INORGANIC NOMENCLATURE II

1. WARM UP

- If you could change something in chemistry, what would that be?
- If you were a teacher of chemistry at a primary/secondary school, how would you change the way chemistry is taught there?
- If you could change something in the way chemistry is taught at Masaryk University, what would you do?

2. INORGANIC NOMENCLATURE II

C. TERNARY COMPOUNDS (compounds that consist of a combination of three elements)

ACIDS

HYDROACIDS: hydrogen + non-metal

Hydro + root + *ic* acid

HCl **hydro**chlor***ic*** acid HCl
HF **hydro**fluor***ic*** acid
HCN **hydro**cyan***ic*** acid

OXYACIDS (OXOACIDS) : polyatomic ion + acid

- only one oxyacid**:** **root + *-ic* acid**

H_3BO_3 bor***ic*** acid
H_4SiO_4 silic***ic*** acid

- two oxyacids with different oxygen content:

- **root + *-ic* acid** indicates **higher oxygen content**
- **root + *-ous*** indicates **lower oxygen content**

H_2SO_4 sulphur**ic** acid (higher oxygen content)
H_2SO_3 sulphur**ous** acid (lower oxygen content)
$H_2S_2O_7$ **di**sulphur**ic** acid
H_3PO_4 phosphor**ic** acid
H_3PO_3 phosphor**ous** acid
HNO_3 nitr**ic** acid
HNO_2 nitr**ous** acid

- more than two oxyacids:

prefix	suffix	Examples	
per (more than)	***-ic***	$HClO_4$	***per*chlor*ic acid***
	-ic	$HClO_3$	chlor***ic acid***
	-ous	$HClO_2$	chlor***ous acid***
hypo (less than)	***-ous***	$HClO$	***hypo*chlor*ous acid***

Practise:

- ***Write chemical formulae for:***
  1. phosphorous acid _____ **H_3PO_3**_____
  2. carbonic acid ___ **H_2CO_3**_____
  3. disulfuric acid ____ **$H_2S_2O_7$**_____
  4. nitric acid _____ **HNO_3**_____
  5. hydrobromic acid ____ **HBr**_____
  6. iodic acid _____ **HIO_3**_____
  7. chromic acid _____ **H_2CrO_4**_____
  8. bromic acid _____ **$HBrO_3$**_____
  9. hypoiodous acid ___ **HIO**_____
  10. phosphoric acid ____ **H_3PO_4**_____

- ***Write the names for:***
  1. H_3PO_4 __**phosphoric**_____
  2. H_2SO_4 __**sulphuric**_____
  3. H_4SiO_4 _____**silicic**_____
  4. HClO __**hypochlorous**_____
  5. H_3BO_3 ___**boric**_____

SALTS

SALTS OF HYDROACIDS

HCl hydrochloric acid

HCl → NaCl sodium chlor***ide*** (salt)

Note: H_2S hydrogen sulph***ide***

SALTS OF OXOACIDS (ternary compound containing oxygen)

- if there is **only one such compound**: **root + *-ate***

Na_2CO_3	sodium carbon**ate**, (no carbonite is known)
Na_3BO_3	sodium bor**ate,** (no borite is known)
Na_4SiO_4	sodium silic**ate,** (no silicite is known)

- if there are **two compounds**, differing only in their oxygen content and oxidation number of the central atom: the one which contains **more oxygen** ends in ***-ate*** and the other, with less oxygen, ends in ***-ite***

Example 1: **sodium salts**

lower oxygen content		**higher oxygen content**	
$NaNO_2$	sodium nitr***ite***	$NaNO_3$	sodium nitr***ate***
Na_3PO_3	sodium phosph***ite***	Na_3PO_4	sodium phosph***ate***
Na_3AsO_3	sodium arsen***ite***	Na_3AsO_4	sodium arsen***ate***
Na_2SO_3	sodium sulph***ite***	Na_2SO_4	sodium sulph***ate***

Example: sodium salts of the oxyacids of chlorine:

