

CHEMICAL FORMULAE

= formulae describing chemical elements, compounds and ions

Molecular formula – expresses the actual of bonded in a molecule, e.g. H_2O means that in the molecule of water there are atoms of hydrogen and atom of oxygen.

1. *What are the molecular formulae of hydrogen peroxide and ethane and what do these formulae say about the composition of their molecules?*

Stoichiometric formula – expresses the simplest between the atoms bonded in a compound, e.g. the stoichiometric formula of hydrogen peroxide (H_2O_2) is

2. *Give the stoichiometric formulae for water and ethane.*

If the ratio of bonded atoms is found by an experiment, the formula is then called **empirical**.

Rational / functional formula – expresses characteristic,

3. *What are the characteristic groups of:*
 - a. NH_4NO_2
 - b. CH_3COOH ?
4. *Write the stoichiometric formulae of ammonium nitrite and ethanoic acid.*

Structural formula – says how the atoms are arranged in the molecules, i.e. expresses the between the atoms in the molecule.

5. *Write the structural formula of water and ethane.*

Structural electronic formula – shows all the Single electrons are represented by dots and electron pairs by dashes. Electron pairs are either (between atoms) or (electron pair of one atom, which does not take part on the bonding).

6. *Write the electronic formulae of water and NO_2 .*

Geometric formula – describes the real of the molecule by keeping the bonding angle.

NAMING INORGANIC SUBSTANCES AND MAKING THEIR FORMULAE

Acids

- **Binary acids:** hydro...ic acid

7. Fill the table:

<i>HF</i>		<i>HI</i>	
<i>HCl</i>			<i>hydrosulphuric acid</i>
	<i>hydrobromic acid</i>	<i>H₂Se</i>	

- **Oxoacids:** suffix: -ic + ox. number of the acid-forming element

8. Fill the table:

<i>HNO₂</i>		<i>HIO</i>	
<i>HClO₃</i>			<i>iodic(VII) acid</i>
	<i>sulphuric(VI) acid</i>	<i>H₂SeO₃</i>	

The names of the most common (and the most important) oxoacids do not have to include the oxidation numbers.

Remember:



HNO₃ = nitric acid
 H₂SO₄ = sulphuric acid
 H₂CO₃ = carbonic acid
 H₃PO₄ = phosphoric acid

9. Give the names or the formulae for the following acids:

<i>HBrO</i>		<i>H₂CrO₄</i>	
	<i>hydroiodic acid</i>	<i>H₂SO₃</i>	
	<i>manganic(VI) acid</i>		<i>nitric(III) acid</i>
<i>H₂S</i>		<i>H₂SeO₄</i>	
	<i>iodic(V) acid</i>		<i>chloric(III) acid</i>
<i>HBr</i>			<i>telluric(IV) acid</i>
	<i>iodic(I) acid</i>	<i>HClO₄</i>	
<i>HMnO₄</i>			<i>bromic(V) acid</i>
	<i>nitric acid</i>	<i>H₂CO₃</i>	
	<i>phosphoric acid</i>		<i>nitric acid</i>

Naming of ions

1. Positive ions:

- **Metal ions:** If the metal forms one ion, its charge is not expressed in the name. If the metal forms two or more ions, its charge is expressed in brackets:

Na: Na⁺ sodium ion

Fe: Fe²⁺ iron(II) ion, Fe³⁺ iron(III) ion

10. In the table below there are listed the most common metals. Write the charges of their ions and name these ions:

<i>Li</i>			<i>Zn</i>		
<i>Na</i>			<i>Ag</i>		
<i>K</i>			<i>Pb</i>		
<i>Be</i>			<i>Sn</i>		
<i>Mg</i>			<i>Fe</i>		
<i>Ca</i>			<i>Cu</i>		
<i>Ba</i>			<i>Hg</i>		
<i>Al</i>			<i>Mn</i>		

- **Molecular positive ions:** made of more atoms: NH₄⁺ ammonium ion , H₃O⁺ oxonium ion

