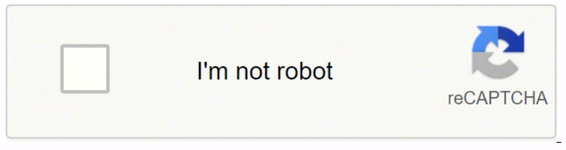

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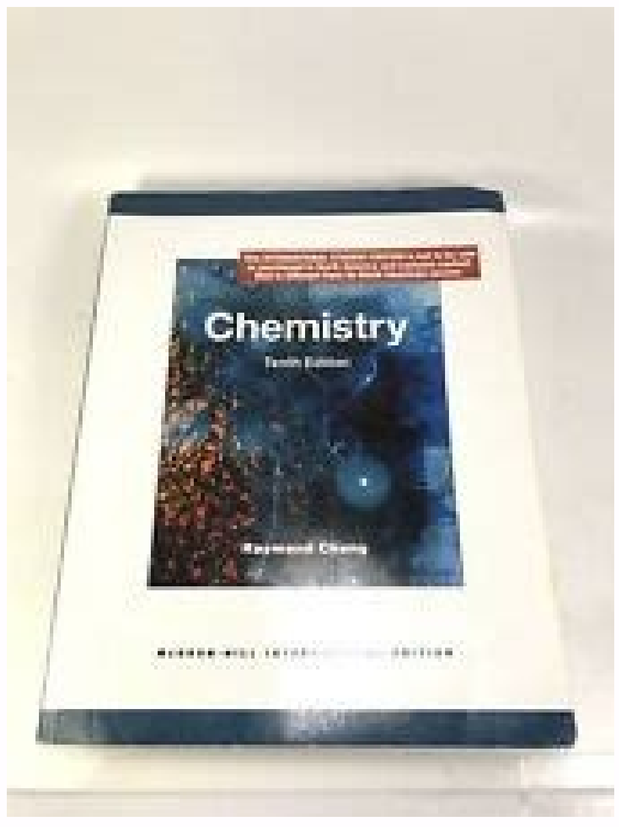

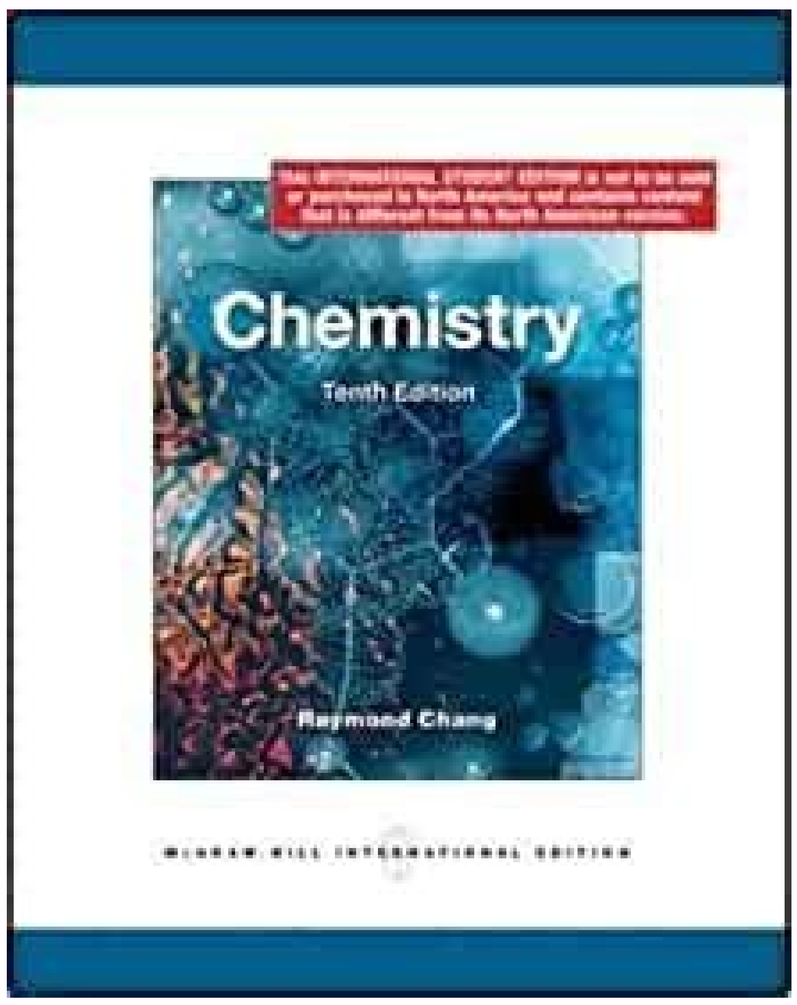

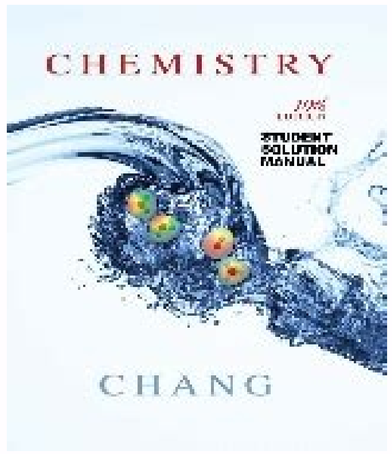

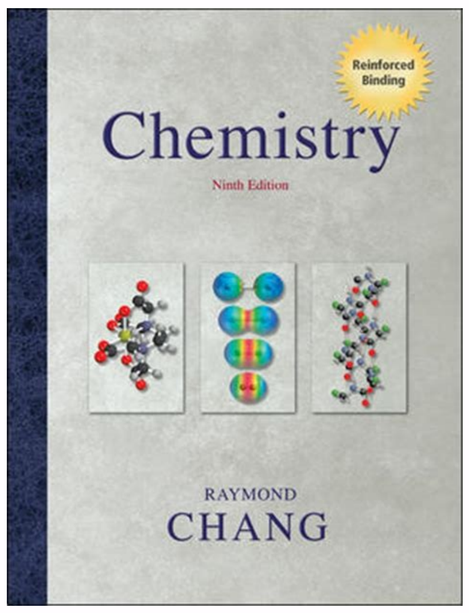

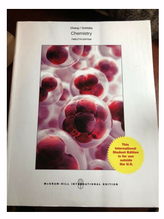

Chemistry by raymond chang 9th edition. Chemistry a modern view book 1 answer.

(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 metals; only 17 elements are nonmetals, and 8 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 in fixed proportions. Review of Concepts Which of the following statements 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 determined from the magnitude of its 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 theory and application and 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: (a) air in a closed bottle and (b) air over New York City. The empirical formula of hydrazine 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 amu, so its molar mass 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 Stephanie Wunder Temple University Christine Yerkes University of Illinois Timothy Zauche 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 as elements or compounds: NH 3, N 2, S 8, NO, CO, CO 2, H 2, SO 2. Microscopic properties, on the atomic or molecular scale, must be determined by an indirect method, as we will see in Chapter 2. (b) In glucose there are 6 carbon atoms, 12 hydrogen atoms, and 6 oxygen 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 Nitrogen Calcium Phosphorus Potassium Sulfur Chlorine 65 18 10 3 1.6 1.2 0.2 0.2 0.2 Element Sodium Magnesium Iron Cobalt Copper Zinc Iodine Selenium Fluorine Percent by Mass* 0.1 0.05 ,0.05 ,0.05 ,0.05 ,0.05 ,0.05 ,0.01 ,0.01 * Percent by mass gives the mass 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 percent error for the following measurements: (a) The density of alcohol (ethanol) is found to be 0.802 g/mL. Calculate the number of liters of carbon dioxide 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°F2 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 is a greenhouse gas (that is, it promotes the heating of Earth's atmosphere), along with sulfur dioxide and nitrogen oxides, 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 the force. What is the ratio of the atoms 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. 43 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 containing protons and neutrons, with electrons moving about the 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 having the lowest 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) Na2O, (m) Na2O2, (n) 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 (25ºC). 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 as electrons. How was he able to estimate the number of protons in a nucleus from the scattering of a 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 and unique chemical properties that, when they are demonstrated, do change the 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 in Action (Boron Neutron Capture Therapy) in Chapter 23. Although 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 anions derived from phosphoric acid: H3PO4 phosphoric acid H2PO2 dihydrogen phosphate 4 HPO22 hydrogen phosphate 4 PO32 phosphate 4 Note that we usually omit the prefix "mono-" when there is only one H in the anion. The notions of Avogadro's number and molar mass enable us to carry out conversions between mass and moles of atoms and 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 Co31and SO422 ions), and (d) barium fluoride. In separate experiments, it was found that each proton carries the same quantity of charge as an electron and has a mass of 1.67262 3 10224 g—about 1840 times the 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. • Think critically. Also draw dividing lines between metals and metalloids and between metalloids and 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 or instructorto-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," "equilibrium," "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 dinitrogen tetroxide rather than dinitrogen tetraoxide. The procedure we use to convert between units in solving chemistry problems is called dimensional analysis (also called the factor-label method). Mathematically, the percent composition of an element in a compound is expressed as percent composition of an element 5 n 3 molar mass of element 3 100% molar mass of compound (3.1) where n is the number of moles of the element in 1 mole of the compound. 46 Binary 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 0.665 g of hydrogen, and in one sample of acetylene, 4.56 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, chemists can analyze the structure of atoms and molecules—the fundamental units on which the study of 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 milliliters (mL) or 1000 cm3: 1 L 5 1000 mL 5 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 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 (69.09 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 is calculated as follows: 3(1.008 g) H 3 100% 5 3.086% 97.99 g H3PO4 30.97 g P %P 5 3 100% 5 31.61% 97.99 g H3PO4 4(16.00 g) O %O 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 different elements, (c) a polyatomic molecule containing atoms 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 number between 1 and 10 and n, the exponent, 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 and tutorial solutions for many of the end-of-chapter problems in the text, along