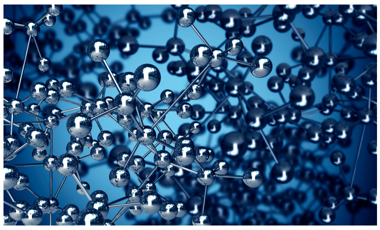
1

The periodic table

MATTER is everywhere around you, from the water you drink to the air you inhale. Matter is made of elements and elements are made of atoms. Even the atoms of an elements can be different, having distinct number of protons and neutrons. This chapter covers the principles of the atomic structure. You will learn what makes an atom and will be able to quantify the particles that make atoms. Perhaps more importantly, you will also learn about the periodic table of the elements and the different types of chemical formulas.



GOALS

1. Navigate the periodic table
2. Calculate average atomic masses, number of electrons, protons and neutrons in an atom
3. Calculate simple molecular weights
4. Calculate molecular formulas from empirical formulas

1.1 The periodic table

The periodic table is a chart containing all known elements arranged in increasing number of electrons per atom in a way that elements with similar chemical and physical properties are located together. The periodic table contains all existing elements–some of them are synthetic others are natural–that form the matter arranged in columns and rows. Every element has a different name accompanied by a symbol that represents their name. The tabular arrangement of elements in the form of rows and columns allow further classification of the elements according to their properties. This section will cover the different features of the periodic table.

Discussion: Why having a periodic table? What is the basic information all periodic tables provide? Do you know any other periodic table design?

Elements and Symbols Elements cannot be broken down into simpler substances. For example aluminum is an element only made of aluminum atoms and if you analyze the composition of a piece of this metals you would only find aluminium atoms. Chemical symbols are one- or two-letter abbreviations that represent the names of the elements. Only the first letter is capitalized and if a second letter exist in the element's name, the second letter should be lowercase. For example, the chemical symbol for aluminum is Al with capital A and lowercase l. The periodic table in next page contains the symbols of all elements.

> “Nothing exists except atoms and empty space; everything else is opinion.”
>
> *Democritus*

Sample Problem 1

Give the symbol or name the following elements: Au, Iron, Na and Iodine.

SOLUTION

The chemical symbol of Au is Gold. The chemical symbol of Iron is Fe and the chemical symbol of Iodine is I.

STUDY CHECK

Give the symbol or name the following elements: Ni.

Periods and groups The periodic table contains all elements arranged in rows and columns. The horizontal rows are called *periods* and the vertical columns are called *groups or families*. For example, the first period contains hydrogen (H) and helium (He), whereas the second group contains Beryllium (Be), Magnesium (Mg), Calcium (Ca), Strontium (Sr), Barium (Ba) and Radium (Ra). There are seven periods (periods 1-7) and 18 groups. Some of the groups are labeled with an A (e.g. group 8A) whereas others are labeled with a B (e.g. group 8B). The groups numbers can be found written with roman numbers and a letters (A or B) or with a more modern group numbering of 1-18 going across the periodic table. For example, the group 2 (Mg-Ra) can also be called IIA, and the group 13 (B-Ti) is also known as IIIA.

Properties in the periodic table The physical and chemical properties of some elements of the table are similar, and these similarities led to the organization of the periodic table. Elements in the same group share properties and for example, oxygen and sulfur have similar properties: both are reactive elements. Differently, the properties across periods change going from metals to nonmetals. For example, the properties of Li and Ne are very different and lithium is a reactive metal whereas neon is a nonreactive gas.

