

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 **hydrochloric** acid HCl
HF **hydrofluoric** acid
HCN **hydrocyanic** acid

OXYACIDS (OXOACIDS): polyatomic ion + acid

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

H₃BO₃ **boric** acid
H₄SiO₄ **silicic** acid

- two oxyacids with different oxygen content:

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

H₂SO₄ sulphuric acid (higher oxygen content)
H₂SO₃ sulphurous acid (lower oxygen content)
H₂S₂O₇ **disulphuric** acid
H₃PO₄ phosphoric acid
H₃PO₃ phosphorous acid
HNO₃ nitric acid
HNO₂ nitrous acid

- more than two oxyacids:

prefix	suffix	Examples	
<i>per</i> (more than)	<i>-ic</i>	<i>HClO₄</i>	<i>perchloric acid</i>
	<i>-ic</i>	<i>HClO₃</i>	<i>chloric acid</i>
	<i>-ous</i>	<i>HClO₂</i>	<i>chlorous acid</i>
<i>hypo</i> (less than)	<i>-ous</i>	<i>HClO</i>	<i>hypochlorous acid</i>

Practise:

- **Write chemical formulae for:**

1. phosphorous acid _____ **H₃PO₃** _____
2. carbonic acid _____ **H₂CO₃** _____
3. disulfuric acid _____ **H₂S₂O₇** _____
4. nitric acid _____ **HNO₃** _____
5. hydrobromic acid _____ **HBr** _____
6. iodic acid _____ **HIO₃** _____
7. chromic acid _____ **H₂CrO₄** _____
8. bromic acid _____ **HBrO₃** _____
9. hypoiodous acid _____ **HIO** _____
10. phosphoric acid _____ **H₃PO₄** _____

- **Write the names for:**

1. H₃PO₄ _____ **phosphoric** _____
2. H₂SO₄ _____ **sulphuric** _____
3. H₄SiO₄ _____ **silicic** _____
4. HClO _____ **hypochlorous** _____
5. H₃BO₃ _____ **boric** _____

SALTS

SALTS OF HYDROACIDS

HCl hydrochloric acid

HCl → NaCl sodium chloride (salt)

Note: H₂S hydrogen sulphide

SALTS OF OXOACIDS (ternary compound containing oxygen)

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

Na ₂ CO ₃	sodium carbonate, (no carbonite is known)
Na ₃ BO ₃	sodium borate, (no borite is known)
Na ₄ SiO ₄	sodium silicate, (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

NaNO ₂	sodium nitrite
Na ₃ PO ₃	sodium phosphite
Na ₃ AsO ₃	sodium arsenite
Na ₂ SO ₃	sodium sulphite

higher oxygen content

NaNO ₃	sodium nitrate
Na ₃ PO ₄	sodium phosphate
Na ₃ AsO ₄	sodium arsenate
Na ₂ SO ₄	sodium sulphate

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	
<i>per</i> (more than)	<i>-ate</i>	$NaClO_4$	<i>sodium perchlorate</i>
	<i>-ate</i>	$NaClO_3$	<i>sodium chlorate</i>
	<i>-ite</i>	$NaClO_2$	<i>sodium chlorite</i>
<i>hypo</i> (less than)	<i>-ite</i>	$NaClO$	<i>sodium hypochlorite</i>

$KMnO_4$ - potassium *permanganate*

Corresponding nomenclature of acids and their salts:

acids		salts (ions)	
<i>perchloric acid</i>	$HClO_4$	<i>perchlorate ion</i>	ClO_4^-
<i>chloric acid</i>	$HClO_3$	<i>chlorate ion</i>	ClO_3^-
<i>chlorous acid</i>	$HClO_2$	<i>chlorite ion</i>	ClO_2^-
<i>hypochlorous acid</i>	$HClO$	<i>hypochlorite ion</i>	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 *trioxosulfate* (IV) – 3 oxygens, oxidation number IV
 Na_2SO_4 sodium *tetraoxosulfate* (VI)

sodium salts:

$NaClO_4$ sodium *tetraoxochlorate* (VII)
 $NaClO_3$ sodium *trioxochlorate* (V)
 $NaClO_2$ sodium *dioxochlorate* (III)
 $NaClO$ sodium *oxochlorate* (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. $\text{Ca}(\text{NO}_3)_2$ calcium trioxonitrate (II)
2. $\text{Ca}(\text{NO}_2)_2$ 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 hydroxide
$\text{Ca}(\text{OH})_2$	calcium hydroxide
$\text{Mg}(\text{OH})_2$	magnesium hydroxide
$\text{Fe}(\text{OH})_2$	iron (II) hydroxide = ferrous hydroxide
KOH	potassium hydroxide
$\text{Fe}(\text{OH})_3$	iron (III) hydroxide = ferric hydroxide
$\text{Ba}(\text{OH})_2$	barium hydroxide

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:

<i>Example:</i>	HCl	+	NaOH	→	NaCl	+	H₂O
<i>We spell as:</i>	H Cl	plus	Na OH	gives	Na Cl	plus	H ₂ O
<i>We read as:</i>	hydrochloric acid reacts with sodium hydroxide to form sodium chloride and water						

