INORGANIC NOMENCLATURE I

1. Periodic table

a. What elements do these symbols stand for?

Mn	B	Mg	W	Pb	Sb	I	Sn	K	Au	Fe	Ag

- **Mn** – manganese
- **B** – boron
- **Mg**- magnesium
- **W** – tungsten
- **Pb** – lead
- **Sb** – antimony
- **I** – iodine
- **Sn** – tin (stannum)
- **K** – potassium
- **Au** – gold
- **Fe** – iron
- **Ag** - silver

b. Listening exercises

Explain the symbols below:

- What do they stand for?
- What do they mean?
- What is an alternative way of using them? (e.g. element 112)

Uub	Uut	Uuq	Uup	Uuh	Uus	Uuo

Answers:

Table II *Temporary names and symbols for elements of atomic number greater than 111*[a]

Atomic number	*Name*[b]	*Symbol*
112	ununbium	Uub
113	ununtrium	Uut
114	ununquadium	Uuq
115	ununpentium	Uup
116	ununhexium	Uuh
117	ununseptium	Uus
118	ununoctium	Uuo
119	ununennium	Uue
120	unbinilium	Ubn
121	unbiunium	Ubu
130	untrinilium	Utn
140	unquadnilium	Uqn
150	unpentnilium	Upn
160	unhexnilium	Uhn
170	unseptnilium	Usn
180	unoctnilium	Uon
190	unennilium	Uen
200	binilnilium	Bnn
201	binilunium	Bnu
202	binilbium	Bnb
300	trinilnilium	Tnn
400	quadnilnilium	Qnn
500	pentnilnilium	Pnn
900	ennilnilium	Enn

[a] These names are used only when the permanent name has not yet been assigned by IUPAC (see Section IR-3.1.1).
[b] One may also write, for example, 'element 112'.

Due to disputes over the discovery of some of the heavier elements, the International Union for Pure and Applied Chemistry (IUPAC) has devised a systematic naming scheme, based on Greek and Latin roots. When a new element is discovered, it is named by the following procedure:

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1. The element's atomic number is examined and broken down into individual numbers. For example, the hypothetical element numbered 119 would be separated into *1-1-9*.

2. The element's numbers are replaced by the Latin and Greek naming system, as shown in this table:

Number	Name		Number	Name
0	nil		5	pent
1	un		6	hex
2	bi		7	sept
3	tri		8	oct
4	quad		9	enn

Using the previous example, 1-1-9 would change to *Un un enn*.

3. All the roots are put together, and -ium is added to the end. If *bi* or *tri*, occur before -ium, the *i* is dropped. If *enn* occurs before nil, the last *n* is dropped. Using the same example, *Un un enn* becomes *Ununennium*.

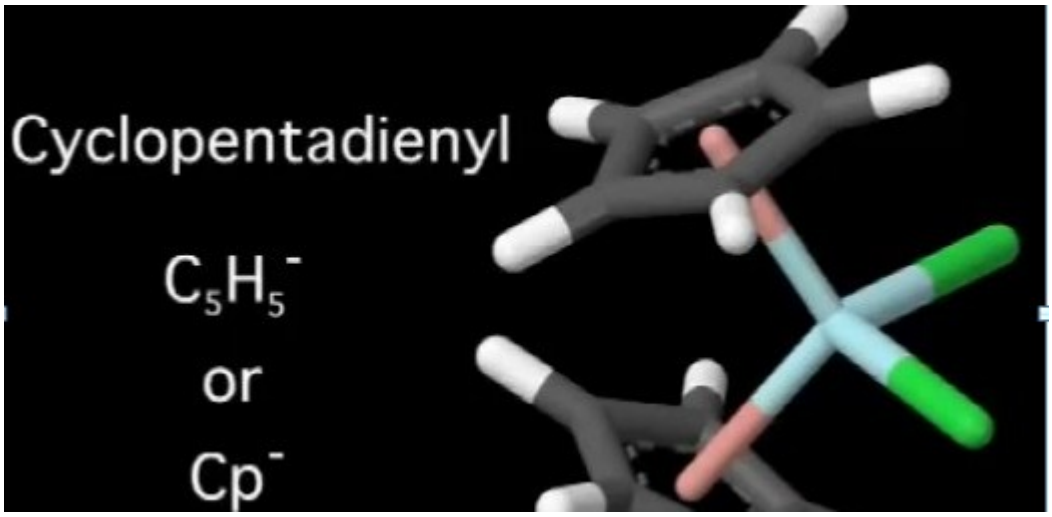
4. The symbol is the first letter of all the Greek and Latin parts that make up the element's name. Thus, the symbol for *Ununennium* is Uue.

Watch the first video and answer the following questions:
Source: http://www.periodicvideos.com/videos/112.htm

1. What element is the professor speaking about?
2. He has mentioned a controversy that was linked to the symbol of the element. What was the controversy based on?
3. Who/What institution made the final decision regarding the symbol?
4. According to the professor, what role did lead play in the element synthesis?
5. Could you describe the process of the element decay as explained in the video?