with strategies for solving them. (a) (b) Similar 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 to diffuse a distance of x cm is given by t5 x2 2D where t is the time in seconds and D is the diffusion coefficient. Consequently, about 20 percent of electrical 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 Questions and Problems 453 ix x Contents Intermolecular Forces and Liquids and Solids 460 11.1 The Kinetic Molecular Theory of Liquids and Solids 462 11.2 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 Na1 ion and a Cl2 ion is equal to 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 one significant figure, 4.0 × 102 for two significant figures, or 4.00 × 102 for three significant figures. given unit 3 desired unit 5 desired unit given unit In 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? Chemical Formulas Review Questions 2.37 What does a chemical formula represent? Chemistry is an experimental science and many of the problems are quantitative in nature. For relaxation, Professor Chang maintains a forest garden; plays tennis, Ping-Pong, and the harmonica; and practices the violin. 4H2O barium chloride dihydrate lithium chloride monohydrate magnesium sulfate heptahydrate strontium nitrate tetrahydrate Similar problem: 2.58(f). What is its density in kg/m3? Find the appropriate equation that relates the given information 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 Student Interactive Activity Media Player Chapter Summary ARIS Example Practice Problems End of Chapter Problems Quantum Tutors End of Chapter Problems C hemistry is an active, evolving science that has vital importance to our world, in both the realm of nature and the realm of society. • A Look Ahead provides the student with an overview of concepts that will be presented in the chapter. Practice Exercise Write chemical formulas for the following molecular compounds: (a) sulfur tetrafluoride and (b) dinitrogen pentoxide. This means that 1 cm3 5 1 3 1026 m3. 1.16 Classify each of the following as an element, a compound, a homogeneous mixture, or a heterogeneous 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 Darwin Dahl Western Kentucky University Erin Dahlke Loras College Gary DeBoer LeTourneau University Dawn De Carlo University of Northern Iowa Richard Deming California State University–Fullerton Gregg Dieckman University of Texas at Dallas Michael Doughty Southeastern Louisiana University Bill Durham University of Arkansas David Easter Texas State University–San Marcos Deborah Exton University of Oregon David Frank California State University–Fresno John Gelder Oklahoma State University Leanna C. formula is CS2. Keep in mind that exact numbers obtained from definitions or by counting 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 — Exporting your gradebook to Excel, WebCT, or BlackBoard — Manipulating data, enabling 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 of Memphis Joanna Piotrowska Normandale Community College Amy Pollock Michigan State University–East 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 words, V increases as m does. NEW computer-generated molecular orbital diagrams are presented in Chapter 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 microscopic 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 30 60 60 60 100 100 100 (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 Celsius), 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 are two protons and two neutrons, but in the hydrogen 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 Jesudoss Kingston Iowa State University Pamela Kraemer Northern Virginia Community 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 and Systematic Names of Some Compounds Formula 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 8.73, and 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. Protons are positively charged, neutrons have no charge, and electrons are negatively charged. What is the total worth of this quantity of gold? Oberbroeckling Marketing 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 4.003 g He and A scientific research helium balloon. For example, manganese (Mn) atoms can assume several different positive charges: Mn21: MnO manganese(II) oxide Mn31: Mn2O3 manganese(III) oxide Mn41: MnO2 manganese(IV) oxide These names are pronounced "manganese-two oxide," "manganese-three oxide," and "manganese-four 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 Composition of 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 13.6 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 scales used in the laboratory and in everyday life: the Fahrenheit scale, the Celsius 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 that burns in air and is found in Group 5A Vertical 1–3: Two-letter symbol for a metalloid 2–4: Two-letter symbol for a metal used in U.S. coins Single Squares 1: 2: 3: 4: A colorful nonmetal A colorless gaseous nonmetal An element that makes fireworks green An element that has medicinal uses Diagonal 1–4: Two-letter symbol for an element used in electronics 2–3: Two-letter 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 an atom and its nucleus by imagining that if an atom were the size 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, and baking 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 unit is defined as a mass exactly equal to one-twelfth the 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 el

