Inorganic and Physics Chemistry Department

Fundamentals of quantitative calculations in pharmacy

Fundamentals of quantitative calculations in pharmacy. Calculations by chemical formulas

For specialty 226 Pharmacy, industrial pharmacy

The main questions

1. Structural particles of matter: atom, molecule, ion.

2. The amount of substance.

3. Basic laws of chemistry, formulas and calculations.

4. Examples of solution of exercise.

Structural particles of matter

Chemistry is the science of the structure, properties, and transformations of substances.

Substance - a set of particles with the same properties.

Simple substances consist of one type of atoms.

C – graphite, consisting of atoms of C;

H_2 – hydrogen, the molecule consists of two atoms of H.

P_4 – phosphorus, the molecule consists of four atoms of P.

Fe – iron, consisting of Fe atoms.

Structural particles of matter

Structural particles of matter are atoms, molecules, ions.

Chemical formula – conditional record of the composition of a substance using the symbols of chemical elements and indices.

symbols

$$H_2SO_4$$

indices

The index is the number of atoms of a given chemical element in the formulas of substances.

Complex substances consist of atoms of various chemical elements.

Valence is the ability of atoms of a chemical element to combine with a certain number of atoms of other elements to form chemical bonds.

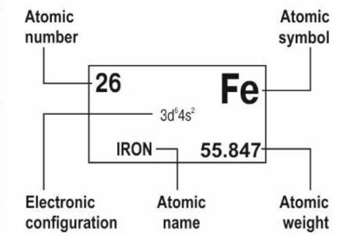
Valence of atoms of some elements

Chemical element	Valence	Examples of compound formulas
	Constant valence	
H, Li, Na, K	I	H_2O, Na_2O
O, Ca, Zn	II	CaO, ZnO
Al	III	Al_2O_3
	Variable valence	
Cu	I i II	Cu_2O, CuO
Fe, Co, Ni	II i III	FeO, Fe_2O_3
C, Sn, Pb	II i IV	CO, CO_2
P	III i V	PH_3, P_2O_5
Cr	II, III i IV	CrO, Cr_2O_3, CrO_3
S	II, IV i VI	H_2S, SO_2, SO_3

