Inorganic nomenclature

- overview -

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Binary compounds

(= compounds composed of two different elements)

GROUP NAME	CATION	ANION -ide
oxides	metal or nonmetal	O^{-II}
peroxides	H^{+I} or s^1 or s^2 metal	O_2^{-I}
oxygen-free acids / salts	H^{+I} / metal	S^{-II} $F^{-I}, Cl^{-I}, Br^{-I}, I^{-I}$

Ternary compounds

(= compounds composed of three different elements)

GROUP NAME	CATION	ANION
hydroxides	metal or NH_4^+	$(OH)^{-1}$ **-ide**
acids	H^{+I}	XO_n (X = central atom)
salts	metal (or NH_4^+)	XO_n (X = central atom)

Naming inorganic compounds

= name of cation + name of anion

NaCl

= sodium chloride

KOH

= potassium hydroxide

Memorize:

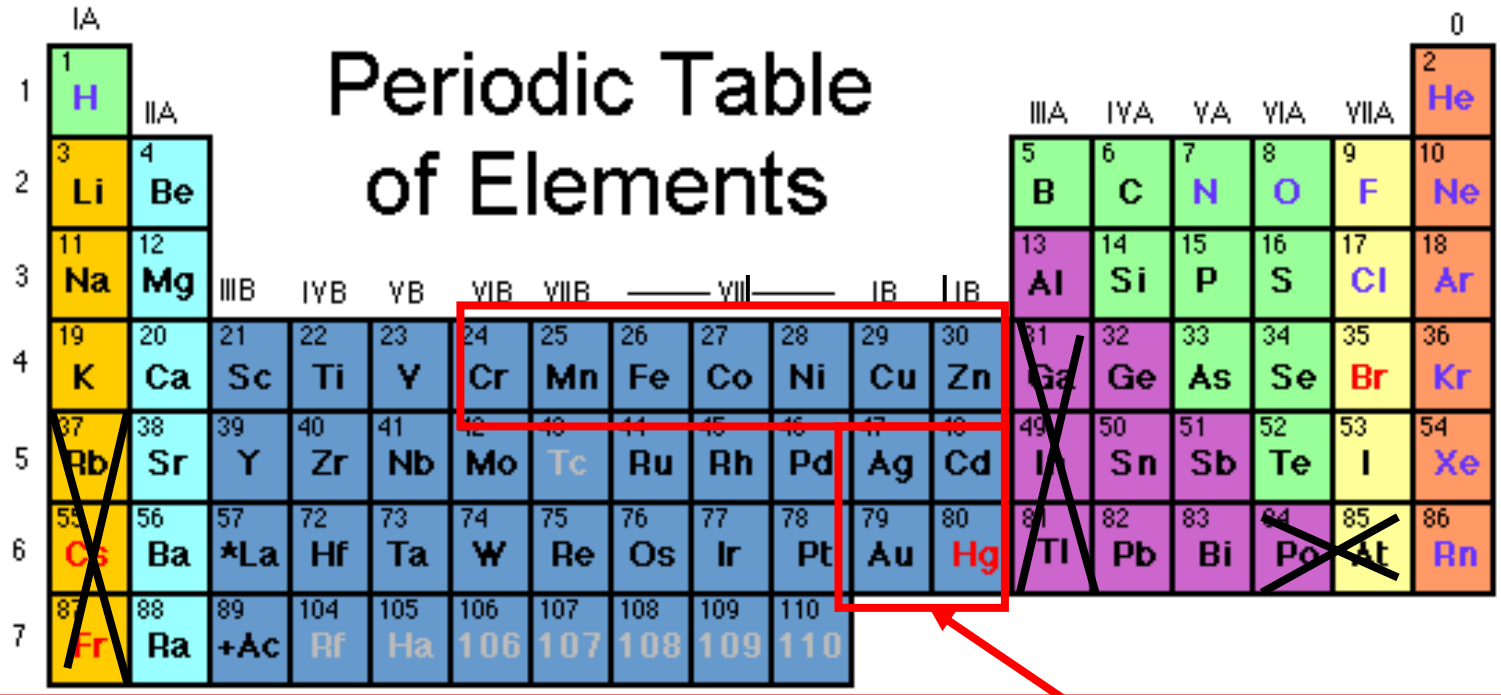
1) classification of elements

2) symbols and English names of elements

3) Latin names of elements

4) names of common cations and anions

5) common names of selected compounds

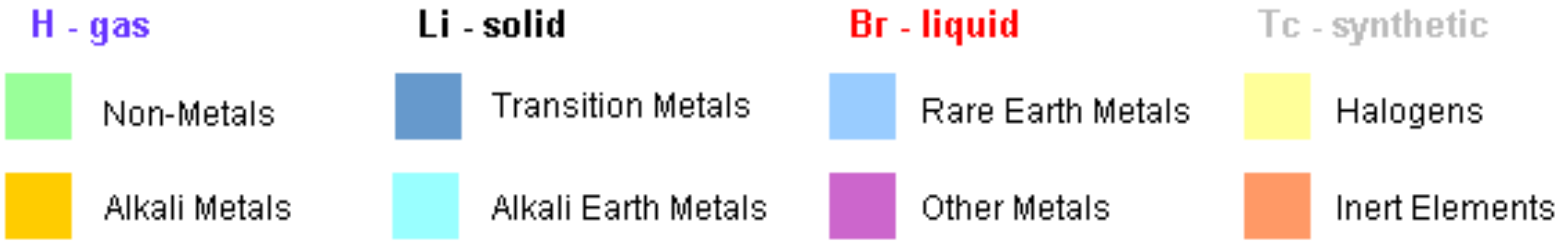


Memorize: symbols and names of elements:

IA, IIA, IIIA, IVA, VA, VIA, VIIA, O

(all except crossed elements) and marked elements from groups „B"

⇒ **use flash cards**



The figure is found at http://www.corrosionsource.com/handbook/periodic/periodic_table.gif (September 2007)

Symbol	Latin name	English name
Na	Natrium	sodium
K	Kalium	potassium
Sn	Stannum	tin
Pb	Plumbum	lead