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 in which the composition of the 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 658 15.1 15.2 15.3 15.4 15.5 15.6 15.7 Brønsted 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 661 pH—A Measure of Acidity 663 Strength of Acids and Bases 666 Weak Acids and Acid Ionization Constants 670 Weak Bases and Base Ionization Constants 678 The Relationship Between the Ionization Constants of Acids and Their Conjugate Bases 680 Molecular Structure and the Strength of Acids 685 Acid-Base Properties of Salts 689 Acid-Base 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 701 Summary of Facts and Concepts 701 Key Words 702 Questions and Problems 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 717 CHEMISTRY in Action Maintaining the pH of Blood 724 16.4 16.5 16.6 16.7 16.8 16.9 16.10 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 746 Complex Ion Equilibria and Solubility 749 CHEMISTRY in Action How an Eggshell Is Formed 753 Contents 16.11 Application of the Solubility Product Principle to Qualitative Analysis 754 Key Equation 756 Summary of Facts and Concepts 757 Key Words 757 Questions and Problems 757 CHEMICAL Mystery A Hard-Boiled Snack 766 Chemistry in the Atmosphere 768 17.1 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Ammonium Nitrate—The Explosive Fertilizer 931 21.5 Oxygen and Sulfur 932 21.6 The Halogens 939 Summary of Facts and Concepts 946 Key Words 946 Questions and Problems 947 Transition Metals Chemistry and Coordination Compounds 952 22.1 22.2 22.3 22.4 22.5 22.6 22.7 Properties of the Transition Metals 954 Chemistry of Iron and Copper 957 Coordination Compounds 959 Structure of Coordination Compounds 964 Bonding in Coordination Compounds: Crystal Field Theory 967 Reactions of Coordination Compounds 973 Applications of Coordination Compounds 974 CHEMISTRY in Action Coordination Compounds in Living Systems 976 CHEMISTRY in Action Cisplatin—The Anticancer Drug 978 Key Equation 976 Summary of Facts and Concepts 976 Key Words 978 Questions and Problems 979 CHEMICAL Mystery Dating Paintings with Prussian Blue 984 xvi Contents Nuclear Chemistry 986 23.1 23.2 23.3 23.4 23.5 The Nature of Nuclear Reactions 988 Nuclear Stability 990 Natural Radioactivity 995 Nuclear Transmutation 999 Nuclear Fission 1001 CHEMISTRY in Action Nature's Own Fission Reactor 1006 23.6 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 Questions and Problems 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 1042 CHEMISTRY in Action The Petroleum Industry 1048 Summary of Facts and Concepts 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 Sickle Cell Anemia—A Molecular Disease 1074 25.4 Nucleic Acids 1076 CHEMISTRY in Action DNA Fingerprinting 1079 Summary of Facts and Concepts 1080 Key Words 1080 Questions and Problems 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 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 society." Throughout the text, Chemistry in Action and Chemical Mysteries give specific examples of chemistry as active and evolving in all facets of our lives. 47 Organic compound, p. (a) 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 is the number of protons in a nucleus; atoms of different elements have different atomic numbers. † Francis William Aston (1877–1945). We find the contribution to the average atomic mass for each isotope, then add the contributions together to 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 part 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 molecule. For safe air quality control, the 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 10228 1.67262 3 10224 1.67493 3 10224 21.6022 3 10219 11.6022 3 10219 0 21 11 0 *More refined measurements have given us a more accurate value of an electron's mass than Millikan's. Depending on whether we round off C to 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 65.3 However, if we had carried out the calculation as 3.66 3 8.45 3 2.11 on a calculator without rounding off the intermediate answer, we would have obtained 65.3 as the answer for E. A 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 beaker, the temperature of the larger quantity of water will be the same as it was in two separate 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 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 and two oxygen 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 Y is 2:1. 2.9 (a) Hypobromous acid, (b) hydrogen sulfate ion. First we need to calculate the molar mass 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 appear at the end of the chapter, following the end-of-chapter problems. Figure 1.12 balance. Answers to 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 protons is equal to the number of electrons, so the atomic number also indicates 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 compounds? 5 5B 16 6A 7 7B Mg2+ 4 4B 15 5A 6 6B Na+ 3 3B 14 4A Al3+ Common monatomic ions arranged according to their positions in the periodic table. There is some justification for this perception. The atoms of one element are different from 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 Trihydrogen nitride Solid carbon dioxide Sodium chloride Dinitrogen monoxide Calcium carbonate Calcium oxide Calcium hydroxide Sodium hydrogen carbonate Sodium carbonate decahydrate Magnesium sulfate heptahydrate 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. Strategy We refer to Table 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. The mystery of the mass ratio could now be explained. Expressed as a unit for force, however, 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: (a) 113°C, the melting point of sulfur, (b) 37°C, the normal body temperature, (c) 357°C, the