As a rule, the maximum valence = № of the group in the Periodic Table

PERIODIC TABLE OF THE ELEMENTS

	I	II	III	IV	V	VI	VII	VIII		
1	(H)						H 1 $1s^1$ 1.0079 HYDROGEN	He 2 $1s^2$ 4.00260 HELIUM		
2	Li 3 $2s^1$ 6.941 LITHIUM	Be 4 $2s^2$ 9.01218 BERYLLIUM	B 5 $2s^2 2p^1$ 10.81 BORON	C 6 $2s^2 2p^2$ 12.011 CARBON	N 7 $2s^2 2p^3$ 14.0067 NITROGEN	O 8 $2s^2 2p^4$ 15.999 OXYGEN	F 9 $2s^2 2p^5$ 18.9994 FLUORINE	Ne 10 $2s^2 2p^6$ 20.179 NEON		
3	Na 11 $3s^1$ 22.98977 SODIUM	Mg 12 $3s^2$ 24.305 MAGNESIUM	Al 13 $3s^2 3p^1$ 26.9815 ALUMINIUM	Si 14 $3s^2 3p^2$ 28.0855 SILICON	P 15 $3s^2 3p^3$ 30.973 PHOSPHORUS	S 16 $3s^2 3p^4$ 32.06 SULFUR	Cl 17 $3s^2 3p^5$ 35.453 CHLORINE	Ar 18 $3s^2 3p^6$ 39.948 ARGON		
4	K 19 $4s^1$ 39.0983 POTASSIUM	Ca 20 $4s^2$ 40.08 CALCIUM	21 Sc $3d^1 4s^2$ SCANDIUM 44.9559	22 Ti $3d^2 4s^2$ TITANIUM 47.90	23 V $3d^3 4s^2$ VANADIUM 50.9415	24 Cr $3d^5 4s^1$ CHROMIUM 51.996	25 Mn $3d^5 4s^2$ MANGANESE 54.938	26 Fe $3d^6 4s^2$ IRON 55.847	27 Co $3d^7 4s^2$ COBALT 58.9332	28 Ni $3d^8 4s^2$ NICKEL 58.70
	29 Cu $3d^{10} 4s^1$ COPPER 63.546	30 Zn $3d^{10} 4s^2$ ZINC 65.38	Ga 31 $4s^2 4p^1$ 69.72 GALLIUM	Ge 32 $4s^2 4p^2$ 72.59 GERMANIUM	As 33 $4s^2 4p^3$ 74.9216 ARSENIC	Se 34 $4s^2 4p^4$ 78.96 SELENIUM	Br 35 $4s^2 4p^5$ 79.904 BROMINE	Kr 36 $4s^2 4p^6$ 83.80 KRYPTON		
5	Rb 37 $5s^1$ 85.4678 RUBIDIUM	Sr 38 $5s^2$ 87.62 STRONTIUM	39 Y $4d^1 5s^2$ YTTRIUM 88.9059	40 Zr $4d^2 5s^2$ ZIRCONIUM 91.22	41 Nb $4d^4 5s^1$ NIOBIUM 92.9064	42 Mo $4d^5 5s^1$ MOLYBDENUM 95.94	43 Tc $4d^5 5s^2$ TECHNETIUM [98]	44 Ru $4d^7 5s^1$ RUTHENIUM 101.07	45 Rh $4d^8 5s^1$ RHODIUM 102.9055	46 Pd $4d^{10} 5s^0$ PALLADIUM 106.4
	47 Ag $4d^{10} 5s^1$ SILVER 107.868	48 Cd $4d^{10} 5s^2$ CADMIUM 112.41	In 49 $5s^2 5p^1$ 114.82 INDIUM	Sn 50 $5s^2 5p^2$ 118.69 TIN	Sb 51 $5s^2 5p^3$ 121.75 ANTIMONY	Te 52 $5s^2 5p^4$ 127.60 TELLURIUM	I 53 $5s^2 5p^5$ 126.9045 IODINE	Xe 54 $5s^2 5p^6$ 131.30 XENON		
6	Cs 55 $6s^1$ 132.9054 CESIUM	Ba 56 $6s^2$ 137.33 BARIUM	57 *La $5d^1 6s^2$ LANTHANUM 138.905	72 Hf $5d^2 6s^2$ HAFNIUM 178.49	73 Ta $5d^3 6s^2$ TANTALUM 180.9479	74 W $5d^4 6s^2$ TUNGSTEN 183.85	75 Re $5d^5 6s^2$ RHENIUM 186.207	76 Os $5d^6 6s^2$ OSMIUM 190.2	77 Ir $5d^7 6s^2$ IRIDIUM 192.22	78 Pt $5d^9 6s^1$ PLATINUM 195.09
	79 Au $5d^{10} 6s^1$ GOLD 196.9665	80 Hg $5d^{10} 6s^2$ MERCURY 200.59	Tl 81 $6s^2 6p^1$ 204.37 THALLIUM	Pb 82 $6s^2 6p^2$ 207.2 LEAD	Bi 83 $6s^2 6p^3$ 208.98 BISMUTH	Po 84 $6s^2 6p^4$ [209] POLONIUM	At 85 $6s^2 6p^5$ [210] ASTATINE	Rn 86 $6s^2 6p^6$ [222] RADON	[ ] mass number of the longest-liveed isotope	
7	Fr 87 $7s^1$ [223] FRANCIUM	Ra 88 $7s^2$ 226,0254 RADIUM	89 **Ac $6d^1 7s^2$ ACTINIUM 227,0278	104 Rf $6d^2 7s^2$ RUTHERFORDIUM [261]	105 Db $6d^3 7s^2$ DUBNIUM [262]	106 Sg $6d^4 7s^2$ SEABORGIUM [263]	107 Bh $6d^5 7s^2$ BOHRIUM [261]	108 Hs $6d^6 7s^2$ HASSIUM [265]	109 Mt $6d^7 7s^2$ MEITNERIUM [266]	110 Ds $6d^8 7s^2$ DARMSTADTIUM [281]
	111 Rg $6d^{10} 7s^1$ ROENTGENIUM [280]	112 Cn $6d^{10} 7s^2$ COPERNICIUM [285]	Nh 113 $7s^2 7p^1$ [286] NIHONIUM	Fl 114 $7s^2 7p^2$ [289] FLEROVIUM	Mc 115 $7s^2 7p^3$ [289] MOSCOVIUM	Lv 116 $7s^2 7p^4$ [293] LIVERMORIUM	Ts 117 $7s^2 7p^5$ [294] TENNESSINE	Og 118 $7s^2 7p^6$ [294] OGANESSON		



