Lecture №　　　　　　　　　　　　　　　　　　　　　　　Date

Classes and nomenclature of inorganic compounds

Substances

- **Simple**
  - **Metals**
    - Na
    - Fe
    - Co
  - **Nonmetallic elements**
    - N
    - O
    - S
- **Complex**
  - **Binary**
    - oxides: CaO
    - hydrides: NaH
    - sulphides: K_2S
    - chlorides: $CuCl_2$
    - nitrides: BN
  - **Polyatomic**
    - bases: NaOH
    - acids: H_2SO_4
    - salts: Na_2CO_3
    - coordination compounds: $Na_3[Al(OH)_6]$

Atoms and Ions

An **atom** is smallest neutral particle of matter characterizes an element.

An **ion** is an electrically charged species consisting of a single atom or a group of atoms. It is formed when a neutral atom or a group of atoms either gains or loses electrons.

A positive ion, called **a cation** (pronounced cat’ eye on).

For example cations Na^+, Mg^{2+}.

If one of the electrons from the sodium atom is lost, there will be eleven positive charges but only ten negative charges. This gives an ion with a net positive one (+1) charge:

$$Na^0 - 1\bar{e} \rightarrow Na^+$$

Neutral sodium atom sodium ion

Some atoms lose more that one electron.

We usually represent this process as follows.

For example, a magnesium atom loses two electrons to form a 2+ cation:

$$Mg^0 - 2\bar{e} \rightarrow Mg^{2+}$$

When electrons are gained by a neutral atom, an ion with a negative charge is formed.

A negative charged ion is called **an anion**.

An example of an atom that forms a 1 – anion is the chlorine atom:

$$Cl^0 \quad + 1\bar{e} \rightarrow Cl^-$$

neutral chlorine atom   chloride ion

Some atoms can add two electrons to form 2 – anions.

$$S^0 \quad + 2\bar{e} \rightarrow S^{2-}$$

sulphur   sulphide ion

Now we will describe how to name compounds in each of those classes in the next several examples.

1. The cation is always named first and the anion second.

2. A simple cation (obtained from a single atom) takes its name from the name of the element. For example, Na^+ is called sodium in the names of compounds containing this ion.

3. A simple anion is named by taking the first part of the element name and adding – **ide**. Thus Cl^- ion is called **chloride**.