boiling point of mercury. Why? One class of hydrocarbons is called the alkanes.Table 2.8 shows the names, formulas, and molecular models of the first ten straight-chain alkanes, in which the carbon chains have no branches. The conversion factor needed is the molar mass of each element. Examples 2.2 and 2.3 deal with writing molecular formulas from 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 charge, so the copper ion must have two positive 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 charge (cesium is in Group 1A, as is sodium). Describe the experimental basis for believing that the 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 cm3 1 kg 3 5 808 kg/m3 1000 g 1 3 1026 m3 (Continued) Liquid nitrogen. Practice Exercise Carry out the following arithmetic operations and 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 basis of Dalton's atomic theory, we can define an atom as 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 amu 1 carbon-12 atom 5 3 gram 1 carbon-12 atom 1.993 3 10223 g 23 5 6.022 3 10 amu/g Thus, 1 g 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°C2 1K 1°C (1.2) (1.3) (1.4) Converting °F to °C Converting °C to °F 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 at B when there are no external fields present or when the effects of the electric field and magnetic field cancel each other. Two of the three are deflected by oppositely charged metal plates (Figure 2.6). The marginal note lists additional similar problems to work in the end-of-chapter 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 HNO3 nitric 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 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 science. 1.3 The Scientific Method All sciences, including the social sciences, employ variations of what is called the scientific method, a systematic approach to research. 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. Keep in mind that the lowest temperature on the Kelvin scale is zero (0 K); therefore, it can never be negative. Thus, adding an O atom to HClO3 changes chloric acid to perchloric acid, HClO4. 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 shape, show that its radius r is proportional to the cube root of mass number (A). Dalton imagined an atom that was both extremely small and indivisible. Each hydrogen atom has a mass of only 0.000000000000000000000000166 g These numbers are cumbersome to handle, and it is easy to make mistakes when using them in arithmetic computations. 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 problem-solving steps built-up throughout the text. S N F Br P Cl 2.93 Show the 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 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 Na Atom 11 protons 11 electrons On the other hand, an anion is an ion whose net charge is negative due to an increase in the number of 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 see at a glance the big picture and focus on the main ideas of the chapter. Assume that we have 1 mole of H3PO4. motions through a microscope (Figure 2.5). 6H2O. Immediate answers are provided to the student over the Internet, day or night, on topics including chemical reactions, chemical bonding, equation balancing, equilibrium, oxidation 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 moles 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 The formulas of ionic compounds are usually the same as their empirical formulas because ionic compounds do not consist of discrete molecular units. (a) Calculate the number of Pt atoms in the cube. The following examples illustrate the use of scientific 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 Hemoglobin Production The Haber Process Antacids and the pH Balance in Your Stomach xviii 10 21 52 108 129 146 158 202 210 239 251 257 288 292 337 355 373 393 424 450 473 486 488 500 501 526 541 580 593 645 646 698 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, and quantitative, comprising numbers 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 protons in the nucleus of an atom of the element; it determines the identity of an element. Exceptions to the use of Greek prefixes are molecular compounds containing hydrogen. 12 Density, p. Some examples are HCl hydrogen chloride HBr hydrogen bromide SiC silicon carbide 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, the hydrogen gas, will have vanished, and all that will be left is a different 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 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 burns in oxygen gas to form water" describes a chemical property of hydrogen, because to observe this property we must carry out 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 are not the same as oxygen 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 The conversion factor on the right is the correct one. Atoms of constituent elements in a particular compound are always combined in the same proportions by mass (law of definite 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 tells us the actual number of N atoms (two) and H atoms (four) present in a hydrazine molecule. 48 Noble gases, p. Information gained from this research contributed greatly to our understanding of atomic structure. Michael 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 Summary ARIS Example Practice Problems End of Chapter Problems Quantum Tutors End of Chapter Problems 79 80 Mass Relationships in Chemical Reactions 3.1 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 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) Limiting reagent (3.9) Making a solution (4.5) 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, weak electrolytes, 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 composition is obtained by dividing the mass of each element in 1 mole of the compound by the molar mass of the compound and multiplying by 100 percent. 