Metals, Nonmetals, and Metalloids Overall, the elements of the periodic table can be classify as metals, nonmetals, and metalloids. Metals are those elements on the left of the table and nonmetals are the elements on the right of the table. The elements between metals and nonmetals are called metalloids and include only B, Si, Ge, As, Sb, Te, Po, and At. Metals are shiny solids and usually melt at higher temperatures. Some examples of metals are Gold (Au) or Iron (Fe). Nonmetals are often poor conductors of heat and electricity with low melting points. They also tend to be matt (non-shinny), malleable, or ductile. Some examples of nonmetals are Carbon (C) or Nitrogen (N). Metalloids are elements that share some properties with metals and others with the nonmetals. For example, they are better conductors of heat and electricity than the nonmetals, but not as good conductors as the metals. Metalloids are semiconductors because they can act as both conductors and insulators under certain conditions. An example of metalloids is Silicon (Si) that should not be confused from silicone, a chemical employed in prosthetics.

Sample Problem 2

Answer the following questions: (a) Give the group and period of the following elements, and give the name: Ca, Ir, and C. (b) Classify as alkali metal, alkali earth metal, transition metal, halogen or noble gas, and give the name: Mg, Li, Co, He, F. (c) Classify as metal, nonmetal or metalloid, and give the name: Ba, N, Si.

SOLUTION

(a)The period and group of Ca (Calcium) is 2 (2A) and 4, respectively. The period and group of Ir (Iridium) is 9 (8B) and 6, respectively. The period and group of C (Carbon) is 14 (IVA) and 2, respectively. (b) Mg (Magnesium) is an alkali earth metal, whereas Li (Lithium) is a alkali metal. Co (Cobalt) is a transition metal. He (Helium) is a noble gas. F (Fluorine) is an halogen. (c) Ba (Barium) is a metal. N (Nitrogen) is a nonmetal. Si (Sillicon) is a metalloid.

STUDY CHECK

Answer the following questions: (a) Give the group and period of the following elements, and give the name: Cl. (b) Classify as alkali metal, alkali earth metal,

> transition metal, halogen or noble gas, and give the name: Ne. (c) Classify as metal, nonmetal or metalloid, and give the name: W.

`Classification of elements in terms of groups` Some of the groups in the periodic table have specific names such as alkali metals, alkaline earth metals, transition metals, chalcogens, halogens or noble gases. Alkali metals are the group 1A elements: lithium (Li), sodium (Na), potassium (K), rubidium (Rb), cesium (Cs), and francium (Fr). Alkali elements are soft and shiny metals, and they are also good conductors of heat and electricity, with low melting points. Alkali earth metals are the group 2A (2) elements: beryllium (Be), magnesium (Mg), calcium (Ca), strontium (Sr), barium (Ba), and radium (Ra). Transition metals are the elements from group 3 to 12 and they are located in the middle of the table. Chalcogens are the group 6A (16) elements: oxygen (O), sulfur (S), selenium (Se), tellurium (Te), and polonium (Po). Halogens are the group 7A (17) elements: fluorine (F), chlorine (Cl), bromine (Br), iodine (I), and astatine (At). Halogens are very reactive elements. Finally, noble gases are the group 8A (18) elements: helium (He), neon (Ne), argon (Ar), krypton (Kr), xenon (Xe), and radon (Rn). They are inert and rarely combine with other elements in the periodic table, like a noble family: have you ever meet a royal?

`How to classify Hydrogen` At first sight, hydrogen (H) may seem to be put in the wrong spot at the periodic table. Although it is located at the top of Group 1A (1), it is not an alkali metal, as it has very different properties. Thus hydrogen does not belong to the alkali metals, being a nonmetal.