Sb	Stibium	antimony
W	Wolframium	tungsten
Fe	Ferrum	iron
Cu	Cuprum	copper
Ag	Argentum	silver
Au	Aurum	gold
Hg	Hydrargyrum	mercury

Names of CATIONS

1. **cations found only in one oxidation state**

name of the cation = name of the element

- H, Li, Na, K, Ag +I
- Be, Mg, Ca, Sr, Ba, Zn +II
- B, Al +III

see position of the elements in the Periodic table

Names of CATIONS

2. cations found in two oxidation states

root of the Latin name + two suffixes:

- *lower oxidation state:* **-ous**
- *higher oxidation state:* **-ic**

- **Cu, Hg** both found in oxidat. states: +I/+II
- **Fe, Co** +II/+III
- **Sn, Pb** +II/+IV

HINT

Names of ANIONS

	ACID	anion
oxygen-free	hydro-.....-ic acid	**-ide**
oxo-acid *lower ox.state*	-ous acid	**-ite**
oxo-acid *higher ox.state*	-ic acid	**-ate**

Names of ANIONS

1. <u>one oxidation state</u>

   a) root of Latin name + suffix: *-ide*

➢ halogen → halide	F, Cl, Br, I	-I
➢ hydrogen → hydride	H	-I
➢ oxygen → oxide	O	-II
➢ sulfur → sulfide	S	-II
➢ hydroxide	OH	-1
➢ cyanide	CN	-1

Names of ANIONS

1. **one oxidation state of a central atom**

   b) root of Latin name + suffix: *-ate*

- carbon**ate** CO_3^{-2} C^{IV}
- silic**ate** SiO_3^{-2} Si^{IV}
- chrom**ate** CrO_4^{-2} Cr^{VI}
- bor**ate** BO_3^{-3} B^{III}

oxidation state of oxygen in anions is always –II

(exception: in peroxides = -I)

