SAWA UNIVERSITY

Atomic structure

جامعة ساوة

كلية التقنية الهندسية

قسم هندسة التبريد والتكييف

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ATOMIC STRUCTURE التركيب الذري

تتكون الذرة من نواة صغيرة جداً تحتوي على جسيمات موجبة الشحنة تسمى البروتونات (Protons)، وجسيمات متعادلة الشحنة تسمى تسمى النيترونات (Neutrons)، وتدور حولها جسيمات سالبة الشحنة تسمى الالكترونات (Electrons). شحنة البروتون الموجبة تساوي شحنة الالكترون السالبة وقدرها $1.602*10^{-19}$ C. كتلة كل من البروتون والنيترون متساويتان تقريباً ($1.67*10^{-23}$ kg)، أمّا كتلة الالكترون فهي أصغر بكثير وقدرها $9.11*10^{-31}$ kg.

Atomic Number, Z = The number of Protons in an Atom (لجميع النظائر) قيمته ثابتة للعنصر الواحد

Atomic Mass, A = Number of Protons + Number of Neutrons

$$A = Z + N$$

Isotope: Same number of protons, but different number of neutrons.

العدد الذري = عدد البروتونات في الذرة = عدد الالكترونات

الكتلة الذرية (أو عدد الكتلة) = عدد البروتونات + عدد النيترونات

النظائر: هي ذرات عنصر واحد تختلف في عدد النيوترونات وبالتالي تختلف في عدد الكتلة ومن ثم تختلف في كتلتها.

مثال ذلك: توجد عدة نظائر لعنصر الكاربون (عدده الذري 6) مثل النظير Carbon-12 ويكتب أيضاً ^{12}C الذي يحتوي على 6 نيترونات، والنظير ^{11}C الذي يحتوي على 5 نيترونات، والنظير ^{9}C الذي يحتوي على 3 نيترونات وهكذا.

وحدة الكتلة الذرية (amu): هي (1/12) من الكتلة الذرية لنظير الكاربون 12.

Atomic Mass Unit, amu = (1/12) of the atomic mass of the carbon 12 isotope (^{12}C).

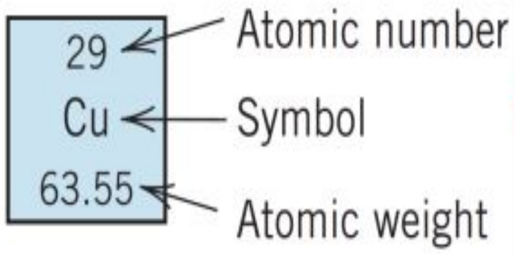
Atomic Weight: is the weighted average of the atomic masses of the atom's naturally occurring isotopes. It is expressed as (amu/atom) or (amu/molecule).

In one **Mole** of a substance, there are $6.0221*10^{23}$ (Avogadro's Number) of atoms or molecules.

المول هو وحدة قياس كمية الأشياء في علم الكيمياء، ويساوي ما مقداره عدد أفوكادرو من الجسيمات (ذرات، أو جزيئات، أو أيونات، ...الخ). إن عدد أفوكادرو الذي يساوي $6.0221*10^{23}$ هو عدد الذرات الموجودة في 12 غرام من نظير الكاربون 12.

إذن يمكننا القول أن وحدة $\frac{amu}{atom}$ تتطابق مع وحدة $\frac{g}{mol}$ ، أي أن $1\frac{amu}{atom}=1\frac{g}{mol}$،

الوزن الذري (Atomic Weight) هو المعدل الموزون للكتل الذرية للنظائر الطبيعية لعنصر ما وفقاً لنسبة وجودها في الطبيعة.



طريقة كتابة العدد الذري والوزن الذري في الجدول الدوري للعناصر

Average Atomic Weight Computation for Cerium

Cerium has four naturally occurring isotopes: 0.185% of ^{136}Ce, with an atomic weight of 135.907 amu; 0.251% of ^{138}Ce, with an atomic weight of 137.906 amu; 88.450% of ^{140}Ce, with an atomic weight of 139.905 amu; and 11.114% of ^{142}Ce, with an atomic weight of 141.909 amu. Calculate the average atomic weight of Ce.

Solution

The average atomic weight of a hypothetical element M, $\overline{A}_M$, is computed by adding fraction-of-occurrence—atomic weight products for all its isotopes; that is,

$$\overline{A}_M = \sum_i f_{i_M} A_{i_M} \tag{2.2}$$

In this expression, f_{i_M} is the fraction-of-occurrence of isotope i for element M (i.e., the percentage-of-occurrence divided by 100), and A_{i_M} is the atomic weight of the isotope.