*Lanthanoid series

58 Ce $4f^1 5d^1 6s^2$ 140.12 CERIUM	59 Pr $4f^3 6s^2$ 140.9077 PRASEODYMIUM	60 Nd $4f^4 6s^2$ 144.24 NEODYMIUM	61 Pm $4f^5 6s^2$ [145] PROMETHIUM	62 Sm $4f^6 6s^2$ 150.4 SAMARIUM	63 Eu $4f^7 6s^2$ 151.96 EUROPIUM	64 Gd $4f^7 5d^1 6s^2$ 157.25 GADOLINIUM
65 Tb $4f^9 6s^2$ 158.9254 TERBIUM	66 Dy $4f^{10} 6s^2$ 162.50 DYSPROSIUM	67 Ho $4f^{11} 6s^2$ 164.9304 HOLMIUM	68 Er $4f^{12} 6s^2$ 167.26 ERBIUM	69 Tm $4f^{13} 6s^2$ 168.9342 THULIUM	70 Yb $4f^{14} 6s^2$ 173.04 YTTERBIUM	71 Lu $4f^{14} 5d^1 6s^2$ 174.967 LUTETIUM

**Actinoid series

90 Th $6d^2 7s^2$ 232,0381 THORIUM	91 Pa $5f^2 6d^1 7s^2$ 231,0359 PROTACTINIUM	92 U $5f^3 6d^1 7s^2$ 238,029 URANIUM	93 Np $5f^4 6d^1 7s^2$ 237,0482 NEPTUNIUM	94 Pu $5f^6 7s^2$ [244] PLUTONIUM	95 Am $5f^7 7s^2$ [243] AMERICIUM	96 Cm $5f^7 6d^1 7s^2$ [247] CURIUM
97 Bk $5f^8 6d^1 7s^2$ [247] BERCELIUM	98 Cf $5f^{10} 7s^2$ [251] CALIFORNIUM	99 Es $5f^{11} 7s^2$ [252] EINSTEINIUM	100 Fm $5f^{12} 7s^2$ [257] FERMIUM	101 Md $5f^{13} 7s^2$ [258] MENDELEVIUM	102 No $5f^{14} 7s^2$ [259] NOBELIUM	103 Lr $5f^{14} 6d^1 7s^2$ [260] LAWRENCIUM

Compilation of formulas for valence

1. $\overset{I}{H}\ \overset{I}{Cl}$

2. H_1Cl_1

3. HCl

1. $\overset{VI}{S}\ \overset{II}{O}$

2. S_2O_6

3. SO_3

1. $Fe^{2+}(SO_4^{2-})$

2. $Fe_2(SO_4)_2$

3. $FeSO_4$

Chemical formulas of complex substances

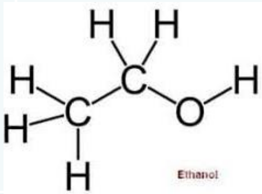
CO_2 – carbon (IV) oxide - one C atom and two O atoms;

H_2SO_4 – sulphuric acid - two H atoms, one S atom and four O atoms;

$Fe(OH)_2$ – iron (II) hydroxide - one Fe atom, two O atoms, two H atoms;

$CuSO_4$ – Copper (II) sulphate is one Cu atom, one S atom, and four O atoms.

Types of chemical formulas

Formula	Description	Examples
The simplest	the ratio of chemical elements	H_2O CH
Rational	groups of atoms characteristic of classes of chemical compounds	$NaOH$ CH_3COOH $K_4[Fe(CN)_6]$ C_2H_5OH $CH_3–CH_2–OH$
Empirical formula	the simplest true	C_2H_6O C_2H_6O C_2H_5OH
Structural	relative position of atoms in a molecule by their of valence	
Electronic	schematic formation of common electronic pairs (chemical bonds)	H H H : C : C : O : H H H

Structural particles of matter

Coefficient - a number before the chemical formula, which indicates the number of atoms, molecules, a given substance or individual ions, atoms

2O – two separate Oxygen atoms;

$2O_2$ – two molecules of Oxygen;

$4K^+$ – four Potassium cations;

$2CuSO_4$ – two molecules of copper (II) sulphate

H_2SO_4: 2(H), 1(S), 4(O);

$(NH_4)_2C_2O_4$: 2(N), 8(H), 2(C), 4(O).

$Ba(OH)_2$: (Ba), 2(O), 2(H);

Atomic unit of mass is 1/12 of the mass of the Carbon isotope ^{12}C $1.660 \cdot 10^{-27}$ kg.

Relative atomic mass (Ar) - a value that shows how many times the mass of the atom of this element is greater than the atomic unit of mass:

$$A_r(\mathrm{H}) = \frac{\mathrm{m(H)}}{{}^1/_{12}\,\mathrm{m}({}^{12}_{6}\mathrm{C})} = \frac{1.674 \times 10^{-27}\mathrm{kg}}{1.660 \times 10^{-27}\mathrm{kg}} = 1.008$$

The values of A_r are given in the Periodic Table

Relative molecular weight (Mr) is a number that indicates how many times the mass of a molecule of a given substance is greater than 1/12 of the mass of a carbon atom. Numerically equal to the molar mass.