11. Give the formulae or name:

<i>calcium ion</i>		<i>Li⁺</i>	
<i>lead(II) ion</i>		<i>Fe³⁺</i>	
<i>potassium ion</i>		<i>Cu²⁺</i>	
<i>cobalt(III) ion</i>		<i>Tl⁺</i>	
<i>oxonium ion</i>		<i>Be²⁺</i>	
<i>magnesium ion</i>		<i>Cr³⁺</i>	
<i>silver ion</i>		<i>NH₄⁺</i>	
<i>manganese(II) ion</i>		<i>Fe²⁺</i>	
<i>zinc ion</i>		<i>Sn²⁺</i>	

Negative ions:

- **Atomic ions:** suffix **-ide**

= ions made from single **non-metal** atoms by accepting one or more electrons

12. In the table below there are listed the most common non-metals. Write the number of their group in the periodic table, the charges of their ions and name these ions:

F				Se			
Cl				Te			
Br				N			
I				P			
O				C			
S				H			

- Molecular ions with the suffix **-ide**

OH⁻ hydroxide

CN⁻ cyanide

- Molecular ions derived from oxoacids: suffix **-ate** (+ oxidation number of the acid-forming element)

13. Determine the oxidation number of the acid-forming element in the following ions and name the ions.

ClO ₂ ⁻			SO ₃ ²⁻		
IO ₄ ⁻			MnO ₄ ²⁻		
BrO ⁻			ClO ₃ ⁻		
NO ₂ ⁻			MnO ₄ ⁻		

14. In the table below there are names of some anions. Write the formulae of their corresponding acids and the formulae of the ions:

chlorate (VII) ion	HClO ₄	ClO ₄ ⁻	iodate(V) ion		
nitrate(V) ion			chromate(VI) ion		
chlorate(I) ion			silicate(IV) ion		
sulphate(VI) ion			chlorate(III) ion		

The names of the salts of the most common (and the most important) oxoacids do not have to include the oxidation numbers.

Remember:



NO_3^- = nitrate
SO_4^{2-} = sulphate
CO_3^{2-} = carbonate
PO_4^{3-} = phosphate

15. Give the names and formulae of hydrogen salts ions derived from:

H_2SO_4			H_3PO_4		
H_2CO_3					

16. Give the names or formulae for:

bromide ion

HSO_3^-

nitrate(III) ion

I^-

selenide ion

NO_3^-

hydrogensulphate ion

H_2PO_4^-

phosphate ion

O^{2-}

sulphide ion

CN^-

hydroxide ion

BrO^-

chlorate(III) ion

HPO_4^{2-}

manganate(VII) ion

MnO_4^{2-}

vanadate(V) ion

IO_3^-

hydrogen carbonate ion

HSO_4^-

hydrogen sulphate(IV) ion

BrO_4^-

Ionic substances

Consist of positive and negative ions, the overall charge is zero.

When **making** their **formulae** they are balanced using the “cross rule”.

17. Give the formulae for the following compounds:

magnesium phosphide

cobalt(III) bromide

iron(II) nitrate

manganese(II) oxide

ammonium sulphate

iron(III) chromate(VI)

calcium hydrogen carbonate

sodium chlorate(I)

potassium cyanide

calcium dihydrogen phosphate

tin(II) chloride

nickel(II) sulphide

sodium hydrogen sulphide

calcium hydride

When **naming** ionic substances, their individual ions must first be identified and then named.

18. Name these substances:

PbS

SnCl₄

KHCO₃

Ag₂O

Cr₂(SO₄)₃

Ca(NO₂)₂

Mg(OH)₂

Hg(NO₃)₂

NaVO₃

KClO₂

NH₄NO₃

Fe₂O₃

NaClO₄

NaH₂PO₄

PbCrO₄

CuS

Covalent substances

They are made by a combination of two nonmetals and the name then describes the composition of the molecule using Greek words: (mono), di, tri, tetra, penta,.....