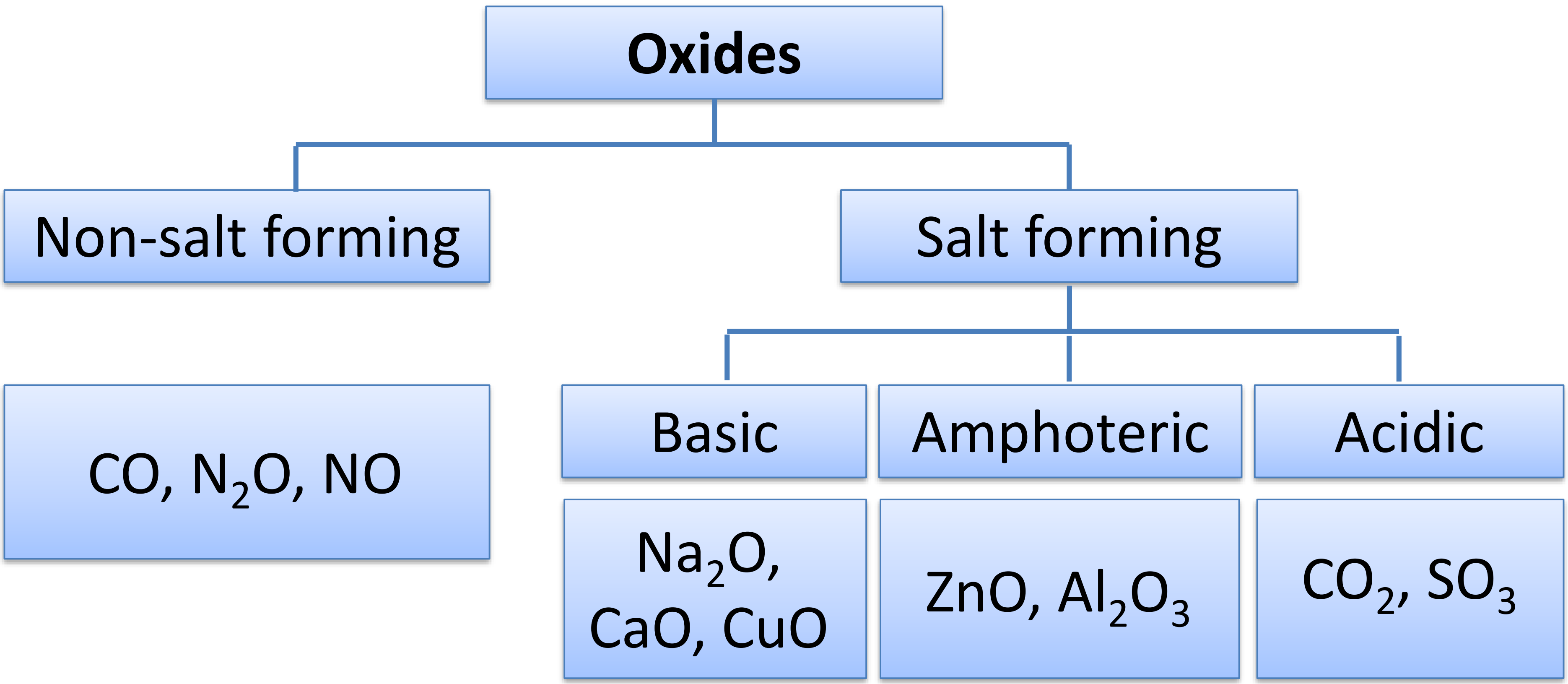
Cation	Name	Anion	Name
H^+	hydrogen	H^-	hydride
Na^+	sodium	F^-	fluoride
K^+	potassium	Cl^-	chloride
Mg^{2+}	magnesium	Br^-	bromide
Ca^{2+}	calcium	I^-	iodide
Fe^{2+}	iron (II)	B^{3-}	boride
Fe^{3+}	iron (III)	N^{3-}	nitride
Al^{3+}	aluminum	O^{2-}	oxide
Ag^+	silver	S^{2-}	sulphide

Naming binary covalent compounds

Formula	Name	
	Using prefixes	Stock system
BCl_3	boron trichloride	boron (III) chloride
NO	nitrogen oxide	nitrogen (II) oxide
PbO_2	lead dioxide	lead (IV) oxide
N_2O_5	dinitrogen pentoxide	nitrogen (V) oxide
PCl_5	phosphorus pentachloride	phosphorus (V) chloride

OXIDES

Oxides are binary compounds of an element or radical with oxygen in the oxidation state of −2.



Highest oxides of elements of III period

I	II	III	IV	V	VI	VII
Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	Cl_2O_7
Sodium oxide	Magnesium oxide	Aluminium oxide	Silicon dioxide	Phosphorus (V) oxide	Sulphur (VI) oxide	Chlorine (VII) oxide
Strong basic	Basic	Amphoteric	Slightly acidic	Acidic	Strong acidic	Very strong acidic

Over the period from the left to the right:

Metallic properties of elements **are decreasing**

Basic properties of oxides **are decreasing**

Acidic properties of oxides **are increasing**

Hydroxides of elements of III period

I	II	III	IV	V	VI	VII
$NaOH$	$Mg(OH)_2$	$Al(OH)_3$	H_2SiO_3	H_3PO_4	H_2SO_4	$HClO_4$
Sodium hydroxide	Magnesium hydroxide	Aluminium hydroxide	Silicic acid	Orthophos-phoric acid	Sulphuric acid	Perchloric acid
Strong basic	Basic	Amphoteric	Slightly acidic	Acidic	Strong acidic	Very strong acidic

