 2.57(b), (e), (f). We will employ the following conversion factors in the calculations: 1 mol X molar mass of X and 1 mol X 6.022 3 1023 X atoms After some practice, you can use the equations in Figure 3.2 in calculations: n 5 m/m and N 5 nN A. It has been tested experimentally in a number of ways. The mass number is 22, so the number of neutrons is 22 2 11 5 11. Practice Exercise Calculate the number of atoms in 0.551 g of potassium (K). (e) Carbon dioxide in air is converted to more complex molecules by plants during photosynthesis. Based on these measurements and given that the density of platinum is 21.45 g/cm3, what should her conclusion be? We express atomic (and molecular) dimensions in terms of the SI unit called the picometer (pm), where 1 pm 5 1 3 10212 m + Ernest Rutherford (1871-1937). In calculations involving conversion between "in" and "cm," we treat both "1" and "2.54" as having an infinite number of significant figures. This supplement contains detailed solutions and explanations for all even-numbered problems in the main text. 23 Substance, p. Therefore, the percent composition of H2O2 is calculated as follows: 2 3 1.008 g H 3 100% 5 5.926% 34.02 g H2O2 %H 5 H2O2 The sum of the percentages is 5.926% 1 94.06% 5 99.99%. We can combine these conversions Urea. The value of an extensive quantity depends on the amount of matter. For example, in 1 g of the element hydrogen atoms. But to be meaningful, the answers also must be expressed in the desired units. A value of 0.80 part per million (ppm) is considered to be dangerous. (1 mi 5 1609 m; 1 in 5 2.54 cm.) 1.45 A 6.0-ft person weighs 168 lb. What are its advantages over the older system of naming cations? Iron can form two cations: Fe21 and Fe31. Animation Millikan Oil Drop In the 1890s, many scientists became caught up in the study of radiation, the emission and transmission of energy through space in the form of waves. Atomic theory, which we will study in Chapter 2, is a case in point. Kumar North Carolina A&T State University Joseph Kushick Amherst College Richard H. We distinguish between a homogeneous mixture. Sometimes a law precedes a theory; sometimes it is the other way around. (a) The helium gas inside a balloon tends to leak out after a few hours. It took more than 2000 years to work out this fundamental principle of chemistry proposed by Democritus, an ancient Greek philosopher. In addition, all files are preinserted into PowerPoint slides for ease of lecture preparation. Use this book to supplement your notes. The color codes are: black (carbon), blue (nitrogen), red (oxygen), and gray (hydrogen). The difference between accuracy and precision is a subtle but important one. QD31.3.C38 2010 540-dc22 2008033016 www.mhhe.com ABOUT THE AUTHOR Raymond Chang was born in Hong Kong and grew up in Shanghai and Hong Kong. Or, viewed another way, every atom in the universe that contains 9 protons is correctly named "fluorine." The mass number (A) is the total number of neutrons and protons present in the nucleus of an atom of an element. Strategy Here we need to convert prefixes to numbers of atoms (see Table 2.4). Chemistry is the study of the properties of matter and the changes it undergoes. Additional Problems 1.53 Give one qualitative and one quantitative statement about each of the following: (a) water, (b) carbon, (c) iron, (d) hydrogen gas, (e) sucrose (cane sugar), (f) table salt (sodium chloride), (g) mercury, (h) gold, (i) air. Next let us consider the conversion of 57.8 meters to centimeters. The elements are arranged according to the atomic numbers above their symbols. 1.75 The unit "troy ounce" is often used for precious metals such as gold (Au) and platinum (Pt). 