CO carbonoxide

CO₂ carbonoxide

PCl₃ phosphoruschloride

PCl₅ phosphoruschloride

P₄O₁₀phosphorusoxide

N₂Onitrogenoxide

NO nitrogenoxide

NO₂ nitrogenoxide

19. Give the names or formulae for:

sulphur hexafluoride

SO₃

oxygen difluoride

P₄O₆

iodine trifluoride

CS₂

nitrogen trichloride

SiF₄

<http://www.gst-d2l.com/homework/NomenTut.html>

<http://chemistry.alanearhart.org/Tutorials/Nomen/nomen-part7.html>

MASS PERCENTAGE w

= how many percent of the mass of a substance $A_xB_yC_z$ the mass of a certain element A forms, it may be calculated as follows:

$$w = \frac{x \times A_r(A)}{M_r(A_xB_yC_z)}$$

22. Calculate the mass percentage of aluminium in aluminium oxide, Al_2O_3

$$w(Al) =$$

23. Calculate the mass percentage of:

- nitrogen in aluminium nitrate
- oxygen in copper sulphate pentahydrate
- carbon in ethanoic acid
- lead (II) oxide in $2 PbO \cdot PbO_2$
- water in zinc sulphate heptahydrate

The use of mass percentage

1. Calculating the mass of an element from the mass of a compound and vice versa

$$m(\dots\dots\dots) = w \times m(\dots\dots\dots)$$

24. Calculate the mass of lead, which may be prepared from 12 g of lead (II) chloride.

2. Finding the empirical formula of a compound

25. A sample of unknown compound contains 75.73% of arsenic and 24.27% of oxygen. Find the empirical formula of this compound As_xO_y .

Questions:

1. Calculate the mass of oxygen present in 12 mg of sodium chlorate(I). (2.6 mg)
2. Calculate the mass percentage of sulphur in tin(IV) sulphide. (35.1 %)
3. How many grams of water of crystalization are there in 13 g of magnesium sulphate heptahydrate? (6.7g)
4. What is the mass percentage of water in strontium hydrogen sulphide tetrahydrate? (32 %)
5. How many grams of calcium are contained in 5 grams of calcium carbonate? (2 g)
6. Calculate the mass percentage of carbon in calcium carbonate. (12 %)
7. How many grams of zinc sulphate heptahydrate of 92 % purity contain 30 grams of anhydrous zinc sulphate? (58.1 g)
8. How many mg of nitrogen is contained in 15 mg of ammonium sulphate(IV)? (3.6 mg)
9. Calculate the mass percentage of phosphorus in calcium dihydrogen phosphate. (26.5 %)
10. What mass of aluminium is present in 10.4 g of aluminium sulphate? (1.642 g)
11. What mass of chromium (III) oxide is needed for the preparation of 7.8 g of chromium metal? (11.4 g)
12. What mass of magnesium nitrate may be prepared from 6.5 g of magnesium? (40.08 g)
13. What mass of vanadium may be manufactured from 1 t of vanadium (III) oxide? (0.68 t)
14. What mass of iron (II) sulphate heptahydrate can you obtain from 20 g of impure iron containing 86% of iron? How can you prepare it? What is the most common impurity in impure iron? (85.4 g)
15. One of the most common iron ores limonite $\text{Fe}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$ contains about 18% of impurities. State what are the most common impurities in iron ores and what mass of iron may be manufactured from 50 t of impure limonite (23.4 t)
16. Calculate the empirical formulae of substances containing:
 - a. 63.18% of manganese and 36.82% of oxygen (MnO_2)
 - b. 45.53% of tin and 54.47% of chlorine (SnCl_4)
 - c. 68.42% of chromium and 31.58% of oxygen (Cr_2O_3)
 - d. 44% of oxygen and 56% of vanadium (V_2O_5)
 - e. 11.45% of phosphorus and 88.55% of bromine (PBr_3)
 - f. 55.25% of potassium, 14.60% of phosphorus and the rest is oxygen (K_3PO_4)
17. 5g of an unknown sample contains 1.22 g of calcium, 0.85 g of nitrogen and the rest is oxygen. Calculate its empirical formula and try to make the functional formula. ($\text{Ca}(\text{NO}_3)_2$)
18. Hydrated cobalt (II) chloride is red. When it is dried out it turns blue and its mass decreases by 35.56%. Calculate the number of molecules of water cobalt (II) crystallizes with. (4)
19. 2.4 g of hydrated manganese (II) sulphate is dried out and its mass decreased to 1.3 g. Make its formula. ($\text{MnSO}_4 \cdot 7\text{H}_2\text{O}$)