1.77 Percent error is often expressed as the absolute value of the difference between the true value and the experimental value, divided by the true value: percent error 5 1.78 1.79 1.80 1.81 1.82 Ztrue value 2 experimental valueZ Ztrue valueZ 3 100% The vertical lines indicate absolute value. (1.3) • We define matter and note that a 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 converting "m" to "cm," we choose the conversion factor that has meters in the denominator, 1 cm 1 3 10 22 m and write the 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

one-step calculations. (True value: 0.864 g.) The natural abundances of elements in the human body, expressed as percent by mass, are: oxygen (O), 65 percent; carbon (C), 18 percent; hydrogen (H), 10 percent; nitrogen (N), 3 percent; calcium (Ca), 1.6 percent; phosphorus (P), 1.2 percent; all other elements, 1.2 percent. Thus, 2.0 mg has two significant figures, 40.062 mL has five significant figures, and 3.040 dm has four significant figures. EXAMPLE 2.4 Write the formula of magnesium nitride, containing the Mg21 and N32 ions. Here we are concerned with two types of formulas: molecular 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, Molecules, and Ions Special Problems 2.96 On p. We will discuss the naming of organic compounds in Chapter 24. Thus, the formula mass of NaCl is the mass of one formula unit: formula mass of 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 no prefix for carbon in (a), it means that 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 10212 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 ⩽ O2⩾ 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 Community College Mary Jo Bojan Pennsylvania State University Steve Boone Central Missouri 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 7A (F, Cl, Br, I, and At) are known as halogens, and 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 lab. 1.4 (a) Two, (b) four, (c) three, (d) two, (e) three or two. The scientific method is a systematic approach to 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 fluoride (DF), where 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 Cl Atom 17 protons 17 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 accurate only to four significant figures (see table of 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 Lyle Wescott University of Mississippi Wayne Wesolowski University of Arizona Ken Williams Francis Marion University W.T. Wong, The University of Hong Kong Troy Wood University of Buffalo Gloria A. The leaf on the right was 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 (Ag) 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 composition does not change, regardless of whether the water comes from a faucet in the United States, a lake in Outer Mongolia, or the ice caps on Mars. Organic compounds contain carbon and elements like hydrogen, oxygen, and nitrogen. His work proved that the charge on each electron was exactly the same. SiCl4, LiF, BaCl2, B2H6, KCl, C2H4 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 liter of water, starting at room temperature (25°C), how much would it cost 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 or heterogeneous, 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 sulfide, (c) sodium hydrogen sulfide, (d) magnesium phosphate, (e) calcium hydrogen phosphate, (f) potassium dihydrogen phosphate, (g) iodine heptafluoride, (h) ammonium 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 and mass number of an atom of an element (X) is as follows: mass number 8n atomic number 8n A ZX Protons and neutrons are collectively called nucleons. Compounds are composed of atoms of more than one element. Example 3.5 illustrates this approach. In space-filling models, atoms are represented by truncated balls held together by snap Molecular formula Structural formula Hydrogen Water Ammonia Methane H2 H2O NH3 CH4 H±N±H W H H W H±C±H W H H±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 sulfuric acid that gives rise to the acid rain 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 degrees Fahrenheit and 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, polyatomic molecules, molecules that are not compounds, molecules that are 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 numbers? Any number expressed in this way is said to be written in scientific notation. The 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 and molecular 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, 1.39, 1.40, 1.44, 1.45, 1.48, 1.56, 1.57, 1.58, 1.61, 1.63, 1.64, 1.65, 1.66, 1.67, 1.76, 1.78, 1.79, 1.80, 1.81, 1.83, 1.88, 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 phenomena that is always the same under the same conditions. 