- if there are **more than two compounds**, differing only in their oxygen content and oxidation number of the central atom:

prefix	suffix	Examples	
per (more than)	***-ate***	$NaClO_4$	***sodium per***chlor***ate***
	-ate	$NaClO_3$	***sodium*** chlor***ate***
	-ite	$NaClO_2$	***sodium*** chlor***ite***
hypo (less than)	***-ite***	$NaClO$	***sodium hypo***chlor***ite***

$KMnO_4$ - potassium permangan***ate***

Corresponding nomenclature of acids and their salts:

	acids		salts (ions)	
	***per**chlor**ic** acid*	$HClO_4$	***per**chlor**ate** ion*	ClO_4^-
	*chlor**ic** acid*	$HClO_3$	*chlor**ate** ion*	ClO_3^-
	*chlor**ous** acid*	$HClO_2$	*chlor**ite** ion*	ClO_2^-
	***hypo**chlor**ous** acid*	$HClO$	***hypo**chlor**ite** ion*	ClO^-

Since the oxygen-acid nomenclature of ternary compounds does not give the absolute number of oxygens involved, the name must be derived from experience. That´s why the chemists use **rational nomenclature (named according to IUPAC regulations):**

- **prefixes *mono-, di-,* tri-, tetra-, penta-…** express the **absolute number of oxygens**
- **root+ suffix - *ate***
- **Roman numerals** express the **oxidation number**

Examples:

Na_2SO_3 sodium ***tri***oxosulf***ate*** (IV) – 3 oxygens, oxidation number IV
Na_2SO_4 sodium ***tetra***oxosulf***ate*** (VI)

sodium salts:

$NaClO_4$ sodium ***tetra**oxochlor**ate*** (VII)
$NaClO_3$ sodium ***tri**oxochlor**ate*** (V)
$NaClO_2$ sodium ***di**oxochlor**ate*** (III)
$NaClO$ sodium *oxochlor**ate*** (I)

Practise

- ***Write the chemical formulae for:***
  1. sodium tetraoxochlorate (VII) ___ **$NaClO_4$** ____
  2. sodium trioxochlorate (V) ___ **$NaClO_3$** ___
  3. sodium phosphite ___ **Na_3PO_3** _____
  4. sodium phosphate ___ **Na_3PO_4** _____
  5. sodium sulphate ___ **Na_2SO_4** _____
  6. sodium sulfite ____ **Na_2SO_3** _____

- ***Write the name for (use the IUPAC system):***

1. $Ca(NO_3)_2$ _____**calcium trioxonitrate (II)** _____
2. $Ca(NO_2)_2$ _____ **calcium dioxonitrate (III)** _____
3. $BaSO_4$ _____ **barium tetraoxosulfate (VI)** _____
4. $NaClO_3$ _____ **sodium trioxochlorate (V)** _____
5. $NaClO_2$ _____ **sodium dioxochlorate (III)** _____
6. $NaHSO_4$ ___ **sodium hydrogen tetraoxosulfate (VI)** _____

HYDROXIDES - (bases containing the OH group) – the same rules applied

NaOH	sodium hydrox***ide***
$Ca(OH)_2$	calcium hydrox***ide***
$Mg(OH)_2$	magnesium hydrox***ide***
$Fe(OH)_2$	iron **(II)** hydrox***ide*** = ferr***ous*** hydrox***ide***
KOH	potassium hydrox***ide***
Fe(OH)3	iron (III) hydrox***ide*** = ferr***ic*** hydrox***ide***
Ba(OH)2	barium hydrox***ide***

3. **LISTENING – v interaktivní osnově ve složce Poslechy link:**

https://www.youtube.com/watch?v=0hxt6hd-wV0

Listen and answer the following questions:

1. What compounds are necessary for the chemical experiment?

_potassium dichromate (diluted), sulphuric acid, mercury drop____

2. What is the position of the iron nail?

___ **It almost touches the mercury** _____

3. What is the mercury drop compared to?

___**beating heart**_____

4. What is the role of the dichromate?

__It oxidizes mercury to mercury (I) ions, they combine with sulphate ions at the surface of the drop to form mercury (I) sulphate_____