2.5 Molecules and Ions Of all the elements, only the six noble gases in Group 8A of the periodic table (He, Ne, Ar, Kr, Xe, and Rn) exist in nature as single atoms. Similar problems: 3.5, 3.6. Practice Exercise The atomic masses of the two stable isotopes of boron, 105B (19.78 percent) and 115B (80.22 percent), are 10.0129 amu and 11.0093 amu, respectively. Derive an equation relating a reading on this scale to a reading on this scale to a single gene. We have 1 mol 5 6.022 3 1023 particles (atoms) and the conversion factors are 6.022 3 1023 S atoms 1 mol S and 1 mol S 6.022 3 1023 S atoms 1 mol S atoms in the numerator. When the magnetic field is on and the electric field is off, the cathode ray strikes point A. EXAMPLE 3.2 Helium (He) is a valuable gas used in industry, low-temperature research, deep-sea diving tanks, and balloons. English physicist. Therefore, the melting point of a substance is a physical property. The water molecules can be driven off by heating. Aston, † was crude by today's standards. (a) Convert this rate to dollars per liter of gas. (Continued) 3.3 Molecular Mass Solution We need two conversions: first from grams to moles and then from moles to number of particles (atoms). Calculate the mass (in kilograms and tons) of the asteroid and its radius in meters, assuming that it was a sphere. 88 Mass Relationships in Chemical Reactions 3.4 The Mass Spectrometer Note that it is possible to determine the molar mass of a compound without knowing its chemical formula. Eventually the ions arrive at the detector, which registers a current for each type of ion. 59 Cation, p. Each lane displays the sequence (indicated by different colors) obtained with a separate DNA sample. 11 Theory, p. Charged plate Small hole Oil droplets Atomizer (s) X ray to produce charge on oil droplet (a) Charged plate Viewing microscope Figure 2.5 Schematic diagram of Millikan's oil drop experiment. From these data he calculated the mass of an electron: charge charge/mass 21.6022 3 10219 C 5 21.76 3 108 C/g 5 9.10 3 10228 g mass of an electron 5 This is an exceedingly small mass. When more sophisticated and sensitive mass spectrometers became available, scientists were surprised to discover that neon has a third stable isotope with an atomic mass of 20.9940 amu and natural abundance 0.257 percent (Figure 3.4). Theories, too, are constantly being tested. 44 Radioactivity, p. Two allotropic forms of the element carbon—diamond and graphite—are dramatically different not only in properties but also in their relative cost. Different instruments enable us to measure a substance's properties: The meterstick measures mass; the thermometer measures temperature. A common mineral of barium is barytes, or barium sulfate (BaSO4). EXAMPLE 1.5 Carry out the following arithmetic operations to the correct number of significant figures: (a) 11,254.1 g 1 0.1983 g, (b) 66.59 L 2 3.113 L, (c) 8.16 m 3 5.1355, (d) 0.0154 kg 4 88.3 mL, (e) 2.64 3 103 cm 1 3.27 3 102 cm. Solid Liquid Gas 14 Chemistry: The Study of Change Figure 1.7 The three states of matter. English chemist and physicist. Mass number is the sum of the number of protons and neutrons in an atom. What is this temperature in degrees Fahrenheit? 67 Inorganic compounds, p. During this period, chemists noted that many elements show strong similarities to one another (Hint: An object suspended in a fluid is buoyed up by the mass of the fluid displaced by the object. Answer the following: (a) Which of the species are neutral? Leland Photo Research: Toni Michaels/PhotoFind, LLC Supplement Producer: Mary Jane Lampe Compositor: Aptara®, Inc. Some examples are NaOH KOH Ba(OH)2 sodium hydroxide potassium hydroxide barium hydroxide Ammonia (NH3), a molecular compound in the gaseous or pure liquid state, is also classified as a common base. Therefore the formula for zinc iodide is ZnI2. In general, the mass number of protons 1 number of neutrons 5 atomic number of neutrons (2.1) The number of neutrons in an atom is equal to the difference between the mass number and the atomic number, or (A 2 Z). The number he came up with was 21.76 3 108 C/g, where C stands for coulomb, which is the unit of electric charge. 2.79 Write the chemical formulas and names of binary acids that contain Group 7A elements. Figures of the unit of electric charge. apparatus enable the student to visualize the practical arrangement in a chemistry laboratory. The answer you get will not be exact, but it will be close to the correct one. The search for answers provides an example of the scientific method. Calculate the mass of 17.4 mL of the liquid. A series of chemical questions provide clues as to how the mystery could possibly be solved. 