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:

HF		*HI*	
HCl			*hydrosulphuric acid*
	hydrobromic acid	*H_2Se*	

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

8. Fill the table:

HNO_2		*HIO*	
$HClO_3$			*iodic(VII) acid*
	sulphuric(VI) acid	*H_2SeO_3*	

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

Remember:

!

HNO_3 = nitric acid
H_2SO_4 = sulphuric acid
H_2CO_3 = carbonic acid
H_3PO_4 = phosphoric acid

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

HBrO		*H_2CrO_4*	
	hydroiodic acid	*H_2SO_3*	
	manganic(VI) acid		*nitric(III) acid*
H_2S		*H_2SeO_4*	
	iodic(V) acid		*chloric(III) acid*
HBr			*telluric(IV) acid*
	iodic(I) acid	*$HClO_4$*	
$HMnO_4$			*bromic(V) acid*
	nitric acid	*H_2CO_3*	
	phosphoric acid		*nitric acid*

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: Fe^{2+} iron(II) ion, Fe^{3+} 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:*

Li			*Zn*		
Na			*Ag*		
K			*Pb*		
Be			*Sn*		
Mg			*Fe*		
Ca			*Cu*		
Ba			*Hg*		
Al			*Mn*		

- **Molecular positive ions:** made of more atoms: NH_4^+ ammonium ion , H_3O^+ oxonium ion

11. *Give the formulae or name:*

calcium ion		Li^+	
lead(II) ion		Fe^{3+}	
potassium ion		Cu^{2+}	
cobalt(III) ion		Tl^+	
oxonium ion		Be^{2+}	
magnesium ion		Cr^{3+}	
silver ion		NH_4^+	
manganese(II) ion		Fe^{2+}	
zinc ion		Sn^{2+}	

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^- hydrox**ide**
  CN^- cyan**ide**

- 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	*$SnCl_4$*
$KHCO_3$	*Ag_2O*
$Cr_2(SO_4)_3$	*$Ca(NO_2)_2$*
$Mg(OH)_2$	*$Hg(NO_3)_2$*
$NaVO_3$	*$KClO_2$*
NH_4NO_3	*Fe_2O_3*
$NaClO_4$	*NaH_2PO_4*
$PbCrO_4$	*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 carbon .....oxide	CO_2 carbon .....oxide
PCl_3 phosphorus .....chloride	PCl_5 phosphorus .....chloride
P_4O_{10} .....phosphorus .....oxide	N_2O .....nitrogen .....oxide
NO nitrogen .....oxide	NO_2 nitrogen .....oxide

19. *Give the names or formulae for:*

sulphur hexafluoride	*SO_3*
oxygen difluoride	*P_4O_6*
iodine trifluoride	*CS_2*
nitrogen trichloride	*SiF_4*

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

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

Hydrogen compounds:

The number of hydrogen atoms in binary compounds is not expressed, e.g. H_2S is hydrogen sulphide, not dihydrogen sulphide.

Traditional names: H_2O ....., NH_3 ....., CH_4 ....., ... phosphine, ... silane

20. Write the names or formulae for:

hydrogen chloride	*HBr*
hydrogen cyanide	*H_2S*

Final revision:

21. Give the names or formulae for the following compounds:

SO_2	*potassium dihydrogen phosphate*	*copper(II) chloride*	*$Mg(ClO_3)_2$*
$KBrO_2$	*sodium hydrogensulphate*	*silver nitrate*	*$PbCO_3$*
$(NH_4)_2CO_3$	*magnesium nitride*	*chloric(VII) acid*	*$Ca(CN)_2$*
$Cr(OH)_3$	*iron(II) sulphate*	*sulphur hexafluoride*	*$PbSO_4$*
HBr	*sodium hydrogensulphide*	*aluminium fluoride*	*$Al_2(SO_3)_3$*
Ag_2S	*magnesium chlorate(VII)*	*magnesium iodate(V)*	*HIO_4*
Al_2S_3	*chloric(V) acid*	*iron(III) sulphate*	*Na_2HPO_4*
PbS	*hydrofluoric acid*	*sodium nitrate(III)*	*$TiCl_4$*
HNO_2	*sodium hydrogensulphate(IV)*	*chloric(III) acid*	*SF_4*
NaClO	*sodium hydride*	*iodine monobromide*	*$KMnO_4$*
$Cr(NO_3)_3$	*dinitrogen tetraoxide*	*potassium cyanide*	*HBrO*
CaH_2	*iron(II) sulphate*	*calcium fluoride*	*KIO_3*

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:*
    a. *nitrogen in aluminium nitrate*
    b. *oxygen in copper sulphate pentahydrate*
    c. *carbon in ethanoic acid*
    d. *lead (II) oxide in $2\,PbO \cdot PbO_2$*
    e. *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(.....) = w × m(.....)
   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_xOy.*

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 $Fe_2O_3 \cdot 2H_2O$ 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.* *($Ca(NO_3)_2$)*
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.* *($MnSO_4 \cdot 7H_2O$)*