5. What compound is formed on the surface of the drop?

_____ **mercury (I) sulphate**_____

6. What do you know about its solubility?

_____**insoluble**_____

7. Why does the mercury drop flatten?

___**the film decreases the surface tension**_____

8. What enables electrons to flow from the nail to the mercury?

_Mercury drop expands to touch the iron nail, at which time electrons flow…

9. How does the shape of the drop change due to the electrons?

_Electrons reduce mercury (I) ions to mercury, destroy the surface film, surface tension increases and the drop becomes more spherical____

10. What happens at the end of the process?

__**Mercury and nail stop touching, mercury I sulphate forms on the surface…**__

4. HOW TO READ CHEMICAL EQUATIONS IN ENGLISH:

Example:	**HCl**	+	**NaOH**	→	**NaCl**	+	**H_2O**
We spell as:	H Cl	**plus**	Na OH	**gives**	Na Cl	**plus**	H_2O
We read as:	hydrochloric acid **reacts with** sodium hydroxide **to form** sodium chloride **and** water						

Reading chemical formulae:

+	***reacts with***, ***combines with***, ***plus***, ***and*** or ***together with***
=	***give***, ***form***, ***pass over to***, ***yield*** or ***go to***
-->	***give***, ***pass over to*** or ***lead to***
<-->	***forms and is formed from***
the sign -	designates the bond and is not to be read in the formulae
the sign =	designates two bonds and is not to be read in formulae
C_3H_2	***c three h two***
2 CO_2	***two molecules of c o two***
$CO_2 + CaO \rightarrow CaCO_3$	***c o two plus c a o give c a c o three***
	c o two reacts with c a o to give c a c o three
$Ca(OH)_2$	***c a o h twice***

You can also use time clauses / conditional clauses to describe the reactions:

When we mix_____ with _____, we will get _____.

If _____mixes together with _____, it will lead to _____.

If we mixed _____ and _____, it would lead to _____.

Practise: Read these equations in pairs.

First spell them, then express in words. You can use a time / conditional clause.

a) $CO_2 + H_2O$ ---> H_2CO_3

b) $CaCO_3$--->$CaO + CO_2$

c) $2\ CO + O_2$-->$2\ CO_2$

d) $2\ Ca_3(PO_4) + 6\ SiO_2 + 10$ C-->$6\ CaSiO_3 + P_4 + 10$ CO

e) $2\ Na + Cl_2 \rightarrow 2\ NaCl$

f) $ZnO + H_2SO_4 \rightarrow 2\ ZnSO_4 + H_2O$

g) $2\ Na + 2\ H_2O \rightarrow 2\ NaOH + H_2$

Work in small groups. Write down two or three equations on a piece of paper. Then present the equations to the others.

Reading numbers and measurements:

31% **k^3** **y^2** **-70°F** **x**

1,203.4 **10°C** **$3a^4$** **:**

0.002

3.14 **0.631** **=** **30.7°**

Text: read out the expressions in bold

Diatoms, microscopic organisms, produce carbohydrates from carbon dioxide and water by normal photosynthesis:

6 CO_2 + 6 H20 + solar energy --> $C_6H_{12}O_6$ + 6 O_2

During the first five years of life whales gain **75 kg** of mass per day by feeding on krill. The whale must consume ten times this mass of krill each day. The whale must consume **10.0 kg** of diatoms to produce 1.0 kg of krill.

a) Assuming that the mass gain in the first years of a whale's life is due to the consumption of carbohydrates, calculate the volume of **CO_2** at **0 °C** and **101 kPa** that must be used by the diatoms to produce the carbohydrates consumed by a blue whale in its first five years of life.

b) There is **0.23 ml** of dissolved **CO_2** per 1 sea water (at **24 °C** and **l0l kPa**). If diatoms can completely remove carbon dioxide from the water they process, what volume of water would they process to produce the carbohydrates required by a blue whale during the first five years of life?

c) **3%** of the mass of a **$9.1.10^4$ kg** adult whale is nitrogen. What is the maximum mass of **NH_4^+** that can become available for other marine organisms if one adult whale dies?

d) 1**8%** of a adult whale's mass is carbon which can be returned to the atmosphere as **CO_2** being removed from there by weathering of rocks containing calcium silicate.