In case the element forms several oxides, acidic properties of oxide are increasing with the increasing of oxidation state of the element. Basic properties decrease accordingly:

+2	+3	+6
CrO	Cr_2O_3	CrO_3
Basic	Amphoteric	Acidic

Double oxides contain an element in two oxidation states:

Fe_3O_4 magnetite, iron (II) iron (III) oxide $FeO{\cdot}Fe_2O_3$

Polymeric oxides:

$(H_2O)_n$ $(P_2O_3)_n$

Peroxides are complex substances, consisting from two elements, one of which oxygen in the oxidation state of −1.

H_2O_2, BaO_2

Bases and acids dissociate differently depending on the nature of molecule bonds:

R–O–H

Bases	Acids
$ROH \leftrightarrows R^+ + OH^-$	$ROH \leftrightarrows H^+ + RO^-$

Bases

Bases are electrolytes, which dissociate in aqueous solution with the formation OH^-.

The acidity of the base is the number of -OH groups formed during dissociation.

Bases are divided:

Monoacidic bases

NaOH – sodium hydroxide, KOH – potassium hydroxide

Diacidic bases

$Ba(OH)_2$ – barium hydroxide, $Fe(OH)_2$ – iron (II) hydroxide

Triacidic bases

$Al(OH)_3$ – aluminium hydroxide, $Fe(OH)_3$ – iron (III) hydroxide

Alkalis are bases good soluble in water:

LiOH, NaOH, KOH, RbOH, CsOH, $Ca(OH)_2$, $Sr(OH)_2$, $Ba(OH)_2$.

Acids

Acids are electrolytes, which dissociate in aqueous solution to form H^+ and acid residue.

Binary Acids

They are named by a combination of the prefix "*hydro*" and nonmetal name modified to have an "ic" ending.

HF *hydro*fluoric acid

HCl *hydro*chloric acid

HBr *hydro*bromic acid

HI *hydro*iodic acid

H_2S *hydro*sulphuric acid

Oxoacids

Formula of acid	Name of acid	Formula of salt	Name of salt
H_2SO_4	sulphur**ic** acid	Na_2SO_4	sodium sulph**ate**
H_2SO_3	sulphur**ous** acid	$Al_2(SO_3)_3$	aluminium sulph**ite**
H_2S	hydrosulphur**ic**	$(NH_4)_2S$	ammonium sulph**ide**
HNO_3	nitr**ic** acid	$Ba(NO_3)_2$	barium nitr**ate**
HNO_2	nitr**ous** acid	$Fe(NO_2)_2$	iron(II) nitr**ite**
H_2CO_3	carbon**ic** acid	$CaCO_3$	calcium carbon**ate**
H_3PO_4	(ortho) phosphor**ic** acid	Na_3PO_4	sodium phosph**ate**
H_3BO_3	(ortho) bor**ic** acid	Na_3BO_3	sodium orthobor**ate**
HBO_2	(meta) bor**ic** acid	$NaBO_2$	sodium metabor**ate**
$HClO_4$	**per**chlor**ic** acid	NH_4ClO_4	ammonium **per**chlor**ate**
$HClO_3$	chlor**ic** acid	$NaClO_3$	sodium chlor**ate**
$HClO_2$	chlor**ous** acid	$KClO_2$	potassium chlor**ite**
$HClO$	**hypo**chlor**ous** acid	$NaClO$	sodium **hypo**chlor**ite**
HCl	hydrochlor**ic** acid	$CuCl_2$	copper(II) chlor**ide**

Note: An **ortho acid** is an oxoacid containing the maximum number of OH groups possible.

A **meta acid** is formed by the elimination of H_2O from the ortho acid.

$$H_3AlO_3 - H_2O \rightarrow HAlO_2$$ **metaluminic acid**

When $2H_2SO_4$ less one H_2O then forms poly-form which is called **disulphuric** acid:

$$2H_2SO_4 - H_2O \rightarrow H_2S_2O_7.$$

By the number of hydrogen cations acids are divided into: monoprotic, diprotic and triprotic.