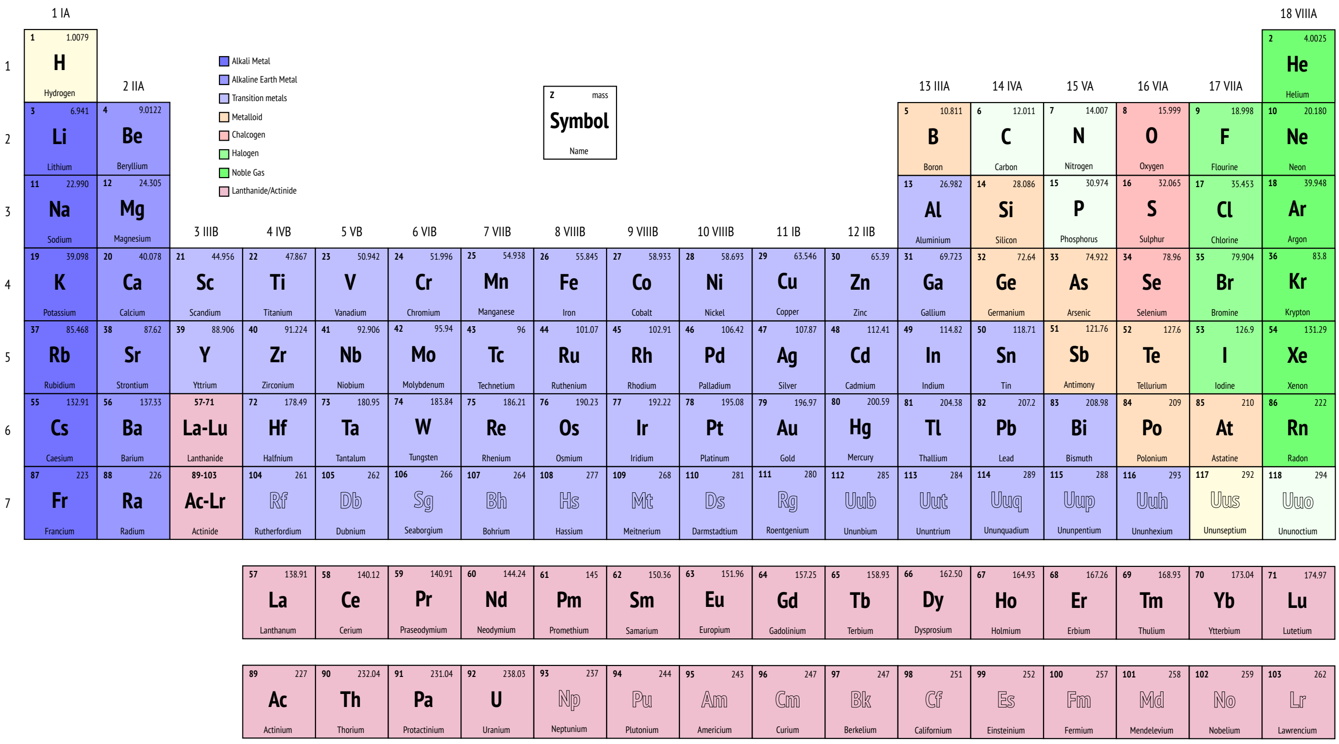


Figure 1.1 The periodic table of the elements

1.2 The atom

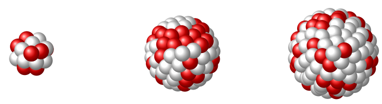
Atoms are the smallest piece of an element that retains its characteristics. They are the building blocks of matter. This section covers the structure of the atom. You will learn how to calculate the number of subatomic particles that made an atom and how to differentiate atoms of an element–all atoms of an elements are not equal.

`Atomic Structure` Atoms contain three atomic particles: the proton, neutron, and electron. Protons have positive charge (+), whereas electrons carry negative charge (–). Neutrons on the other hand are neutral, and they have no electrical charge. Protons and neutrons are located in the core of the atom, which is called the nucleus, and account for the mass of the atom. Electrons are delocalized in the exterior part of the atoms. They are not necessarily located in a specific spot and their existence spreads in the area next to the nucleus. When an atoms is neutral it has no charge and the number of electrons and protons are the same. Some atoms have positive charge, resulting of removing electrons, and we call these cations. Others–called anions–can have negative charge as a result of accepting a negatively charged electron.