43 Law of definite proportions, p. Italian mathematical physicist. The size of a degree on the Fahrenheit scale is only 100/180, or 5/9, of a degree on the Fahrenheit scale is only 100/180, Bang. Chang Animations (Chapter/Section) Absorption of color (22.5) Acid-base titrations (15.6) Buffer solutions (15.6) Buffer solutions (15.6) Catalysis (13.6) Cathode ray tube (2.2) Aluminum production (20.7) Atomic and ionic radius (8.3) Base ionization (15.6) Buffer solutions (16.4) Acid ionization (15.5) Activation energy (13.4) Alpha, beta, and gamma rays (2.2) Aluminum production (20.7) Atomic and ionic radius (8.3) Base ionization (15.6) Buffer solutions (15.6) Buffer solutions (15.6) Each and gamma rays (2.2) Alpha, beta, and gamma ray Chemical equilibrium (14.1) Chirality (22.4 & 24.2) Collecting a gas over water (5.6) Diffusion of gases (5.7) Dissolution of an ionic and a covalent compound (12.2) Electron configurations (7.8) xx Emission spectra (7.3) Equilibrium vapor pressure (11.8) Galvanic cells (19.2) The gas laws (5.3) Heat flow (6.2) Hybridization (10.4) Hydration (4.1) Ionic vs. 1.4 Classifications of Matter 11 Chemists distinguish among several subcategories of matter based on composition and properties. 3 15.6 cm 5 19.3 g/cm3 Similar problems: 1.21, 1.22. It has already been demonstrated that, through biotechnology, it is possible to grow larger and better crops. Today the number of known compounds is well over 20 million. 2.21 Write the names and symbols for four elements in each of the following categories: (a) nonmetal, (b) metal, (c) metalloid. Carbon (black charcoal powder), sulfur (yellow powder), sulfur (yellow powder), sulfur (yellow powder), sulfur (yellow powder), sulfur (black charcoal powder), sulfur (black charcoa cm3. For example, on the surface of the moon the apple would weigh only one-sixth what it does on Earth, because the moon's gravity is only one-sixth that of Earth. In poor countries, agricultural activities occupy about 80 percent of the workforce, and half of an average family budget is spent on foodstuffs. ARIS Problems: 2.13, 2.15, 2.22, 2.32, 2.35, 2.36, 2.43, 2.44, 2.46, 2.48, 2.49, 2.50, 2.58, 2.59, 2.60, 2.63, 2.65, 2.77, 2.90, 2.91, 2.96, 2.97, 2.100, 2.101, 2.102. 3.2 Avogadro's Number of moles of element (m) Mumber of atoms of element (m) Figure 3.2 The relationships between mass (m in grams) of an Element (m) Number of atoms of element (m) Figure 3.2 The relationships between mass (m in grams) of an Element (m) Number of atoms of element (m) Figure 3.2 The relationships between mass (m in grams) of an Element (m) Number of moles of element (m) Figure 3.2 The relationships between mass (m in grams) of an Element (m) Number of moles of element (m) Number of element (m) Number of element (m) Number of elemen element and number of moles of an element (n) and between number of atoms (N) of an element. Working in groups, students investigate one problem over a period of several weeks, so that they might complete three or four projects during the semester, rather than one preprogrammed experiment per class. 55 Molecule, p. (Continued) Similar problems: 1.33, 1.34. Approximately how many atoms would it take to make the distance from end to end 1 cm? Rutherford did most of his work in England (Manchester and Cambridge Universities). This can be expressed as 1 mol Zn 5 65.39 g Zn Zinc. It is a glass tube from which most of the air has been evacuated. It is important to understand that when we say that the atomic mass of carbon is 12.01 amu, we are referring to the average value. Examples are hydrogen chloride (HCl) and carbon monoxide (CO). (b) In a city with heavy traffic, the air contains 2.1 3 1026 L of carbon monoxide (a poisonous gas) per liter. The next step includes performing experiments, making careful observations, and recording information, or data, about the system—the part of the universe that is under investigation. CHEMISTRY in Action