43 Carbon monoxide 1 O ± ±±± ± 1 C Carbon dioxide 2 O ± ±±±±±±± ± 1 C Ratio of oxygen in carbon monoxide to oxygen in carbon dioxide: 1:2 Figure 2.2 An illustration of the law of multiple proportions. Gene therapy promises to be the fourth revolution in medicine. If only 74 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 synthesized, although they have not yet 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. Among the many hypotheses put forward to account for their disappearance 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 negative charges, it must consist of negatively charged particles. How does it 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 conversions is pounds → grams → milligrams Using the following 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 the pheromone (in grams per liter) in a cylindrical air space having a radius of 0.50 mi and a height 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: Check your understanding by using the 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 cations and anions. How many atoms of H would 60.06 g of urea contain? 2.101 A cube 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) HClO (hypochlorous acid) ClO2 4 ClO2 3 ClO2 2 ClO2 (perchlorate) (chlorate) (chlorite) (hypochlorite) 2.7 Naming Compounds Example 2.9 deals with the nomenclature for an oxoacid and an oxoanion. Substances differ from one another in composition and can be identified by their appearance, smell, taste, 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 sodium atom. Each one makes three measurements. Thus, sugar can be recovered from a water solution by heating 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 3 103 cm and then carry out the addition (2.64 cm 1 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 English physicist, James Chadwick,† in 1932. (2.8) S ince ancient times humans have pondered the nature of 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 wire until it is reduced to two separate 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 moles contained in 16.3 g of S, and then calculating the number of S atoms from the number of moles of S: grams of S → moles of S → 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 joined in a ring. The sum of the charges is 2(13) 1 3(22) 5 0. As we will see in Chapter 3, when chemists analyze an unknown compound, the first step is usually the determination of the compound's empirical formula. Nothing could be easier! Accessed from the instructor side of your textbook's ARIS website, Presentation Center's dynamic search engine enables you to explore by discipline, course, textbook chapter, asset type, or keyword. Dalton was described as an indifferent experimenter, and singularly wanting in the language and power of illustration. It is the love of the search that keeps many scientists in the laboratory. How does the study of dinosaur extinction illustrate the scientific method? Strategy Note that the compounds in (a) and (b) contain both metal and nonmetal atoms, so we expect them to be ionic compounds. The problem-solving steps guide the student 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 Hg2(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, (h) tetraphosphorus decasulfide, (i) mercury(II) oxide, (j) mercury(I) iodide, (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. Some examples include: — Revised the treatment of Amounts of Reactants and Products in Chapter 3. For example, two copper pennies will have a combined mass that is the sum of the masses of each penny, and the length of two tennis courts is the sum of the lengths of each tennis court. For example, the atomic number of fluorine is 9. Note that 1 mole of water weighs 18.02 g and contains 6.022 3 1023 H2O molecules, just as 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 for that particular section of the chapter. When subjected to a temperature of about 100°C, the yolk and the egg white undergo changes that alter 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 Chromium Cobalt Copper Some Common Elements and Their Symbols Symbol Al As Ba Bi Br Ca C Cl Cr Co Cu Name Fluorine 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 for the student to solve. Our reference for the names of cations and anions is Table 2.3. Keep in mind that if a metal atom can form cations 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 symbols and equations for communication; 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 brief 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 Dayton Bridget Trogden Mercer University Cyriacus Uzomba Austin Community College John B. • Student Interactive Activity shows where the electronic media are used in the chapter. † 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: 2.57(c), (i), (j). This index makes it convenient to quickly look up information when you are solving 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 one neutron, and tritium has one proton and two neutrons. In this system, the Roman numeral I indicates one positive charge, II means two 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, we should keep in mind that (1) the elements are not evenly distributed throughout Earth's 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 When chemistry was a young science and the number of known 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 electrons Number of protons 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 at the end of the number and 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 3 106) 1.32 Express the answers to the following calculations in scientific notation: (a) 0.0095 1 (8.5 3 1023) (b) 653 4 (5.75 3 1028) (c) 850,000 2 (9.0 3 105) (d) (3.6 3 1024) 3 (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 element 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) and iron(III), 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 xxv 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 Stuart Burris Western Kentucky University Les Butler Louisiana State University Bindu Chakravarty Houston Community College Liwei Chen Ohio University Tom Clausen University of Alaska–Fairbanks Allen Clabo Francis Marion University 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 exactly 12 atomic mass unit (amu). Can you suggest what "noble" means in this context? [Hint: The atomic 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 Chang CHEMISTRY Chemistry The Study of 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 divided by the molar mass 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 accepted concentration for this purpose is 1 ppm chlorine, or 1 g of chlorine per million grams of water. 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