`Atomic and mass number` Elements are made of atoms, and each atom of an element is characterized by a atomic number (Z) and a mass number (A). The atomic number (Z) of an element indicates the number of electrons of an atom. This number can be easily located in the periodic table. The mass number (A) of an element indicates the combined number of protons and neutrons. Mass numbers are nowhere located in the periodic table as different atoms of the same element can have different mass numbers. Both A and Z for an atom X are indicated in the following form called isotope notation:

$$^{A}_{Z}X$$

As an example, the notation $^{24}_{12}Mg$ means that the atomic number of Mg is Z=12 and the mass number is A=24. Remember that the atomic number can be found in the periodic table whereas the mass number A is not on the table. By means of the isotope notation, one can quickly identify the number of protons, neutrons and electrons in an atom. As the atomic number is always indicated on the bottom part (e.g. Mg has 12 electrons). At the same time, the number of electrons and protons in a neutral atom is the same–neutral means an atom without a charge. The number of neutrons of an isotope can be computed by subtracting the atomic number from the mass number.



$^{12}_{6}C$ $^{44}_{20}Ca$ $^{197}_{79}Au$

Sample Problem 3

Calculate the number of protons, neutrons and electrons of the following atoms:

(a) $^{27}_{12}Mg$ (b) $^{22}_{10}Ne$ (c) $^{20}_{10}Ne$

SOLUTION

(a) $^{27}_{12}Mg$ has 12 electrons (Z=12) and 12 protons as well (the number of electrons and protons are the same if the atom is neutral), and 15 neutrons, as 27-12=15. (b) $^{22}_{10}Ne$ has 10 electrons and 10 protons, and 12 neutrons. (c) $^{20}_{10}Ne$ has10 electrons and 10 protons, and 10 neutrons as well.

STUDY CHECK

Calculate the number of protons, neutrons and electrons of the following atoms:

(a) $^{32}_{16}S$ (b) $^{34}_{16}S$ (c) $^{36}_{16}S$

Isotopes All atoms of the same element are not the same. Some are heavier than others. Isotopes are atoms of the same element with different numbers of neutrons and therefore with different mass number but with the same atomic number. For example: $^{24}_{12}Mg$, $^{25}_{12}Mg$ and $^{26}_{12}Mg$ are three isotopes of Mg. $^{27}_{12}Mg$ is heavier than $^{24}_{12}Mg$ as it contain more neutrons and protons in the nucleus. Each of the isotopes has a specific abundance, as some isotopes are more abundant than other. For example, the abundance of $^{24}_{12}Mg$ is 79%, and the abundance of $^{25}_{12}Mg$ and $^{26}_{12}Mg$ is 10% and 11%, respectively. This means, $^{24}_{12}Mg$ is more abundant than for example $^{26}_{12}Mg$.

Average atomic mass The average atomic mass represents the mass of the atoms of an element and results from all existing isotopes taking into account their abundance. The units of atomic mass are called *amu*, which stands for atomic mass units. This value can be simply found at any periodic table. Using the periodic table provided in this manual Figure1.1, you can find the atomic mass of each element on top of the symbol at the right side. For example, the atomic mass of oxygen (O) is 15.999 amu and the atomic mass of nitrogen (N) is 14.007 amu. As atoms are made of numerous isotopes–this means different atoms of the same element but with different number of neutrons and hence different weight–the atomic mass found in the periodic table is an average that result from including the mass of the different isotopes and their abundance. That is you need to do an average of the mass of each isotope using values of abundance. In another words: the *average atomic mass* of an element–herein called simply atomic mass–, expressed in amu (atomic mass units), is the weighted average of the masses of the individual isotopes of the element. For an element with n isotopes with different masses (A_1, A_2, ..., A_n) and different fractional abundances for each isotope (f_1, f_2, .., f_n), the atomic mass is given by

$$\text{Atomic mass} = \sum_{i=1}^{n} A_i \cdot f_i = A_1 \cdot f_1 + A_2 \cdot f_2 + \cdots + A_n \cdot f_n$$

Also, note that when adding the fractional abundaces of all isotopes, one should obtain a value of one:

$$\sum_{i=1}^{n} f_i = f_1 + f_2 + \cdots + f_n = 1$$

Sample Problem 4

Naturally occurring copper (Cu) consists of 69.17% ^{63}Cu and 30.83% ^{65}Cu. The mass of ^{63}Cu is 62.939598 amu, and the mass of ^{65}Cu is 64.927793 amu. What is the atomic mass of copper?