Reading chemical formulae:

+	<i>reacts with, combines with, plus, and or together with</i>
=	<i>give, form, pass over to, yield or go to</i>
-->	<i>give, pass over to or lead to</i>
<-->	<i>forms and is formed from</i>
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
C₃H₂	<i>c three h two</i>
2 CO₂	<i>two molecules of c o two</i>
CO₂ + CaO → CaCO₃	<i>c o two plus c a o give c a c o three</i>
	<i>c o two reacts with c a o to give c a c o three</i>
Ca(OH)₂	<i>c a o h twice</i>

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

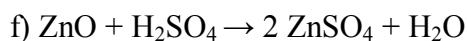
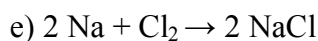
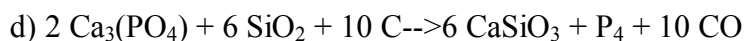
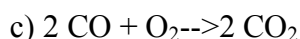
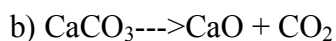
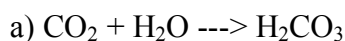
When we mix _____ with _____, we will get _____.

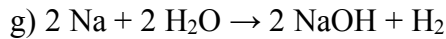
If _____ mixes together with _____, it will lead to _____.

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.





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 $3a^4$:
 3.14 0.631 = 30.7° 0.002

Text: read out the expressions in bold

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



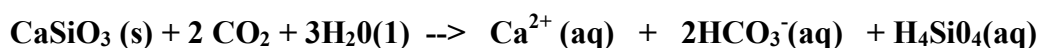
During the first five years of life whales gain **75 kg** of mass per day by feeding on krill. The whale must consume ten times this mass of krill each day. The whale must consume **10.0 kg** of diatoms to produce 1.0 kg of krill.

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 **101 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 **$9.1 \cdot 10^4 \text{ kg}$** 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) **18%** 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.



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?

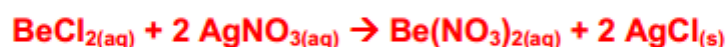
Assignment 9:

A. Write equations for the following chemical reactions:

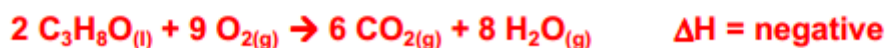
Word Equations Worksheet - Solutions

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

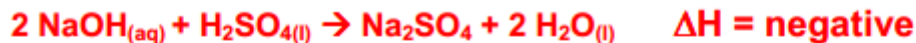
- 1) When dissolved beryllium chloride reacts with dissolved silver nitrate in water, aqueous beryllium nitrate and silver chloride powder are made.



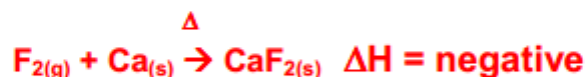
- 2) When isopropanol ($\text{C}_3\text{H}_8\text{O}$) burns in oxygen, carbon dioxide, water, and heat are produced.



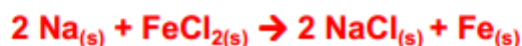
- 3) When dissolved sodium hydroxide reacts with sulfuric acid, aqueous sodium sulfate, water, and heat are formed.



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



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



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)
$2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$	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
$\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$	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
$2\text{Na} + 2\text{H}_2\text{O} \rightarrow 2\text{NaOH} + \text{H}_2$	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
$\text{Ca} + 2\text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2 + \text{H}_2$	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
$2\text{NaBr} + \text{Cl}_2 \rightarrow 2\text{NaCl} + \text{Br}_2$	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
$\text{AgNO}_3 + \text{KCl} \rightarrow \text{AgCl}\downarrow + \text{KNO}_3$	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
$2\text{AgNO}_3 + \text{CaBr}_2 \rightarrow 2\text{AgBr}\downarrow + \text{Ca(NO}_3)_2$	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
$\text{Na}_2\text{CO}_3 + 2\text{HCl} \rightarrow 2\text{NaCl} + \text{CO}_2\uparrow + \text{H}_2\text{O}$	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)
$2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$	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
$\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$	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
$2\text{Na} + 2\text{H}_2\text{O} \rightarrow 2\text{NaOH} + \text{H}_2$	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
$\text{Ca} + 2\text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2 + \text{H}_2$	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
$2\text{NaBr} + \text{Cl}_2 \rightarrow 2\text{NaCl} + \text{Br}_2$	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
$\text{AgNO}_3 + \text{KCl} \rightarrow \text{AgCl}\downarrow + \text{KNO}_3$	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
$2\text{AgNO}_3 + \text{CaBr}_2 \rightarrow 2\text{AgBr}\downarrow + \text{Ca(NO}_3)_2$	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 g of calcium nitrate
$\text{Na}_2\text{CO}_3 + 2\text{HCl} \rightarrow 2\text{NaCl} + \text{CO}_2\uparrow + \text{H}_2\text{O}$	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