permanganate (MnO2 4) peroxide (O22 2) phosphate (PO32 4) sulfate (SO22) 4 sulfide (S22) sulfite (SO22 3) thiocyanate (SCN2) *Mercury(I) exists as a pair as shown. In Chapter 2, we will begin to explore the microscopic world of atoms and molecules. He was the first scientist to explore the dangers of mercury poisoning. Track Student Progress • • Assignments are automatically graded. (e) A spoonful of table salt dissolves in a bowl of soup. Giancarlo University of Mary Washington Kenneth Goldsby Florida State University Eric Goll Brookdale Community College John Gorden Auburn University Todor Gounev University of Missouri–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 or from 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 subscripts to show the type and number of atoms contained in the smallest unit of a compound. 337 8.4 8.5 8.6 Ionization Energy 337 Electron Affinity 341 Variation in Chemical Properties of the Representative Elements 344 CHEMISTRY in Action Discovery of the Noble Gases 355 Contents Key Equation 356 Summary of Facts and Concepts 356 Key Words 356 Questions and Problems 356 Chemical Bonding I: Basic Concepts 364 9.1 9.2 9.3 Lewis Dot Symbols 366 The Ionic Bond 367 Lattice 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 Structure 383 The Concept of Resonance 386 Exceptions to the Octet Rule 389 CHEMISTRY in Action 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 and Hybridization of Atomic Orbitals 408 10.1 Molecular Geometry 410 10.2 Dipole Moment 420 CHEMISTRY in Action Microwave Ovens—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 Molecules Containing Double and Triple Bonds 437 Molecular Orbital Theory 440 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 Avogadro's number is the key to the second step. Calculate the mass of 5.50 mL of the liquid. These relationships in turn will help us to explain the composition of compounds and the ways in which composition 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 N (which is between 1 and 10). Instead, we write the formula as MgxNy, where x and y are subscripts to be determined. This mass of carbon-12 is its molar mass (m), defined as the mass (in grams 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 they form between atoms approximate the bond 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 the "-ous" acid, the anion's name ends with "-ite." Thus, the anion ClO2 2 derived 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 Cu1 ion), (b) manganese oxide (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 electrons is equal to 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 and write formulas for 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 1.98 2. 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. 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 1026 m3 1 dm3 5 (1 3 1021 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- 1 2 3 4 5 6 7 8 9 10 Binary compounds containing carbon and hydrogen are organic 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 Raymond Chang Williams College CHEMISTRY, TENTH EDITION Published by McGraw-Hill, a business unit of The McGraw-Hill Companies, Inc., 1221 Avenue of the Americas, New 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. Austin State 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 provides a quick review of 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 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. CHEMISTRY in Action Distribution of Elements on Earth and in Living Systems T he majority of elements are naturally occurring. 2H2O LiCl ? Careful study of 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 from Examples TEXT problem Electronic Homework problem Test your knowledge using ARIS, the McGraw-Hill solution to electronic homework. (Because electrons are much lighter than protons, their contribution 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" acid, the 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 molecules) produce positive ions by dislodging an electron from each atom 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 2.15 Naming oxoacids and oxoanions. This approach is sometimes called the "back-of-the-envelope calculation" because it can be done easily without 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. 7H2O 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 CH4 Ethane C2H6 Propane C3H8 Butane 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 Methylamine H H O C C OH H Acetic acid CH3COOH 70 Atoms, Molecules, and Ions The chemical properties of these 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 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 equal that on a Fahrenheit thermometer? Therefore, isotopes of the same element have similar chemistries, forming the same types of compounds and displaying 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 microwave region. If a number is greater than 1, then all the zeros written to the right of the decimal point count as significant figures. The "engine" that drives the ongoing computer revolution is 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 → kg and cm3 → 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 composition by mass of the compound. Practice Exercise How many H atoms are in 72.5 g of isopropanol (rubbing alcohol), C3H8O? 