SOLUTION

The weighted average is the sum of the mass of each isotope times its fractional abundance. We have that the isotope ^{63}Cu has a mass of 62.939598 amu and an abundance of 69.17%, that is the same as 0.6917. At the same time, the isotope ^{65}Cu has a mass of 64.927793 amu and an abundance of 0.3083. After adding both contributions, we have:

$$62.939598\, amu \times \frac{69.17}{100} + 64.927793\, amu \times \frac{30.83}{100} = 63.55\, amu$$

STUDY CHECK

Lithium is made up of two isotopes, Li-7 (7.016003 amu) and Li-6 (6.015121 amu). Calculate the percent abundance of each isotope knowing that copper's atomic weight is 6.94 amu.

Table 1.1 Isotope abundance of some elements

Element	Isotope	% Abundance	Element	Isotope	% Abundance
Hydrogen	^{1}H	99.9885%	Silicon	^{28}Si	92.2297%
	^{2}H	0.0115%		^{29}Si	4.6832%
Helium	^{3}He	0.000137%		^{30}Si	3.0872%
	^{4}He	99.999863%	Sulfur	^{32}S	94.93%
Lithium	^{6}Li	7.59%		^{33}S	0.76%
	^{7}Li	92.41%		^{34}S	4.29%
Boron	^{10}B	19.9%		^{36}S	0.02%
	^{11}B	80.1%	Chlorine	^{35}Cl	75.78%
Carbon	^{12}C	98.93%		^{37}Cl	24.22%
	^{13}C	1.07%	Argon	^{36}Ar	0.3365%
Nitrogen	^{14}N	99.632%		^{38}Ar	0.0632%
	^{15}N	0.368%		^{40}Ar	99.6003%
Oxygen	^{16}N	99.757%	Potassium	^{39}K	93.2581%
	^{17}O	0.038%		^{40}K	0.0117%
	^{16}O	0.205%		^{41}K	6.7302%

1.3 An introduction to molecules

The periodic table contains all elements in nature. At the same time, elements combine to form molecules. For example, in the air there are traces of Argon–this is an element– and also water, a molecule (H_2O) that results from the combination of two elements, hydrogen (H) and oxygen (O). This section will first introduce some of the properties of molecules, without paying attention to their chemical names that will covered in the following chapters.

`Molecular weight` Here are two example of molecules: molecular oxygen O_2 and molecular nitrogen N_2. How do we interpret these formulas? The subscript "2" indicates that each molecule contains two atoms. For example, a O_2 molecule is made of two oxygen atoms O. At the same time, the weight of a set of molecules is called the molecular weight (MW). However, you will find different terms to refer to the same property such as: molecular mass, molar mass, or formula unit mass. All these terms indeed mean the weight a large set of molecules. We can calculate the MW by adding the weight of each atom that form the molecule taking into the account the number of atoms of each element present in the molecule.The units of molecular weight are the same as the units of atomic weight: amu, atomic mass units.

Sample Problem 5

Calculate: (a) The atomic weight of O; (b) the molecular mass of molecular oxygen, O_2

SOLUTION

(a) According to the periodic table the atomic weight (AW) of O is 15.999 amu.

(b) The molar mass of O_2 is the result of adding the atomic masses of 2O atoms, that is 31.998 amu, close to 32 amu.