Monoprotic acides

HCl – hydrochlor**ic** acid

CH_3COO**H** – acetic acid

HCN – hydrocyanic acid

Diprotic acides

$\mathbf{H_2}SO_4$ – sulphur**ic** acid

$\mathbf{H_2}CO_3$ – carbon**ic** acid

$\mathbf{H_2}CrO_4$ – chrom**ic** acid

$\mathbf{H_2}Cr_2O_7$ – dichrom**ic** acid

Triprotic acides

$\mathbf{H_3}PO_4$ – phosphor**ic** acid

$\mathbf{H_3}AsO_4$ – ortho arsenic**ic** acid

$\mathbf{H_3}AsO_3$ – ortho arsen**ous** acid

Salts

Salts are electrolytes which dissociate by cations of metal and anions of the acidic moiety.

Salts are ionic compounds in which hydrogen atoms of acids are replaced by metal ions.

All the salts divided into three parts: **means, acidic** and **basic**.

The **means salts** are product of complete replacement of hydrogen atoms of acids by the metal or ammonium ion (NH_4^+).

Acidic salts are product of partial replacement of hydrogen atoms of polyprotic acids by metal.

Basic salts are product of partial replacement of the hydroxyl group of polyacidic base by acidic moiety.

Salts		
Means	**Acidic**	**Basic**
$H_2SO_4 \rightarrow Na_2SO_4$ sodium sulph**ate**	$H_2CO_3 \rightarrow NaHCO_3$ sodium hydrogen carbon**ate**	$Al(OH)_3 \rightarrow AlOHCl_2$ aluminium hydroxo chlor**ide**
$H_2CO_3 \rightarrow CaCO_3$ calcium carbon**ate**	$H_3PO_4 \rightarrow Na_2HPO_4$ sodium hydrogen phosph**ate**	$Cu(OH)_2 \rightarrow (CuOH)_2CO_3$ copper hydroxo carbon**ate**
$H_2CrO_4 \rightarrow Fe_2(CrO_4)_3$ iron (III) chrom**ate**	$H_3PO_4 \rightarrow Ca(H_2PO_4)_2$ calcium dihydrogen phosph**ate**	

Anion / Cation	Bromide Br^-	Hydrogen Carbonate HCO_3^-	Acetate CH_3COO^-	Phosphate PO_4^{3-}	Nitrate NO_3^-
Hydrogen, H^+	HBr	H_2CO_3	CH_3COOH	H_3PO_4	HNO_3
Ammonium, NH_4^+	NH_4Br	NH_4HCO_3	CH_3COONH_4	$(NH_4)_3PO_4$	NH_4NO_3
Calcium, Ca^{2+}	$CaBr_2$	$Ca(HCO_3)_2$	$Ca(CH_3COO)_2$	$Ca_3(PO_4)_2$	$Ca(NO_3)_2$
Aluminum, Al^{3+}	$AlBr_3$	$Al(HCO_3)_3$	$Al(CH_3COO)_3$	$AlPO_4$	$Al(NO_3)_3$
Sodium, Na^+	$NaBr$	$NaHCO_3$	CH_3COONa	Na_3PO_4	$NaNO_3$
Iron (III) , Fe^{3+}	$FeBr_3$	$Fe(HCO_3)_3$	$Fe(CH_3COO)_3$	$FePO_4$	$Fe(NO_3)_3$
Nickel (II), Ni^{2+}	$NiBr_2$	$Ni(HCO_3)_2$	$Ni(CH_3COO)_2$	$Ni_3(PO_4)_2$	$Ni(NO_3)_2$
Silver, Ag^+	$AgBr$	$AgHCO_3$	CH_3COOAg	Ag_3PO_4	$AgNO_3$