$CaSiO_3$ (s) + 2 CO_2 + 3$H_2$0(1) --> Ca^{2+} (aq) + 2HCO_3^-(aq) + H_4Si0_4(aq)

What is the maximum number of grams of $CaSiO_3$ that can be weathered by the carbon dioxide produced from the decomposition of 1000 blue whales, the number estimated to die annually?

Assignment 9:

A. Write equations for the following chemical reactions:

Word Equations Worksheet - Solutions

Write the word equations for each of the following chemical reactions:

1) When dissolved beryllium chloride reacts with dissolved silver nitrate in water, aqueous beryllium nitrate and silver chloride powder are made.

$$BeCl_{2(aq)} + 2\ AgNO_{3(aq)} \rightarrow Be(NO_3)_{2(aq)} + 2\ AgCl_{(s)}$$

2) When isopropanol (C_3H_8O) burns in oxygen, carbon dioxide, water, and heat are produced.

$$2\ C_3H_8O_{(l)} + 9\ O_{2(g)} \rightarrow 6\ CO_{2(g)} + 8\ H_2O_{(g)} \qquad \Delta H = \text{negative}$$

3) When dissolved sodium hydroxide reacts with sulfuric acid, aqueous sodium sulfate, water, and heat are formed.

$$2\ NaOH_{(aq)} + H_2SO_{4(l)} \rightarrow Na_2SO_4 + 2\ H_2O_{(l)} \qquad \Delta H = \text{negative}$$

4) When fluorine gas is put into contact with calcium metal at high temperatures, calcium fluoride powder is created in an exothermic reaction.

$$F_{2(g)} + Ca_{(s)} \xrightarrow{\Delta} CaF_{2(s)} \quad \Delta H = \text{negative}$$

5) When sodium metal reacts with iron (II) chloride, iron metal and sodium chloride are formed.

$$2\ Na_{(s)} + FeCl_{2(s)} \rightarrow 2\ NaCl_{(s)} + Fe_{(s)}$$

B. Read out the following equations:

How to Read Chemical Equations

Reaction	**Reading by Elementary Entities (Formula Units)**	**Reading by Mole (N_A of elementary entities or formula units)**
$2\ H_2 + O_2 \rightarrow 2\ H_2O$	**2 molecules** of hydrogen react with **1 molecule** of oxygen to form **2 molecules** of water	**2 moles** of hydrogen react with **1 mole** of oxygen to form **2 moles** of water
$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$	**1 molecule** of methane reacts with **2 molecules** of oxygen to form **1 molecule** of carbon dioxide and **2 molecules** of water	**1 mole** of methane reacts with **2 moles** of oxygen to form **1 mole** of carbon dioxide and **2 moles** of water
$2\ Na + 2\ H_2O \rightarrow 2\ NaOH + H_2$	**2 atoms** of sodium react with **2 molecules** of water to form **2 formula units** of sodium hydroxide and **1 molecule** of hydrogen	**2 moles** of sodium reacts with **2 moles** of water to form **2 moles** of sodium hydroxide and **1 mole** of hydrogen
$Ca + 2\ H_2O \rightarrow Ca(OH)_2 + H_2$	**1 atom** of calcium reacts with **2 molecules** of water to form **1 formula unit** of calcium hydroxide and **1 molecule** of hydrogen	**1 mole** of calcium reacts with **2 moles** of water to form **1 mole** of calcium hydroxide and **1 mole** of hydrogen
$2\ NaBr + Cl_2 \rightarrow 2\ NaCl + Br_2$	**2 formula units** of sodium bromide react with **1 molecule** of chlorine to form **2 formula units** of sodium chloride and **1 molecule** of bromine	**2 moles** of sodium bromide react with **1 mole** of chlorine to form **2 moles** of sodium chloride and **1 mole** of bromine
$AgNO_3 + KCl \rightarrow AgCl\downarrow + KNO_3$	**1 formula unit** of silver nitrate reacts with **1 formula unit** of potassium chloride to form **1 formula unit** of silver chloride (precipitate) and **1 formula unit** of potassium nitrate	**1 mole** of silver nitrate reacts with **1 mole** of potassium chloride to form **1 mole** of silver chloride (precipitate) and **1 mole** of potassium nitrate
$2AgNO_3 + CaBr_2 \rightarrow 2\ AgBr\downarrow + Ca(NO_3)_2$	**2 formula units** of silver nitrate react with **1 formula unit** of calcium bromide to form **2 formula units** of silver bromide (precipitate) and **1 formula unit** of calcium nitrate	**2 moles** of silver nitrate react with **1 mole** of calcium bromide to form **2 moles** of silver bromide (precipitate) and **1 mole** of calcium nitrate
$Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2\uparrow + H_2O$	**1 formula unit** of sodium carbonate reacts with **2 formula units** of hydrochloric acid to form **2 formula units** of sodium chloride, **1 molecule** of carbon dioxide (gas), and **1 molecule** of water	**1 mole** of sodium carbonate reacts with **2 moles** of hydrochloric acid to form **2 moles** of sodium chloride, **1 mole** of carbon dioxide (gas), and **1 mole** of water