STUDY CHECK

Calculate the molar mass of water H_2O and ammonia, NH_3

`Mass percent composition of a compound` Look at these two molecules: C_2H_2 and C_2H_6. They contain different amounts of hydrogen. We quantify the amount of an element in a compound by means of the mass $\%$ composition. The mass $\%$ of an element in a compound is the mass of the element with respect to the molecular weight of the molecule in percent form. Mind that you have to take into account the molecular indexes in the compound as C_2H_2 is made of 2H and C_2H_6 is made of 6H. For example, given that the molar mass of C_2H_2 is 26 amu, the mass $\%$ of hydrogen in C_2H_2 would be:

$$\%_H \text{ in } \mathrm{C_2H_2} = \frac{2 \cdot AW(H)}{MW(\mathrm{C_2H_2})} \times 100 = \frac{2 \cdot 1}{26} \times 100 = 7.7\%$$

Similarly, the mass $\%$ of C would be:

$$\%_C \text{ in } \mathrm{C_2H_2} = \frac{2 \cdot AW(C)}{MW(\mathrm{C_2H_2})} \times 100 = \frac{2 \cdot 12}{26} \times 100 = 92.3\%$$

By adding the mass $\%$ of all elements in a molecule we should obtain 100.

$$\%_H \text{ in } \mathrm{C_2H_2} + \%_C \text{ in } \mathrm{C_2H_2} = 100$$

Sample Problem 6

Calculate the mass $\%$ composition for each element of glucose, $C_6H_{12}O_6$.

SOLUTION

We first need the molecular weight of glucose, $C_6H_{12}O_6$, that is: $6 \cdot 12 + 12 \cdot 1 + 6 \cdot 16 = 180$ amu. Now we can calculate the mass percent of carbon, hydrogen and oxygen:

$$\%_C \text{ in } \mathrm{C_6H_{12}O_6} = \frac{6 \cdot 12}{180} \times 100 = 40\%$$

$$\%_H \text{ in } \mathrm{C_6H_{12}O_6} = \frac{12 \cdot 1}{180} \times 100 = 6.6\%$$

By subtraction, we have that $\%_C$ in $\mathrm{C_6H_{12}O_6} = 53.4$.

STUDY CHECK

Ureas $CO(NH_2)_2$ is a colorless crystalline compound excreted in urine, product of protein metabolism in mammals. Calculate the mass $\%$ composition for each element of urea.

1.4 Empirical and molecular formula of a chemical

There are two different types of formulas: molecular formulas and empirical formulas. Empirical formula (EFs) are simplified formulas resulting from an experiment, whereas molecular formulas (MFs) are exact formulas of molecules. For example: the molecular formula of hydrogen peroxide, a mild antiseptic used on the skin to prevent infection of minor cuts, is H_2O_2 as the hydrogen peroxide molecule is made of two oxygen and two hydrogen atoms. Differently, the empirical formula of the same chemical is HO, being this the result of the simplification of H_2O_2. One can obtain empirical formulas simply by dividing the molecular formula by the smallest integer number, of course, given you know the molecular formula. The word empirical means "from an experiment", and the use of empirical formulas comes from the fact that the formulas of all chemicals actually come from experiments, and from experiments one normally can only obtain ratios of atomic composition.

Sample Problem 7

From the following formulas identify the empirical and molecular formulas: P_4O_{10}, C_3H_6O, N_2O_4 and C_5H_{11}.

SOLUTION

Empirical formulas are simplified versions of molecular formulas. For example, C_3H_6O and C_5H_{11} are empirical formulas. Differently, P_4O_{10} and and N_2O_4 are molecular formulas.

STUDY CHECK

Given the following molecular formulas, obtain the corresponding empirical formula: P_4O_{10}, N_2O_4 and $C_6H_{18}O_3$.

Molecular weight of empirical formulas and molecular formulas

The molecular weight of an empirical formula and its corresponding molecular formula are related by the following formula:

$$\boxed{n = \frac{MW_{MF}}{MW_{EF}}}$$

where:

MW_{EF} is the molecular weight of the empirical formula

MW_{MF} is the molecular weight of the molecular formula

n is a integer number such as 1, 2, 3...

