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THE BASIC LAWS OF STOICHIOMETRY AND EQUATION OF CHEMICAL REACTION

Balogh József[1], Szemrád Emil[2], Starosta Vladimir[3].
[1]DSc, Prof. of Department of Chemistry, College of Nyíregyháza
[2]CSc, Associate prof. of Department of Inorganic Chemistry, Uzhgorod National University, Ukraine
[3]CSc, Associate prof. of Department of Physics Chemistry, Uzhgorod National University, Ukraine

The concept “the equation of chemical reaction”, as well as anyone another is characterized by the certain contents and volume. The various publications shine questions of application of the equations of chemical reactions for carrying out of various accounts. However, there is an open question on the basis of that all described operations are possible. Therefore purpose of the present work - demonstration of a possible path of an explanation for the pupil through the basic laws of stoichiometry and analysis of the equation of chemical reaction, and as a consequence, - possible accounts.

As for chemical reactions the defect of weights can be neglected, all accounts on the basis of the equation of chemical reaction base on the law of perdurability of matter of M. Lomonosov, which in this case for reaction

$$aA + bB = cC + dD \pm Q_r, \qquad (1)$$

where A, B – starting material; C, D - species; a, b, c, d - appropriate stoichiometrical coefficients ; Q_r - heat effect of reaction; it is possible to present in such form

$$m(A) + m(B) = m(C) + m(D), \qquad (2)$$

where m(A), m(B), m(C), m(D) - appropriate mass of substances A, B, C, D. If the stoichiometrical coefficients express number of structural units of substance, the equation (2) can be presented in the form

$$a \cdot m_0(A) + b \cdot m_0(B) = c \cdot m_0(C) + d \cdot m_0(D), \qquad (3)$$

where - mass of structural units of substances A, B, C that D accordingly. The starting equation (1) and the appropriate expressions of the law of perdurability of matter (2), (3) have all properties of the algebraic equation from the point of view of carrying out of mathematical transformations. Let's make multiplication of the equation (3) on number Avogadro N_A:

$$a \cdot m_0(A) \cdot N_A + b \cdot m_0(B) \cdot N_A = c \cdot m_0(C) \cdot N_A + d \cdot m_0(D) \cdot N_A \qquad (4)$$

As in case of substance A: $m_0(A) \cdot N_A = M(A)$, for other substances - is similar, is received the following equation

$$a \cdot M(A) + b \cdot M(B) = c \cdot M(C) + d \cdot M(D) \qquad (5)$$

Thus, the stoichiometrical coefficients in the equation of chemical reaction can designate both number of structural units of substance, and amount of substance.

If in the equation (1) multiply all stoichiometrical coefficients on some positive number k, the further analysis enables to receive the information, which is possible to utillize at drawing up of a series of the similar tasks:

$$ka \cdot M(A) + kb \cdot M(B) = kc \cdot M(C) + kd \cdot M(D) \qquad (6)$$

The size k can designate number of structural units or amount of substance, for example, $n(A) = k$ mol. In such case:

$$k \cdot M(A) + kb/a \cdot M(B) = kc/a \cdot M(C) + kd/a \cdot M(D) \qquad (7)$$

The appropriate weights on an example of two substances A and B for each case are equal

$$m_1(A) = a \cdot M(A);\; m_1(B) = b \cdot M(B);$$
$$m_2(A) = ka \cdot M(A);\; m_2(B) = kb \cdot M(B);$$
$$m_3(A) = k \cdot M(A);\; m_3(B) = kb/a \cdot M(B).$$

The relation of received mass of substances:

$$\frac{m_1(A)}{m_1(B)} = \frac{m_2(A)}{m_2(B)} = \frac{m_3(A)}{m_3(B)} = \frac{a \cdot M(A)}{b \cdot M(B)} \qquad (8)$$

The similar relations is received by other way:

$$\frac{m(A)}{m(B)} = \frac{a \cdot m_0(A)}{b \cdot m_0(B)} = \frac{a \cdot m_0(A) \cdot N_A}{b \cdot m_0(B) \cdot N_A} = \frac{a \cdot M(A)}{b \cdot M(B)} \qquad (9)$$

The relation of mass also we can represent with use of relative molecular mass of substances:

$$\frac{m(A)}{m(B)} = \frac{a \cdot m_0(A)}{b \cdot m_0(B)} = \frac{a \cdot \dfrac{m_0(A)}{\frac{1}{12} m_0(^{12}C)}}{b \cdot \dfrac{m_0(B)}{\frac{1}{12} m_0(^{12}C)}} = \frac{a \cdot M_r(A)}{b \cdot M_r(B)} \qquad (10)$$

Insignificant the change of the received equation results in the principle of equivalents of Richter:

$$\frac{m(A)}{m(B)} = \frac{a \cdot M(A)}{b \cdot M(B)} = \frac{M(A)/b}{M(B)/a} = \frac{M(f_{eq}A)}{M(f_{eq}B)} \qquad (11)$$