Reaction	**Reading by Mole (N_A of elementary entities or formula units)**	**Reading by Mass (Molar mass of each substance is needed)**
$2\ H_2 + O_2 \rightarrow 2\ H_2O$	**2 moles** of hydrogen react with **1 mole** of oxygen to form **2 moles** of water	**4 g** of hydrogen react with **32 g** of oxygen to form **36 g** of water
$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$	**1 mole** of methane reacts with **2 moles** of oxygen to form **1 mole** of carbon dioxide and **2 moles** of water	**16 g** of methane react with **32 g** of oxygen to form **44 g** of carbon dioxide and **36 g** of water
$2\ Na + 2\ H_2O \rightarrow 2\ NaOH + H_2$	**2 moles** of sodium reacts with **2 moles** of water to form **2 moles** of sodium hydroxide and **1 mole** of hydrogen	**46 g** of sodium react with **36 g** of water to form **80 g** of sodium hydroxide and **2 g** of hydrogen
$Ca + 2\ H_2O \rightarrow Ca(OH)_2 + H_2$	**1 mole** of calcium reacts with **2 moles** of water to form **1 mole** of calcium hydroxide and **1 mole** of hydrogen	**40 g** of calcium react with **36 g** of water to form **74 g** of calcium hydroxide and **2 g** of hydrogen
$2\ NaBr + Cl_2 \rightarrow 2\ NaCl + Br_2$	**2 moles** of sodium bromide react with **1 mole** of chlorine to form **2 moles** of sodium chloride and **1 mole** of bromine	**206 g** of sodium bromide react with **71 g** of chlorine to form **117 g** of sodium chloride and **160 g** of bromine
$AgNO_3 + KCl \rightarrow AgCl\downarrow + KNO_3$	**1 mole** of silver nitrate reacts with **1 mole** of potassium chloride to form **1 mole** of silver chloride (precipitate) and **1 mole** of potassium nitrate	**170 g** of silver nitrate react with **74 g** of potassium chloride to form **143 g** of silver chloride (precipitate) and **101 g** of potassium nitrate
$2AgNO_3 + CaBr_2 \rightarrow 2\ AgBr\downarrow + Ca(NO_3)_2$	**2 moles** of silver nitrate react with **1 mole** of calcium bromide to form **2 moles** of silver bromide (precipitate) and **1 mole** of calcium nitrate	**240 g** of silver nitrate react with **200 g** of calcium bromide to form **356 g** of silver bromide (precipitate) and **184** of calcium nitrate
$Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2\uparrow + H_2O$	**1 mole** of sodium carbonate reacts with **2 moles** of hydrochloric acid to form **2 moles** of sodium chloride, **1 mole** of carbon dioxide (gas), and **1 mole** of water	**106 g** of sodium carbonate reacts with **73 g** of hydrochloric acid to form **117 g** of sodium chloride, **44 g** of carbon dioxide (gas), and **18 g** of water