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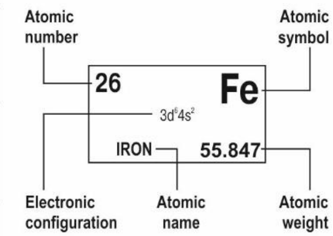


*Lanthanoid series

58	Ce	$4f^1 5d^1 6s^2$	140.12	CERIUM
59	Pr	$4f^3 6s^2$	140.9077	PRASEODYMIUM
60	Nd	$4f^4 6s^2$	144.24	NEODYMIUM
61	Pm	$4f^5 6s^2$	[145]	PROMETHIUM
62	Sm	$4f^6 6s^2$	150.4	SAMARIUM
63	Eu	$4f^7 6s^2$	151.96	EUROPIUM
64	Gd	$4f^7 5d^1 6s^2$	157.25	GADOLINIUM
65	Tb	$4f^9 6s^2$	158.9254	TERBIUM
66	Dy	$4f^{10} 6s^2$	162.50	DYSPROSIUM
67	Ho	$4f^{11} 6s^2$	164.9304	HOLMIUM
68	Er	$4f^{12} 6s^2$	167.26	ERBIUM
69	Tm	$4f^{13} 6s^2$	168.9342	THULIUM
70	Yb	$4f^{14} 6s^2$	173.04	YTTERBIUM
71	Lu	$4f^{14} 5d^1 6s^2$	174.967	LUTETIUM

**Actinoid series

90	Th	$6d^2 7s^2$	232,0381	THORIUM
91	Pa	$5f^2 6d^1 7s^2$	231,0359	PROTACTINIUM
92	U	$5f^3 6d^1 7s^2$	238,029	URANIUM
93	Np	$5f^4 6d^1 7s^2$	237,0482	NEPTUNIUM
94	Pu	$5f^6 7s^2$	[244]	PLUTONIUM
95	Am	$5f^7 7s^2$	[243]	AMERICIUM
96	Cm	$5f^7 6d^1 7s^2$	[247]	CURIUM
97	Bk	$5f^8 6d^1 7s^2$	[247]	BERCELIUM
98	Cf	$5f^{10} 7s^2$	[251]	CALIFORNIUM
99	Es	$5f^{11} 7s^2$	[252]	EINSTEINIUM
100	Fm	$5f^{12} 7s^2$	[257]	FERMIUM
101	Md	$5f^{13} 7s^2$	[258]	MENDELEVIUM
102	No	$5f^{14} 7s^2$	[259]	NOBELIUM
103	Lr	$5f^{14} 6d^1 7s^2$	[260]	LAWRENCIUM

The amount of matter of structural particles

The relative molecular mass of a compound is the sum of the relative atomic masses of the elements that make up this compound, taking into account their number.

$M_r(H_3PO_4) = 3A_r(H) + A_r(P) + 4A_r(O) =$
$= 3\times1 + 31 + 4\times16 = 98;$

$M_r[(Ca(OH)_2] = A_r(Ca) + 2\,A_r(O) + 2A_r(H) =$
$= 40 + 2\times16 + 2\times1 = 74;$

$M_r[(NH_4)_2SO_4] = 2A_r(N) + 8A_r(H) + A_r(S) + 4A_r(O) =$
$= 2\times14 + 8\times1 + 32 + 4\times16 = 132;$

$M_r(K_4Fe(CN)_6) = 4A_r(K) + A_r(Fe) + 6A_r(C) + 6A_r(N) =$
$= 4\times39 + 56 + 6\times12 + 6\times14 = 368.$

The amount of matter of structural particles

Avogadro's number ($6.02 \cdot 10^{23}$) - the number of atoms contained in 12 g of Carbon ^{12}C, calculated by dividing 12 g by the mass of one carbon atom (1.993×10^{-23} g):

$$N_A = \frac{12}{1.993 \times 10^{-23}} = 6.02 \times 10^{23} \frac{1}{\text{mol}} (\text{or mol}^{-1})$$

Quantity of matter - the ratio of the number of structural units of matter (atoms, molecules, etc.) to the Avogadro constant:

$$\nu = \frac{\mathrm{N}}{\mathrm{N_A}}$$

ν – amount of substance, mol;

N – the number of structural units of matter.

The amount of matter of structural particles

The amount of substance of the element in a certain amount of the substance of the compound:

$$\nu_{(element)} = n_{(element)} \cdot \nu_{(substance)}$$

n – index in the chemical formula.