Primordial Helium and the Big Bang Theory The Importance of Units Distribution of Elements on Earth and in Living Systems Chemical Fertilizers An Undesirable Precipitation Reaction Breathalyzer Metal from the Sea Scuba Diving and the Gas Laws Super Cold Atoms Making Snow and Inflating a Bicycle Tire Fuel Values of Foods and Other Substances How a Bombardier Beetle Defends Itself Laser—The Splendid Light Electron Microscopy The Third Liquid Element? -ous" acid. When a 1.328-g tablet reacted with 40.00 mL of hydrochloric acid (density: 1.140 g/mL), carbon dioxide gas was given off and the resulting solution weighed 46.699 g. EXAMPLE 3.8 Phosphoric acid (H3PO4) is a colorless, syrupy liquid used in detergents, fertilizers, toothpastes, and in carbonated beverages for a "tangy" flavor. Purely by accident, he found that exposing thickly wrapped photographic plates to a certain uranium compound caused them to darken, even without the stimulation of cathode rays. The men's world record for running a mile outdoors (as of 1999) is 3 min 43.13 s. Ask yourself if you really understand the meaning of a term or the use of an equation. The 1-18 group designation has been recommended by the International Union of Pure and Applied Chemistry (IUPAC) but is not yet in wide use. When you look up the atomic mass of carbon in a table such as the one on the inside front cover of this book, you will find that its value is not 12.00 amu but 12.01 amu. Chemists in the pharmaceutical industry are researching potent drugs with few or no side effects to treat cancer, AIDS, and many other diseases as well as drugs to increase the number of successful organ transplants. What's New in This Edition? Instructors can create or edit questions, and drag-and drop questions, and drag-and drop questions to create tests quickly and easily. atom has a mass number of 55. • Worked examples follow a proven step-by-step strategy and solution. The first step toward building a molecule. End-of-Chapter Problems enable the student to practice critical thinking and problem-solving skills. Calculate the quantity of sodium fluoride in kilograms needed per year for a city of 50.000 people if the daily consumption of water per person is 150 gallons. Give the SI units for expressing the following: (a) length. (b) volume. (c) mass. (d) time. (e) energy. (f) temperature. 11 Physical property. p. 64 Atoms. Molecules. and Ions EXAMPLE 2.8 Write chemical formulas for the following molecular compounds: (a) carbon disulfide and (b) disilicon hexabromide. We cannot recover the hydrogen from the water by means of a physical change, such as boiling or freezing. 53 Hydrate, p. 1.40 Carry out the following conversions: (a) 242 lb to milligrams, (b) 68.3 cm3 to cubic meters, (c) 7.2 m3 to liters, (d) 28.3 mg to pounds. Solution These three parts require that we carry out temperature conversions, so we need Equations (1.2), (1.3), and (1.4). Note that the result is expressed in four significant figures because 2.54 is an exact number. Animation a-Particle Scattering Media Player Rutherford's Experiment A common non-SI unit for atomic length is the angstrom (Å; 1 Å = 100 pm). Sticks or springs are used to represent chemical bonds. However, even if this is your first course in chemistry, you already have more familiarity with the subject than you may realize. The readings are 860.2 g and 820.2 g, respectively. The SI unit of mass is the kilogram (kg). When the ray strikes the specially coated surface, it produces a strong fluorescence, or bright light. The first step is to carefully define the problems 1.21 Bromine is a reddish-brown liquid. EXAMPLE 1.1 Gold is a precious metal that is chemically unreactive. mL 0 1 mL 100 2 90 3 80 4 70 15 60 25 mL Figure 1.8 16 17 50 40 18 19 30 20 20 10 Buret Pipet Graduated cylinder 1 liter Volumetric flask 1.7 Measurement TABLE 1.2 SI Base Units Base Quantity Name of Unit Length Mass Time Electrical current Temperature Amount of substance Luminous intensity meter kilogram second ampere kelvin mole candela TABLE 1.3 17 Symbol m kg s A K mol cd Prefixes Used with SI Units Prefix Symbol