Let's present settlement opportunities of the equation of chemical reaction through the relation of stoichiometrical coefficients (again on an example of two substances):

$$a : b = n(A) : n(B) = \frac{n(A)}{N_A} : \frac{n(B)}{N_A} = N(A) : N(B), \qquad (12)$$

$$a : b = n(A) : n(B) = [n(A) \cdot V_m] : [n(B) \cdot V_m] = V(A) : V(B), \qquad (13)$$

$$a : b = n(A) : n(B) = \left[\frac{p \cdot V(A)}{RT}\right] : \left[\frac{p \cdot V(B)}{RT}\right] = V(A) : V(B) \qquad (14)$$

$$a:b = n(A):n(B) = \left[p(A)\cdot\frac{V}{RT}\right]:\left[p(V)\cdot\frac{V}{RT}\right] = p(A):p(B), \qquad (15)$$

$$a:b = n(A):n(B) = \frac{n(A)}{V}:\frac{n(B)}{V} = C(A):C(B), \qquad (16)$$

where N, V, p, C - accordingly number of structural units, meaning of volume, fractional pressure and molarities of substances, which have entered reaction. The similar relations can be written down for all stoichiometrical coefficients. Parities (12) - can be an illustration of the law of fixed ratioes Proust (law of definite proportions) under condition of reception of daltonides. Parities (13) - illustration of the law of combining volumes of the Gay-Lussac and consequence from the Avogadro's principle about molar volume. Identical to (13) results (14) is received with use of the Mendeleev-Clapeyron equation, that enables to emphasize validity of parities (13), (14) under condition of use of volumes of substances under identical conditions (temperature, pressure). Parities (13), (14), (15), (16) - illustration of model of ideal gas on an example of chemical reactions (gaseous reagents or resultants of reaction): (13), (14) - the volumes for gases in a condition of a task are given in identical temperatures and pressure; (15) - the fractional pressure for gases in a condition of a task is given(reduced) in identical temperatures and pressure; (16) - the concentration for gases in a condition of a task are given in identical volume. Thus, at a formulation of the tasks for carrying out of accounts on the basis of the equation of chemical reaction in case of gaseous substances it is necessary depending on unknown or known physical quantities to specify the appropriate conditions (pressure, temperature, volume). The parities (16) do not depend on pressure, and therefore can be utilised and for condensed systems, for example, liquid solutions.

The received equations (12) - (16) enable to carry out both relative calculations of the submitted physical quantities, and revertive - presence of stoichiometrical coefficients, and last can be the following step if necessary of further definition of composition of substance:

$$N(A):N(B) = V(A):V(B) = p(A):p(B) = C(A):C(B) = n(A):n(B) = a:b \, (17)$$

Interrelation of physical quantities for one substance (on an example of substance A):

$$\frac{m_1(A)}{m_2(A)} = \frac{n_1(A)}{n_2(A)} = \frac{N_1(A)}{N_2(A)} = \frac{V_1(A)}{V_2(A)} = \frac{p_1(A)}{p_2(A)} = \frac{C_1(A)}{C_2(A)} = \frac{Q_1}{Q_2} \qquad (18)$$

where Q_1, Q_2 - heat effects of reaction, which correspond $m_1(A), m_2(A)$ and $v_1(A), v_2(A)$ etc. Accordingly on an example of substances **A** and **B** it is received:

$$\frac{m(A)}{m(B)} = \frac{a\cdot M(A)}{b\cdot M(B)} = \frac{N(A)\cdot M(A)}{N(B)\cdot M(B)} = \frac{V(A)\cdot M(A)}{V(B)\cdot M(B)} = \frac{p(A)\cdot M(A)}{p(B)\cdot M(B)} = \frac{C(A)\cdot M(A)}{C(B)\cdot M(B)} \qquad (19)$$

The received equations enable to carry out accounts of the following physical quantities: weights, amount of substance, structural units, volumes, fractional pressure, concentration, heat effects. Thus the careful starting analysis of the equation of chemical reaction always yields the information necessary for the further calculations, that it is possible to illustrate on an example of the equation (1), if all substances gaseous:

The amount of substance agrees conditions of the task and equation of reaction:								
Before reaction	$n(A)$		$n(B)$		0		0	
Result of reaction	$n(A)\cdot a/a$		$n(A)\cdot b/a$		$n(A)\cdot c/a$		$n(A)\cdot d/a$	
After reaction	0		$n(B)-n(A)\cdot b/a$		$0+n(A)\cdot c/a$		$0+n(A)\cdot d/a$	
	aA	$+$	bB	$=$	cC	$+$	dD	$+Q_r$
Agrees the equations of reaction								
M (Molar mass), g/mol	$M(A)$		$M(B)$		$M(C)$		$M(D)$	
n (Amount of substance), mol	a		b		c		d	
m (Mass), g	$a\cdot M(A)$		$b\cdot M(B)$		$c\cdot M(C)$		$d\cdot M(D)$	
V (Volume), l	$a\cdot V_m$		$b\cdot V_m$		$c\cdot V_m$		$d\cdot V_m$	

Thus the general form of the task is taken over, according to which substance and completely reacts and for such condition all subsequent calculations on an example of amount of substance of reagents and resultants of reaction (result of reaction, after reaction) are submitted.

Thus, the specified approaches enable consciously and comprehensively to use receptions and concepts of mathematics, physics, chemistry for more penetrating understanding of essence of the equation of chemical reaction.

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