Mol (ν) – unit of substance: contains as many structural units as atoms contained in 12 g of Carbon ^{12}C

1 mole of Hydrogen contains 6.02×10^{23} molecules H_2;

1 mol of hydrogen atoms contains 6.02×10^{23} atoms of H;

1 mol of water contains 6.02×10^{23} molecules of H_2O

Molar mass (M) - mass of 1 mol of substance : $M = \frac{m}{\nu}$

Units of measurement - g/mol or kg /mol.

Mass percent of an element in a compound

the ratio of the mass of the element to the corresponding mass of the compound:

$$\omega(\mathrm{E}) = \frac{\mathrm{m(E)}}{\mathrm{m(compound)}}$$

- ✓ the mass of the element and the compound must be in the same dimension (g or kg)
- ✓ expressed in% or fractions of 1

Based on the compound formula:

$$\omega(\mathrm{E}) = \frac{\mathrm{n(E)} \cdot \mathrm{A_r(E)}}{\mathrm{M_r(compound)}}$$

the mixture – a system consisting of two or more substances (components of a mixture).

Homogeneous the mixture - solution (gaseous, liquid or solid).

Heterogeneous - mechanical the mixture.

Any of the mixture can be divided into components by physical methods; the components of the mixture do not change the properties.

Mass percent of an element in in the mixture

the ratio of the mass of the element to the corresponding mass of the mixture:

$$\omega(E) = \frac{m(E)}{m(mixture)}$$

- ✓ expressed in% or fractions of 1
- ✓ the mass of the element and the mixture is denoted in same dimension (g or kg)

The law of constant **composition** states, *(1808)*

law of constant **composition** states that a given chemical compound always contains its component elements in fixed ratio (by mass) and does not depend on its source and method of preparation.

Obtaining CO_2:

$$CaCO_3 = CO_2 + CaO$$

$$2HCl + Na_2CO_3 = CO_2 + 2NaCl + H_2O$$

$$CH_4 + 2O_2 = CO_2 + 2H_2O$$

$$2CO + O_2 = 2CO_2$$

Always composed CO_2 36.6% C and 63.4% O

It is valid only for molecular compounds - daltonides.

Daltonides are substances of constant composition - simple formulas with integer indices : H_2SO_4, HCl, CO_2.

The law of multiple proportions(1803)

Law of multiple proportions, statement that when two elements combine with each other to form more than one compound, the mass of one element that combine with a fixed mass of the other are in a ratio of small whole numbers

The composition of nitrogen oxides (as a percent by mass):

Formula	N_2O	NO	N_2O_3	NO_2	N_2O_5
N, %	63.7	46.7	36.8	30.4	25.9
O, %	36.3	53.3	63.2	69.6	74.1
Ratio O/N	0.57	1.14	1.71	2.28	2.85
Valence N	1	2	3	4	4

$CaCl_2{\cdot}H_2O$, $CaCl_2{\cdot}2H_2O$, $CaCl_2{\cdot}4H_2O$, $CaCl_2{\cdot}6H_2O$

water masses are rated to as water masses are rated to as 1:2:4:6

the same volumes of gases under the same conditions contain the same number of molecules

The first consequence:

1 mole of any gas under the same conditions will occupy the same volume - the molar volume V_m:

$$V_m = \frac{M}{\rho} = \frac{V}{\nu}$$

$$[V_m] = {}^{L}/_{mol}$$

Under normal conditions Vm = 22.4 L/mol (or m^3/mol)

Normal conditions – T = 273 K (0 ˚C)

p = 101.3 kPa (1 atm. or 760 millimeters of mercury).

Avogadro's law and its consequences

The second consequence :

the ratio of the masses of the same volumes of different gases under the same conditions is the density of one gas by another:

$$D = \frac{m}{m_1} = \frac{M}{M_1}, therefore$$

$$D(Xgas/MH_2) = \frac{M_{gas}}{2} \qquad D(Xgas/air) = \frac{M_{gas}}{29}$$

For conditions other than normal

Clapeyron-Mendeleev’s law

$$pV = \frac{m}{M}RT$$

combined gas law

Boyle-Marriott and Gay-Lussac

$$\frac{p_0V_0}{T_0} = \frac{pV}{T}$$

where: p - pressure, Pa;

V - volume, m^3;

m – mass, kg;

M – molar mass, kg/mol;

R – universal gas table, 8.314 J · $mol^{-1} \cdot K^{-1}$;

T – temperature, K.

The volume fraction of the component in the gas mixture:

$$\varphi_{(\mathrm{component})} = \frac{V_{(\mathrm{component})}}{V_{(\mathrm{mixture})}}$$

- ✓ the volumes of the components and mixtures are denoted in the same dimension (L or mL)
- ✓ expressed in % or fractions of 1

The average molar mass of the gas mixture($\bar{M}$):

$$\bar{M} = \sum M_i \varphi_i = M_1 \varphi_1 + M_2 \varphi_2 + \cdots + M_n \varphi_n$$

M_1, M_2, M_n – molar masses of gases;

φ_1, φ_2, φ_n – volume fractions of gases;

n – number of components.