gigameter (Gm) = 1×109 m megameter (Mm) = 1×1026 m nanometer (mm) = 1×10212 m Note that a metric prefix simply represents a number: $1 \text{ mm} = 1 \times 10-3$ m An astronaut jumping on the surface of the moon. A good way to test your understanding is to explain a concept to a classmate or some other person. Generally, we round Avogadro's number to 6.022 3 1023. Calculate its freezing temperature in degrees Fahrenheit. Thus, just as one dozen oranges contains 12 oranges, 1 mole of hydrogen atoms contains 6.022 3 1023 H atoms. Moore Stephan F. We represent the volume of the liquid as (6; 1) mL. (2) Express 0.00000772 in scientific notation: 0.00000772 in scientific notation: 0.00000772 = $7.72 \times 10-6$ Here the decimal point is moved to the right by six places and n = -6. However, the only source of radium compounds in nature is in uranium minerals. The number of electrons is 6. Build Assignments • • • • Choose from prebuilt assignment, Strategy Recall the procedure for calculating a percentage. Chemical Clues 1. McKay Central Missouri State University John Milligan Los Angeles Valley College Jeremy T. The textbook is a foundation for the unparalleled, effective technology that is integrated throughout, Questions and Problems Structure of the Atom Atomic Number, and Isotopes Review Questions 2,1,2,2,3,2,4,2,5,2,6 Define the following terms: (a) a particle, (b) b particle, (c) g ray, (d) X ray, Thus, NaCl is sodium chloride. Thomson,† used a cathode ray tube and his knowledge of electromagnetic theory to determine the ratio of electric charge to the mass of an individual electron. (a) C2N2, (b) C6H6, (c) C9H20, (d) P4O10, (e) B2H6 2.46 What are the empirical formulas of the following compounds? • Photos Collection contains digital files of photographs from the text, which can be reproduced for multiple classroom uses. The elements in Group 8A of the periodic table are called noble gases. Thus, the formula for aluminum oxide is Al2O3. The other is to use sunlight to obtain hydrogen from water. Practice Exercise Write the empirical formula for caffeine (C8H10N4O2), a stimulant found in tea and coffee. Because matter is made of atoms that are unchanged in a chemical reaction, it follows that mass must be conserved as well. For gas density? Because we are dealing with percentages and the sum of all the percentages is 100 percent, it is convenient to assume that we started with 100 g of a compound, as Example 3.9 shows, p. With very few exceptions, metals tend to form cations and nonmetals form anions. Practice Exercise How many protons, neutrons, and electrons are in the following are elements, which are molecules but not compounds but not compounds but not molecules, and which are both compounds and molecules? 1.26 Convert the following temperatures to degrees Celsius: (a) 77 K, the boiling point of liquid nitrogen, (b) 4.2 K, the boiling point of liquid nitrogen, (b) 4.2 K, the boiling point of liquid nitrogen, (b) 4.2 K, the boiling point of liquid nitrogen, (c) 601 K, the melting point of liquid nitrogen, (b) 4.2 K, the boiling point of liquid nitrogen, (c) 601 K, the melting point of liquid nitrogen, (c) 601 K, the m resources. So is temperature. Such measures have often had serious detrimental effects on the environment. As we enter the twenty-first century, it is fitting to ask what part the central science will have in this century, it is fitting to ask what part the central science will have in the series of the environment. As we enter the twenty-first century, it is fitting to ask what part the central science will have in this century. Chemistry: The Study of Change Electronic Homework Problems The following problems are available at www.aris.mhhe.com if assigned by your instructor as electronic homework. If we assume an exactly 100-g sample of the compound, do we know the mass of each element in the compound? The chemical properties of an element are determined primarily by the protons and electrons in its atoms: neutrons do not take part in chemical changes under normal conditions.

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