Understanding the formula above is simple. On one hand, the MW of a molecular formula H_2O_2 that is 34 amu. On the other hand, the molecular weight of the empirical formula of the same chemical HO is 17 amu. If we do $34/17$ we would obtain 2, as we need to multiply HO by two in order to obtain H_2O_2. As a final note, mind that empirical formulas are just simplified formulas. So when we think about the molecular weight of a chemical we normally have molecular formula in mind. Let us work on an example:

Sample Problem 8

Given that the empirical formula of dichloromethane is $ClCH_2$ and the molecular weigh of the chemical is 98amu, calculate the molecular formula of dichloromethane.

SOLUTION

Given the empirical formula of dichloromethane one can think of many different molecular formulas, for example: $Cl_3C_3H_6$ or $Cl_2C_2H_4$. From these, and many other, there is only on real molecular formula. How do we calculate the real molecular formula? By comparing the MW of the molecular and empirical formula we can figure out the number of time we need to multiply the MF to obtain the EF. We know the MW is 98amu. Using the EF we can also calculate a MW: $35 + 12 + 2 \cdot 1 = 49$ amu. If we compare both number using the formula:

$$n = \frac{MW_{MF}}{MW_{EF}}$$

we have: $n = 98/49$ and solving we have $n = 2$. Therefore the MF is: $Cl_2C_2H_4$.

STUDY CHECK

The empirical formula of dinitrogen tetroxide, a red-brown liquid with an unpleasant chemical odor, is NO_2 and the molecular weigh of the chemical is 92 amu. Calculate the molecular formula of dinitrogen tetroxide.

1.5 Determining empirical formulas

We said that the formula of a chemical that takes into a count the correct number of atoms in a molecule is the molecular formula and therefore the real molecular weight of a chemical comes from these formulas. Empirical formulas are obtained from experiments in which a chemical is fragmented and analyzed so that the elements in the molecule and the mass percentage of each element is determined. Molecular formulas are obtained by using the molecular weight of the chemical and the empirical formula. Mind that the formula of a chemical that takes into a count the correct number of atoms in a molecule is the molecular formula and therefore the real molecular weight of a chemical comes from these formulas. Let us work on an example in order to learn the procedure of obtaining molecular formulas.

Calculating molecular formulas By means of a experiment, we want to calculate the empirical formula of a chemical given that the chemical contains 2.8 g of nitrogen and 6.4 g of oxygen. In order to calculate the EF we will set up a table like the one presented below.

Empirical Formula Calculation		
	N	O
Grams	2.8g	6.4g
AW	14	16
Grams/AW	0.2	0.4
$\div$ by smallest	1	2
Formula	N_1O_2=NO_2	

In each column we will add each of the elements that form the molecule. In the first row we will include the grams of each element (sometimes this information is given in terms of mass %), in the second we will divide the grams of each element by its atomic weight (AW(N)=14amu,AW(O)=16amu). Among all numbers of the second row (in this example 0.2 and 0.4), we will select the smallest number (0.2). Once we have the smallest, we will divide all numbers by the smallest and that will give us round numbers (1 and 2); these will be the numbers in an empirical formula: NO_2.

Sample Problem 9

The mass percentage composition of a compound is: 18.59% O, 37.25% S, and 44.16% F. Calculate its empirical formula.

SOLUTION

We will set up the the molecular formula table, knowing that the percentage are mass percentages, that is the mass of each element in the chemical, hence they should go in the grams row. Also the atomic weights of O, S and F are 16, 32 and 19 amu.

Empirical Formula Calculation

	O	S	F
Grams	0.1859g	0.3725g	0.4416g
AW	16	32	19
Grams/AW	0.0116	0.0116	0.0232
÷ by smallest	1	1	2
Formula	OSF_2		

STUDY CHECK

What is the empirical formula of a compound if a sample contains 10.28 g of C, 1.71 H and 12.71 g of oxygen?