Average molar mass of air($\bar{M}$)

1) Oxigen (21%) and Nitrogen (79%):

$$\bar{M}_{air} = M_{O_2}\varphi_{O_2} + M_{N_2}\varphi_{N_2}$$

$$\bar{M}_{air} = 32 \times 0.21 + 28 \times 0.79 = 28.82 \approx 29\,\frac{g}{mol}$$

Basic formulas for calculations

$\nu_{(element)} = n_{(element)} \cdot \nu_{(compound)}$

$n_A : n_B : \ldots : n_Z = \nu_A : \nu_B : \ldots : \nu_Z$

$$\nu = \frac{N}{N_A} \qquad \nu = \frac{m}{M} \qquad \nu = \frac{V}{V_m}$$

$$\frac{N}{N_A} = \frac{m}{M} = \frac{V}{V_m}$$

$$\omega(E) = \frac{n(E) \cdot A_r(E)}{M_r(\text{compound})} \qquad \omega(E) = \frac{m(E)}{m(\text{mixture})}$$

$$\varphi_{(\text{volume fraction of component})} = \frac{V_{(\text{component})}}{V_{(\text{mixture})}}$$

$$\bar{M}_{\text{average molar mass}} = \sum M_i \varphi_i = M_1 \varphi_1 + M_2 \varphi_2 + \cdots + M_n \varphi_n$$

1. For water mass of 9 g, calculate : a) amount of substance; b) the number of molecules; c) volume.

Given:

$m(H_2O)$ = 9 г

$\nu(H_2O)$ – ?

$N(H_2O)$ – ?

$V(H_2O)$ – ?

Solution:

$$\nu = \frac{m}{M} \qquad \nu = \frac{N}{N_A} \qquad \nu = \frac{V}{V_m}$$

$$\nu(H_2O) = \frac{m(H_2O)}{M(H_2O)} = \frac{9\ g}{18\ g/mol} = 0.5\ mol$$

$$N(H_2O) = \nu(H_2O) \cdot N_A = 0.5\ mol \times 6.02 \cdot 10^{23} = $$
$$= 3.01 \times 10^{23} (molecules)$$

$$V(H_2O) = \nu(H_2O) \cdot V_m = 0.5\ mol \times 22.4 L/mol = $$
$$= 11.2\ L$$

Answer: a) 0.5 mol; b) 3.01×10^{23} (molecules); c) 11.2 L.

2. Calculate the amount of calcium orthophosphate containing 1.6 mol of Oxygen.

Given :

$\nu(O) = 1.6$ mol

$\nu(Ca_3(PO_4)_2)$ – ?

Solution:

$$\nu(\text{element}) = n(\text{element}) \cdot \nu(\text{compound})$$

$$\nu(\text{compound}) = \frac{\nu(\text{element})}{n(\text{element})}$$

$$\nu(Ca_3(PO_4)_2) = \frac{\nu(O)}{n(O)} = \frac{1.6 \text{ mol}}{8} = 0.2 \text{ mol}$$

Answer : 0.2 mol.

3.Determine the formula of the compound containing 0.14 g of Iron and 0.06 g of Oxygen.

Given :

m(Fe) = 0.14 g
m(O) = 0.06 g

Fe_xO_y – ?

Solution:

$$\nu(\mathrm{Fe}) = \frac{\mathrm{m(Fe)}}{\mathrm{M(Fe)}} = \frac{0.14\ \mathrm{g}}{56\ \mathrm{mol}} = 0.0025\ \mathrm{mol}$$

$$\nu(\mathrm{O}) = \frac{\mathrm{m(O)}}{\mathrm{M(O)}} = \frac{0.06\ \mathrm{g}}{16\ \mathrm{mol}} = 0.00375\ \mathrm{mol}$$

$$\mathrm{n(Fe)}:\mathrm{n(O)} = \nu(\mathrm{Fe}):\nu(\mathrm{O})$$

$$\mathrm{n(Fe)}:\mathrm{n(O)} = 0.0025 : 0.00375$$

$$\mathrm{n(Fe)}:\mathrm{n(O)} = 1 : 1.5 = ratio\ 2 : 3$$

Answer : Fe_2O_3.

4. At roasting 2.66 g of unknown substance A gave 784 mL of carbon (IV) oxide and 1568 mL of sulphur (IV) oxide. Determine the gross formula of substance A.