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 superscript denotes the mass number (A) and 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 quest. 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-five") and uranium-238 (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 neutrons in the nucleus. To separate the iron-sand mixture, we can use a magnet to remove the iron filings from the sand, because sand is not attracted to the magnet [see Figure 1.4(b)]. Iridium is very rare in Earth's crust but is comparatively abundant in asteroids. Like ozone, water (H2O) and ammonia (NH3) are polyatomic molecules. The key equations are also presented in the chapter summary materials for easy access in review and study. Table 1.2 shows the seven SI base units. For example, Element Na sodium K potassium Mg magnesium Al aluminum 1 Na K1 Mg21 Al31 Name of Cation sodium ion (or sodium cation) potassium ion (or potassium cation) magnesium ion (or magnesium cation) aluminum ion (or aluminum cation) Many ionic compounds are binary compounds, or compounds formed from just two elements. Note that the Hg221 ion contains 2.6 Chemical Formulas 2.6 Chemical Formulas Chemists use chemical formulas to express the composition of molecules and ionic compounds in terms of chemical symbols. The development of science has been irregular and sometimes even illogical. In other 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 problem-solving and think through problems logically and systematically. Figure 2.1 (a) According to Dalton's atomic theory, atoms of the same element are identical, but atoms of one 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 without changing the identities of the 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 chloride HCl hydrochloric acid The name assigned to the compound depends on its physical state. Why wasn't the more abundant hydrogen detected? — Revised the explanation of thermochemical equations in Chapter 6. For example, the molecular mass of H2O is 2(atomic mass of H) 1 atomic mass of O or 2(1.008 amu) 1 16.00 amu 5 18.02 amu In general, we need to multiply the 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, especially the transition 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, and so on. 34 Chemistry: The Study of Change 1.38 Three apprentice tailors (X, Y, and Z) are assigned the task of measuring the seam of a pair of trousers. Check your answer for the correct sign, units, and significant figures. 44 Empirical formula, p. Roach Emporia State University Rojrit Rojanathanes, Chulalongkorn University Steve Rowley Middlesex County College Kresimir Rupnik Louisiana State University Somnath Sarkar Central Missouri State University Jerry Sarquis Miami University Susan Scheble Metropolitan 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 alkali metals, and the Group 2A elements (Be, Mg, Ca, Sr, Ba, and Ra) 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 and an example of a heterogeneous 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 answers are reported, all answers, intermediate and final, will be rounded. (b) There are two silicon atoms 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, read the chapter outline and 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 10 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 numbers involved are integers (for example, in counting 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: 0.0000000056 × 0.00000000048 = 0.0000000000000000002688 It would be easy for us to miss one zero or add one more zero after the decimal point. Thus, 8.724 rounds off to 8.72 if we want only two digits after the decimal point. Animations can be found online in the Chang ARIS website. In general, to apply dimensional analysis we use the relationship given quantity 3 conversion factor 5 desired quantity and the units cancel as follows: Remember that the unit we want appears in the numerator and 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 The simplest type of 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 compounds: (a) sulfur dioxide (SO2) and (b) caffeine (C8H10N4O2). (The density of mercury 5 13.6 g/mL.) 1.59 The following procedure was used to determine the volume of a flask. Thus, 400 cm may have one significant figure (the digit 4), two significant figures (40), or three significant figures (400). 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 observed without changing its identity and chemical 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 enable us to deduce the 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 Y Atoms of element X (a) Compounds of elements X and Y (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 iridium (Ir). 49 Metal, p. For each element, we multiply the atomic mass of the element by the number of atoms of that 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: A Science for the Twenty-First Century The Chinese characters for chemistry mean "The study of change." Chemistry is the study of matter and the changes it undergoes. Calculate the volume in liters 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 H2O

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