CHAPTER 1

The periodic table

1.1 Select from below the atomic symbol for the element Gold is:

(a) Go (c) G (e) Ol
(b) Au (d) Ca

1.2 The atomic symbol for aluminum is:

(a) Al (c) A (e) Ag
(b) Am (d) Sn

1.3 The atomic symbol for iron is:

(a) Ir (c) Fe (e) Ir
(b) Fs (d) In

1.4 Ca is the symbol for:

(a) Carbon (d) Copper
(b) Calcium
(c) Cobalt (e) Cadmium

1.5 Which of the following elements is a metal?

(a) Nitrogen (d) Iron
(b) Lithium
(c) Calcium (e) Iodine

1.6 Which of the following elements is a alkaline metal?

(a) Nitrogen (d) Iron
(b) Lithium
(c) Calcium (e) Ruthenium

1.7 Which of the following elements is a nonmetal?

(a) Nitrogen (d) Iron
(b) Lithium
(c) Calcium (e) Iodine

1.8 Which of the following elements is a halogen?

(a) Nitrogen (d) Iron
(b) Lithium
(c) Calcium (e) Iodine

1.9 What is the symbol of the element in Period 4 and Group 2?

(a) Be (d) C
(b) Mg
(c) Ca (e) Si

The Atom

1.10 In an atom, the nucleus contains

(a) an equal number of protons and electrons.
(b) all the protons and neutrons.
(c) all the protons and electrons.
(d) only neutrons.
(e) only protons.

1.11 The atomic number of an atom is equal to the number of

(a) nuclei
(b) neutrons
(c) neutrons plus protons.
(d) electrons plus protons.
(e) electrons

1.12 The mass number of an atom is equal to the number of

(a) nuclei
(b) neutrons
(c) neutrons plus protons.
(d) electrons plus protons.
(e) electrons

1.13 The mass number of an atom is equal to the number of

(a) electrons
(b) neutrons
(c) neutrons plus protons.
(d) protons

1.14 Consider a neutral atom with 30 protons and 34 neutrons. The atomic number of the element is

(a) 30
(b) 32
(c) 34
(d) 64
(e) 94

1.15 Consider a neutral atom with 30 protons and 34 neutrons. The mass number of the element is

(a) 30
(b) 32
(c) 34
(d) 64
(e) 94

1.16 The atomic mass of Ga is 69.72 amu. There are only two naturally occurring isotopes of gallium: 69Ga, with a mass of 69.0 amu, and 71Ga, with a mass of 71.0 amu. Calculate the natural abundance of the 69Ga isotope.

An introduction to molecules

1.17 Calculate the molecular mass of the following molecule: CCl_2F_2

1.18 Calculate the molecular mass of the following molecule: C_4H_{10}

1.19 Calculate the molecular mass of the following molecule: $C_6H_{10}O_8$

Empirical and Molecular Formulas

1.20 What is the empirical formula of a compound if a sample of this compound contains 2.8 g of nitrogen and 3.2 g of oxygen?

1.21 What is the empirical formula and the molecular formula of a compound if a sample contains 3 g of C, 0.5 H and 4 g of oxygen? MW=60amu

1.22 What is the empirical and molecular formula of a compound with a percent composition of 49.47% C, 5.201% H, 28.84% N, and 16.48% O, if its molecular mass is 194.2 amu.

1.23 A 1.587 g sample of a compound containing N and O was analyzed finding a composition of 0.483 g of Nitrogen and 1.104 g of Oxygen. Calculate the empirical formula of the compound.

Answers **1.1** (b) **1.3** (c) **1.5** (d) **1.7** (a) **1.9** (c) **1.11** (e) **1.13** (c) **1.15** (d) **1.17** 121 amu **1.19** 210 amu **1.21** CH_2O **1.23** NO_2