Given :

m(A) = 2.66 g
$V(CO_2)$ = 784 mL
$V(SO_2)$ = 1568 mL

$C_xS_yO_z$ – ?

Solution:

$$\nu(C) = \nu(CO_2)$$

$$\nu(\mathrm{CO_2}) = \frac{\mathrm{V(CO_2)}}{\mathrm{V_m}} = \frac{0.784\ \mathrm{L}}{22.4\ \mathrm{L/mol}} = 0.035\ \mathrm{mol};$$

$$\mathrm{m(C)} = \nu(\mathrm{C}) \cdot \mathrm{M(C)} = 0.035\ \mathrm{mol} \cdot 12\ \mathrm{g/mol} = 0.42\ \mathrm{g}.$$

$$\nu(\mathrm{S}) = \nu(\mathrm{SO_2});\quad \nu(\mathrm{SO_2}) = 0.07\ \mathrm{mol};\quad \mathrm{m(S)} = 2.24\ \mathrm{g}.$$

$$\mathrm{m(C)} + \mathrm{m(S)} = 0.42\ \mathrm{g} + 2.24\ \mathrm{g} = 2.66\ \mathrm{g}.$$

O is absent (z = 0)

$$\mathrm{n(C)}:\mathrm{n(S)} = \nu(\mathrm{C}):\nu(\mathrm{S}) = 0.035:0.07 = 1:2$$

Answer : CS_2

5. In compound B, the mass percent of Hydrogen is 3.03%, and that of sulphur is 96.97%. Determine the formula of compound B if its relative molecular mass is 66.

Given :

$\omega(H) = 3.03\%$

$\omega(S) = 96.97\%$

$M_r(B) = 66$

H_xS_y – ?

Solution:

$$\omega(E) = \frac{n(E) \cdot A_r(E)}{M_r(compound)}$$

$$n(E) = \frac{\omega(E) \cdot M_r(compound)}{A_r(E)}$$

$$n(H) = \frac{0.0303 \cdot 66}{1} = 2 \qquad n(S) = \frac{0.9679 \cdot 66}{32} = 2$$

x = 2; y = 2

Answer : H_2S_2

6. Calculate the mass of Carbon contained in 4.4 g of carbon (IV) oxide.

Given :

$m(CO_2) = 4.4$ g

$M_r(CO_2) = 44$

m(C) – ?

Solution:

$$\omega(C) = \frac{n(C) \cdot A_r(C)}{M_r(CO_2)} \qquad \omega(C) = \frac{m(C)}{m(CO_2)}$$

$$\frac{n(C) \cdot A_r(C)}{M_r(CO_2)} = \frac{m(C)}{m(CO_2)}$$

$$m(C) = \frac{n(C) \cdot A_r(C) \cdot m(CO_2)}{M_r(CO_2)} = \frac{1 \times 12 \times 4{,}4\ g}{44} = 1.2\ g$$

Answer : 1.2 g

7. At roasting crystal hydrate composition $Na_2SO_3 \cdot xH_2O$, its mass decreased by 50%. Set the formula of the crystal hydrate.

Given :

$\omega(H_2O) = 50\%$

$Na_2SO_3 \cdot xH_2O$ – ?

Solution:

$$\omega(H_2O) = \frac{n(H_2O) \cdot M_r(H_2O)}{M_r(Na_2SO_3 \cdot xH_2O)}$$

$$M_r(Na_2SO_3 \cdot xH_2O) = \frac{n(H_2O) \cdot M_r(H_2O)}{\omega(H_2O)}$$

$$M_r(Na_2SO_3 \cdot xH_2O) = 2 \cdot 23 + 32 + 3 \cdot 16 + x \cdot 18 = 126 + 18x$$

$$126 + 18x = \frac{x \cdot 18}{0.5}$$

$$x = 7$$

Anser: $Na_2SO_3 \cdot 7H_2O$

Examples of solution of the tasks

8. The sample of table salt (the main component of NaCl) contains 60% Chlorine. Calculate the mass percent of impurities in the salt.

Given :

ω(Cl) = 60%

ω(impurities) – ?