For cerium, Equation 2.2 takes the form

$$\overline{A}_{Ce} = f_{^{136}Ce} A_{^{136}Ce} + f_{^{138}Ce} A_{^{138}Ce} + f_{^{140}Ce} A_{^{140}Ce} + f_{^{142}Ce} A_{^{142}Ce}$$

Incorporating values provided in the problem statement for the several parameters leads to

$$\overline{A}_{Ce} = \left(\frac{0.185\%}{100}\right)(135.907 \text{ amu}) + \left(\frac{0.251\%}{100}\right)(137.906 \text{ amu}) + \left(\frac{88.450\%}{100}\right)(139.905 \text{ amu})$$

$$+ \left(\frac{11.114\%}{100}\right)(141.909 \text{ amu})$$

$$= (0.00185)(135.907 \text{ amu}) + (0.00251)(137.906 \text{ amu}) + (0.8845)(139.905 \text{ amu})$$

$$+ (0.11114)(141.909 \text{ amu})$$

$$= 140.115 \text{ amu}$$

يمتلك عنصر السيريوم أربعة نظائر طبيعية وهي كما مبينة في نص السؤال:

1) النظير ^{136}Ce يتواجد بنسبة 0.185% في الطبيعة ووزنه الذري 135.907 وحدة كتلة ذرية amu

2) ....الخ

ويتم ترتيب الحل كما في الجدول أدناه:

(1)	(2)	(3)	(4)
Isotope	**Atomic Weight (amu)**	**Ratio of Occurrence**	**(2) × (3)**
^{136}Ce	135.907	$\frac{0.185}{100}$	0.2514
^{138}Ce	137.906	$\frac{0.251}{100}$	0.3461
^{140}Ce	139.905	$\frac{88.45}{100}$	123.746
^{142}Ce	141.909	$\frac{11.114}{100}$	15.772
		SUM =	**140.115**

Homework:

Lead (Pb) has four naturally occurring isotopes as shown in the table. Calculate its average atomic weight.

Isotope	Occurrence	Atomic Weight (amu)
^{204}Pb	1.4%	203.973
^{206}Pb	24.1%	205.974
^{207}Pb	22.1%	206.976
^{208}Pb	52.4%	207.977

SOLUTION:

Atomic Models النماذج الذرية

During the latter part of the nineteenth century, it was realized that many phenomena involving electrons in solids could not be explained in terms of classical mechanics. What followed was the establishment of a set of principles and laws that govern systems of atomic and subatomic entities that came to be known as **quantum mechanics.** An understanding of the behavior of electrons in atoms and crystalline solids necessarily involves the discussion of quantum-mechanical concepts. However, a detailed exploration of these principles is beyond the scope of this text, and only a very superficial and simplified treatment is given.

quantum mechanics

One early outgrowth of quantum mechanics was the simplified **Bohr atomic model,** in which electrons are assumed to revolve around the atomic nucleus in discrete orbitals, and the position of any particular electron is more or less well defined in terms of its orbital. This model of the atom is represented in Figure 2.1.

Bohr atomic model

Another important quantum-mechanical principle stipulates that the energies of electrons are *quantized*—that is, electrons are permitted to have only specific values of energy. An electron may change energy, but in doing so, it must make a quantum jump either to an allowed higher energy (with absorption of energy) or to a lower energy (with emission of energy). Often, it is convenient to think of these allowed electron energies as being associated with *energy levels* or *states*. These states do not vary continuously with energy—that is, adjacent states are separated by finite energies. For example, allowed states for the Bohr hydrogen atom are represented in Figure 2.2*a*. These energies are taken to be negative, whereas the zero reference is the unbound or free electron. Of course, the single electron associated with the hydrogen atom fills only one of these states.

wave-mechanical model

This Bohr model was eventually found to have some significant limitations because of its inability to explain several phenomena involving electrons. A resolution was reached with a **wave-mechanical model,** in which the electron is considered to exhibit both wave-like and particle-like characteristics. With this model, an electron is no longer treated as a particle moving in a discrete orbital; rather, position is considered to be the probability of an electron being at various locations around the nucleus. In other words, position is described by a probability distribution or electron cloud. Figure 2.3 compares Bohr and wave-mechanical models for the hydrogen atom. Both models are used throughout the course of this text; the choice depends on which model allows the simplest explanation.