Names of ANIONS

2. <u>two oxidation states of a central atom</u>

root of Latin name + two suffixes:

- *lower oxidative state:* **-ite**
- *higher oxidative state:* **-ate**

➢ nitrite / nitrate	NO_2^-/NO_3^-	$N^{+III/+V}$
➢ phosphite/phosphate	PO_3^{-3}/PO_4^{-3}	$P^{+III/+V}$
➢ sulfite / sulfate	SO_3^{-2}/SO_4^{-2}	$S^{+IV/+VI}$
➢ selenite/selenate	SeO_3^{-2}/SeO_4^{-2}	$Se^{+IV/+VI}$

Names of ANIONS

3. more oxidative states of a central atom

root of Latin name + prefixes and suffixes:

- *the lovest oxidative state:* *hypo- -ite*
- *lower oxidative state:* *-ite*
- *higher oxidative state:* *-ate*
- *the highest oxidative state:* *hyper- -ate*

➢ **Cl, Br, I, Mn**

(hypochlorite, chlorite, chlorate, perchlorate)

ClO^- ClO_2^- ClO_3^- ClO_4^-

Compounds called by their common names

- H_2O water H_3O^+ hydronium
- NH_3 ammonia NH_4^+ ammonium
- NO nitric oxide
- NaCl salt
- HCO_3^- bicarbonate

Types of compounds

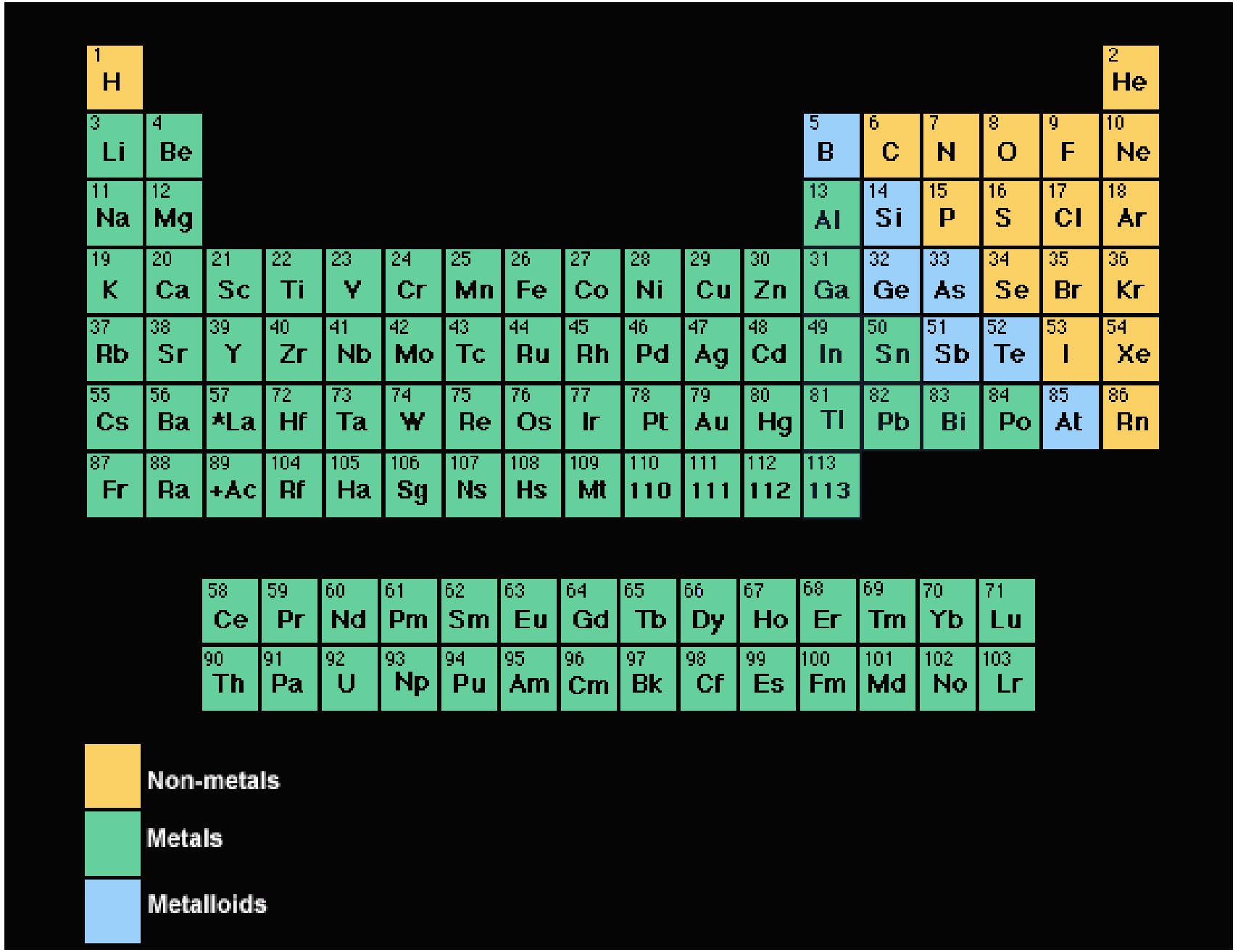
- ionic compounds are composed of:

cation and anion

- cation is positively charged
- anion is negatively charged

} molecule: its total charge is ZERO

- <u>naming the compounds</u>: **cation name + anion name**



The figure is found at http://www.windows.ucar.edu/earth/geology/images/periodic_table.gif (September 2007)

Important prefixes

1	2	3	4	5	6	7	8	9	10	11	12
mono	di	tri	tetra	penta	hexa	hepta	octa	nona	deca	un-deca	do-deca

Inorganic Compounds

Oxides anion: O^{-II}

- acid-forming: **nonmetal / oxygen**
  - use multiple prefixes (mono, di, tri,...)
- base-forming: **metal / oxygen**
  - use sufixes -ous / -ic or (oxidation state)
- amphoteric

MnO_2, N_2O, BaO, CO, K_2O, SO_2, FeO, Cu_2O, CaO

Inorganic Compounds

Peroxides anion: O_2^{-2} $\Rightarrow$ O^{-I}

- s^1 elements (hydrogen and alkali metals): M_2O_2

- s^2 elements (alkali earth metals): MO_2

sodium peroxide

barium peroxide

hydrogen peroxide

magnesium peroxide

potassium peroxide

lithium peroxide

Inorganic Compounds

Hydroxides

anion: $(OH)^{-1}$

- basic properties (pH > 7)
- strong or weak hydroxides
- metal / hydroxide anion
  - use sufixes <u>-ous / -ic</u> or (<u>oxidation state</u>)
- ammonium / hydroxide anion

$NaOH$, $LiOH$, NH_4OH, $Fe(OH)_3$, $Cu(OH)_2$, $Ca(OH)_2$

Inorganic Compounds

Acids **cation**: H^+ (pH < 7)

a) oxygen free acids

hydro-.....-ic acid

HF, HCl, HBr, HI, H_2S, HCN (in aqueous solutions)

anion: -ide

- monoprotic / diprotic acids

Inorganic Compounds

Acids **cation: H^+**

b) oxoacids

- the highest oxidative state — per-.....-ic acid
- higher (or **only**) oxidative state — **-ic acid**
- lower oxidative state — -ous acid
- the lowest oxidative state — hypo-...-ous acid

anion:

-ic acid	→	-ate
-ous acid	→	-ite

Inorganic Compounds

The most important oxoacids:

H_2CO_3	carbon**ic** acid	→ carbon**ate**
H_2SiO_3	silic**ic** acid	→ silic**ate**
H_2CrO_4	chrom**ic** acid	→ chrom**ate**
H_3BO_3	bor**ic** acid	→ bor**ate**
H_3PO_4	phosphor**ic** acid	→ phosph**ate**
H_2SO_3	sulfur<u>ous</u> acid	→ sulf<u>ite</u>
H_2SO_4	sulfur**ic** acid	→ sulf**ate**
HNO_2	nitr<u>ous</u> acid	→ nitr<u>ite</u>
HNO_3	nitr**ic** acid	→ nitr**ate**

Inorganic Compounds

The most important oxoacids:

$HClO$	hypochlorous acid	→ hypochlorite
$HClO_2$	chlorous acid	→ chlorite
$HClO_3$	chloric acid	→ chlorate
$HClO_4$	perchloric acid	→ perchlorate
(or Br, I)		
$HMnO_4$	permanganic acid	→ permanganate

Important suffixes

	ACID	anion
oxygen-free	hydro-.....-ic acid	-ide
oxo-acid *lower ox.state*	-ous acid	-ite
oxo-acid *higher ox.state*	-ic acid	-ate

Inorganic Compounds

Salts

are formed by neutralization:

acid + hydroxide → salt + water

cation: metal or NH_4^+

derived from the hydroxide (= cation of the hydroxide)

anion: oxygen-free or polyatomic anion

derived from the acid (= anion of the acid)

KCl, ZnS, $CuCl_2$, Fe_2S_3, $CaCO_3$, Na_2CO_3, $(NH_4)_2SO_4$

Inorganic Compounds

acidic salts of ACIDS

- **„cation hydrogen anion"**

KH_2PO_4	potassium dihydrogen phosphate
K_2HPO_4	(di)potassium hydrogen phosphate
K_3PO_4	*(tri)potassium phosphate (not acidic)*
NH_4HCO_3	ammonium hydrogen carbonate
$Ca(HS)_2$	calcium hydrogen sulfide

Other types of compounds

basic salts of ACIDS

- „cation hydroxy anion"

$Mg(OH)Cl$	magnesium hydroxychloride
$Sb(OH)_2(NO_3)$	antimony(III) dihydroxynitrate

Total charge of molecule is ZERO

Other types of compounds

double salts of ACIDS

a) „cation1 cation2 anion"

$KMgF_3$ potassium magnesium fluoride

$KLiSO_4$ potassium lithium sulfate

Total charge of molecule is ZERO

Other types of compounds

double salts of ACIDS

b) „cation anion1 anion2"

$CaCl(ClO)$	calcium chloride hypochlorite
$Cu_3(CO_3)_2F_2$	copper(II) carbonate fluoride

Total charge of molecule is ZERO

Other types of compounds

HYDRATES OF SALTS

- „cation anion *multiple prefix* hydrate"

$MgCl_2 \cdot 6H_2O$ magnesium chloride hexahydrate

$CaHPO_4 \cdot 2H_2O$ calcium hydrogen phosphate dihydrate

Other types of compounds

THIOACIDS AND THIOSALTS

- **„thio.... acid"**

$H_2S_2O_3$	thiosulfuric acid	(H_2SO_4 = sulfuric acid)
HSCN	thiocyanic acid	(HOCN = cyanic acid)

- **„cation thio....anion"**

$K_2S_2O_3$	potassium thiosulfate
KSCN	potassium thiocyanate

Other types of compounds

POLYACIDS AND SALTS

- *„multiple prefix.... acid"*

$H_2B_4O_7$ tetraboric acid

$H_2Cr_2O_7$ dichromic acid

- *„cation multiple prefix....anion"*

$Na_2B_4O_7$ sodium tetraborate

$K_2Cr_2O_7$ potassium dichromate

Keep in mind the rules:

1. **names of compounds** are derived from the **names of cations, anions and polyatomic ions**: *cation anion (NaCl = sodium chloride)*
2. **all binary compounds** end in **–ide**
   CaO, H_2O_2, $NaCl$, $HF(g)$, ZnS
3. **binary compounds** composed of two **nonmetals**: *Greek prefixes*
   SO_2, N_2O_5, CO

Keep in mind the rules:

4. **binary compounds** composed of a **metal ion** with fixed or variable oxidation numbers and nonmetal ion: ***no Greek prefixes***

    a) -ous / -ic suffix system

    b) Stock system (prefered), *e.g. iron(II) oxide*

$CuCl_2$, $CuCl$, Fe_2O_3, FeO

Keep in mind the rules:

5. ternary compounds:

- hydrogen cation H^+ (= acid)
- or metal cation (= salt or hydroxide)

(fixed or variable oxidation number)

- and a polyatomic anion (e.g. SO_4^{2-} or OH^{1-})

H_2SO_4 Na_2SO_4 $NaOH$

Total charge of a molecule = 0

Inorganic Compounds

Make groups of compounds:

Na_2O, HCl, CO_2, Na_2O_2, $Ca(OH)_2$, $KClO$, HCN, HNO_2,

H_2S, H_2O_2, BaO_2, PbO_2, H_2SO_3, KOH, $MgSO_4$, NaF,

NH_4HCO_3, HI, $Al(OH)_3$, HIO_4, CdS, MgO_2, NaH_2PO_4

? oxides hydroxides peroxides acids salts

Solution: **Inorganic Compounds**

Make groups of compounds:

Na_2O, HCl, CO_2, Na_2O_2, $Ca(OH)_2$, $KClO$, HCN, HNO_2,

H_2S, H_2O_2, BaO_2, PbO_2, H_2SO_3, KOH, $MgSO_4$, NaF,

NH_4HCO_3, HI, $Al(OH)_3$, HIO_4, CdS, MgO_2, NaH_2PO_4

NAME THESE COMPOUNDS

? oxides hydroxides peroxides acids salts

Inorganic Nomenclature

Solution:

Na_2O / sodium oxide, HCl / hydrochloric acid or hydrogen chloride, CO_2 / carbon dioxide, Na_2O_2 / sodium peroxide, $Ca(OH)_2$ / calcium hydroxide, KClO / potassium hypochlorite, HCN / hydrocyanic acid or hydrogen cyanide, HNO_2 / nitrous acid, H_2S / hydrosulfuric acid or hydrogen sulfide, H_2O_2 / hydrogen peroxide, BaO_2 / barium peroxide, PbO_2 / lead(IV) oxide or plumbic oxide, H_2SO_3 / sulfurous acid, KOH / potassium hydroxide, $MgSO_4$ / magnesium sulfate, NaF / sodium fluoride, NH_4HCO_3 / ammonium hydrogen carbonate, HI / hydroiodic acid or hydrogen iodide, $Al(OH)_3$ / aluminium hydroxide, HIO_4 / periodic acid or hyperiodic acid, CdS / cadmium sulfide, MgO_2 / magnesium peroxide, NaH_2PO_4 / sodium dihydrogen phosphate

Problems – *add formulas*

- sodium sulfite
- potassium phosphate
- ammonium hydrogen phosphate
- lithium dihydrogen phosphate
- calcium hydrogen carbonate
- silver sulfide
- zinc sulfate
- potassium permanganate
- sodium hypobromite
- barium nitrate
- hydrargyric chloride

Problems – *add formulas*

- sodium tetraborate decahydrate
- potassium aluminium sulfate
- sodium aluminium sulfate dodecahydrate
- ammonium carbonate
- calcium sulfate hemihydrate *(hemi = $\frac{1}{2}$)*
- zinc sulfate heptahydrate
- potassium dichromate
- potassium magnesium fluoride
- ammonium magnesium phosphate
- led(II) chloride fluoride
- cupric biscarbonate difluoride *(bis = twice)*