Solution:

$$\text{Let's admit m(sample)} = 100\ \text{g}$$

$$\nu(\text{Cl}) = \frac{\text{m(Cl)}}{A_r(\text{Cl})} = \frac{60\ \text{g}}{35.5\ \text{g/mol}} = 1.7\ \text{mol}$$

$$\nu(\text{Na}) = \nu(\text{Cl}) = 1.7\ \text{mol}$$

$$\text{m(Na)} = \nu(\text{Na}) \cdot A_r(\text{Na}) = 1.7\ \text{mol} \cdot 23\ \text{g/mol} = 39.1\ \text{g}$$

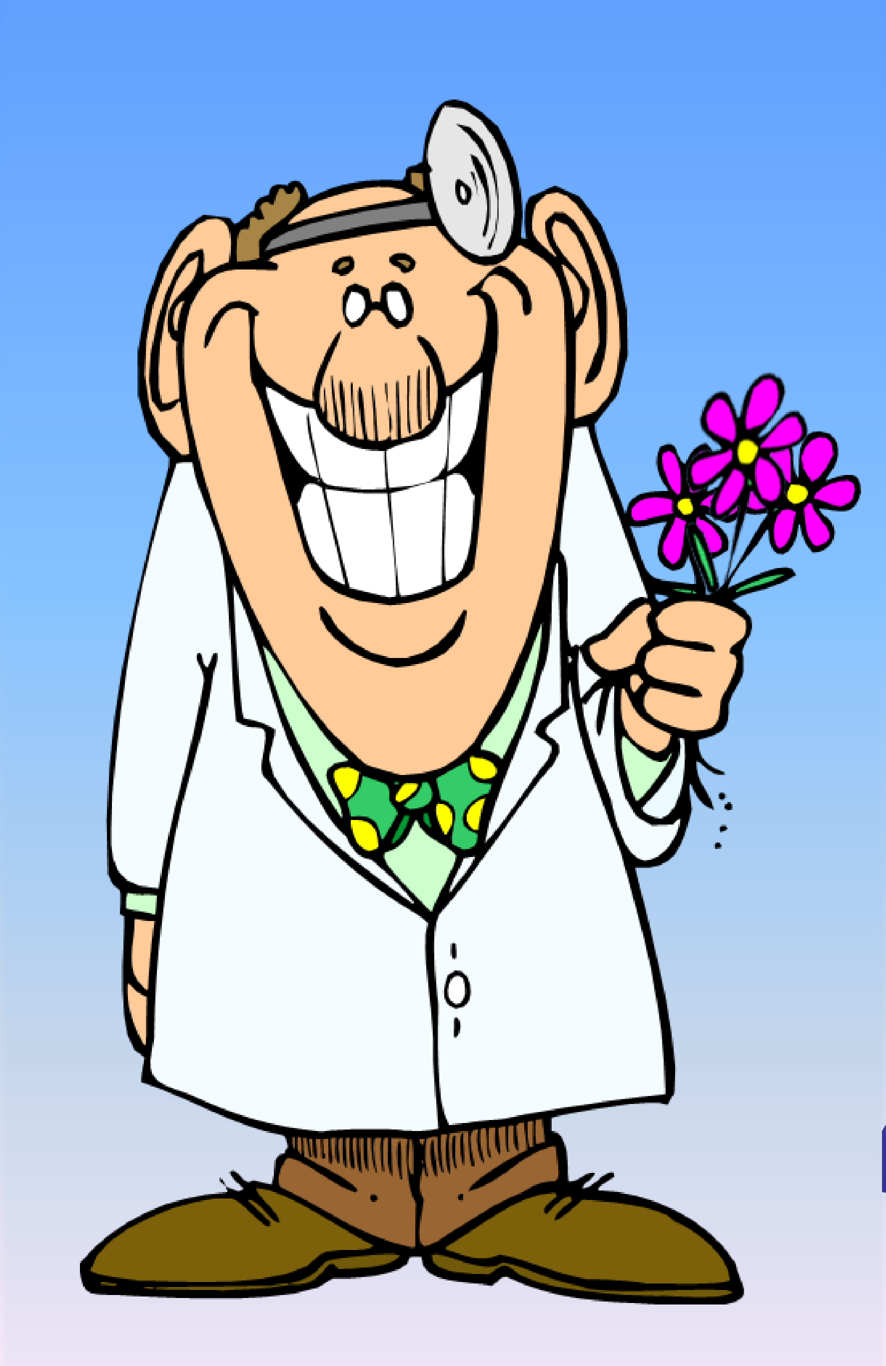
$$\text{m(NaCl)} = \text{m(Na)} + \text{m(Cl)} = 39.1\ \text{g} + 60\ \text{g} = 99.1\ \text{g}$$

$$\text{m(sample)} = \text{m(NaCl)} + \text{m(impurities)}$$

$$\text{m(impurities)} = \text{m(sample)} - \text{m(NaCl)} = 100\ \text{g} - 99.1\ \text{g} = 0.9\ \text{g}$$

$$\omega(\text{impurities}) = \frac{\text{m(impurities)}}{\text{m(sample)}} = \frac{0.9\ \text{g}}{100\ \text{g}} = 0.009$$

Answer: 0.009 or 0,9%



- Thank you for attention!