Answers:

1. Copernicium / Cn
2. Originally - symbol Cp, but it is used for cyclopentadienyl by organic chemists



Plus the scientists realized that many years ago (in some older books and papers), the symbol Cp was used as an alternative symbol for Lutetium which was in some countries called Cassiopeium) – old books are being digitized, it could cause confusion

3. IUPAC – International Union of Pure and Applied Chemistry
4. The principle of synthesis: atoms of lighter elements are bound together to get 112, i.e. Pb (82) + Zn (30) – Zn atoms are accelerated in a high speed accelerator towards Pb atoms, 2 nuclei fuse together as a result
5. It does not blow into parts, it starts to decay by steps (112 – 110 – 109 - 107… until it gets to a number below the mass of Uranium 92 (which is stable)

Watch the second video and try to explain the meaning of the following facts / dates / expressions within the context of the talk:
Source: http://www.periodicvideos.com/videos/114.htm

Stop after the introductory part in which the scientist speaks Russian – question:

What language does he speak? Why?

(Element 114 got its official name (Flerovium) and symbol (Fl), excitement, his father was born in Russia)

The rest of the video

114	**December 2011**	**Plutonium**	**Fljorov**
30th May 2012	**Dubna**	**memorial**	
Russian	**discussion period**	**bombardment**	

114 – element 114, its atomic number

December 2011 - the name Flerovium for element 114 suggested to IUPAC

Plutonium – Pu (94) + Ca (20) – synthesis of the element

Fljorov – Russian scientist, founder of Dubna, the element named after him

30th May 2012 – the element´s name officially adapted

Dubna – Russian research centre north of Moscow

memorial – the fact that the element was named after Fljorov is kind of his memorial

discussion period – when a new name of an element is suggested to IUPEC, people are allowed to point out if there are any problems connected to it

bombardment – superheavy new artificial elements are synthesized by taking a nucleus of a heavy element and binding into it an element that is lighter – Ca atoms are accelerated rapidly and plutonium is bombarded with millions of atoms, one will eventually fuse with one atom of Pu

Follow up question:
Why does such an element need a symbol?

Not useful for day-to-day chemistry, but for physics (unstable element decay – see explanation using his tie)

2. Types of chemical nomenclature

A. Trivial names

HG_2Cl_2 – mercurous chloride (systematic - mercury (II) chloride)

- H_2O (*water*, not dihydrogen oxide)/
- H_2O_2 (*hydrogen peroxide*, not dihydrogen dioxide)
- H_2S (*hydrogen sulfide*, not dihydrogen sulfide)
- NH_3 (*ammonia*, not nitrogen trihydride)
- NO (*nitric oxide*, not nitrogen monoxide)
- N_2O (*nitrous oxide*, not dinitrogen oxide)
- CH_4 (*methane*, not carbon tetrahydride)

B. Popular names

Chemical substances that are employed in the home, the arts, or in industry have acquired traditional or "popular" names that are still in wide use.

popular name	chemical name	formula
borax	sodium tetraborate decahydrate	$Na_2B_4O_7 \cdot 10H2O$
calomel	mercury(I) chloride	Hg_2Cl_2
milk of magnesia	magnesium hydroxide	$Mg(OH)_2$
muriatic acid	hydrochloric acid	$HCl(aq)$
oil of vitriol	sulfuric acid	H_2SO_4
saltpeter	sodium nitrate	$NaNO_3$
slaked lime	calcium hydroxide	$Ca(OH)_2$

C. Systematic nomenclature:

a. **compositional**
b. **substitutive**
c. **additive**

Example: **PCl_3**

- compositional: **phosphorus trichloride**

- substitutive: **trichlorophosphane**

- additive: **trichloridophosphorus**

3. Chemical nomenclature of

a. ions
b. binary compounds
c. ternary compounds

4. IONS

a. CATIONS

i. monoatomic: name of the element and charge

Na^+ sodium (1+), /n a plus/, sodium ion, univalent positive sodium ion,

H^+ hydrogen (1+), /h plus/, hydrogen ion, univalent positive hydrogen ion,

Cu^{2+} copper (2+), /c u two plus/, copper ion, divalent positive copper ion, copper (II) ion

Cr^{3+} chromium (3+), /c r three plus/, chromium ion, trivalent positive chromium ion,

Some of the metallic ions are multivalent, meaning that they can exhibit more than one electric charge. For these there are systematic names that use Roman numerals and endings ***–ous*** and ***–ic*** to denote the lower and higher charges, respectively. In cases where more than 2 charge values are possible, the systematic names are used.
Examples:

Cu^+	Cu^{2+}	Fe^{2+}	Fe^{3+}	* Hg_2^{2+}	Hg^{2+}	Sn^{2+}	Sn^{4+}
copper(I)	copper(II)	iron(II)	iron(III)	mercury(I)	mercury(II)	tin(II)	tin(IV)
cuprous	cupric	ferrous	ferric	mercurous	mercuric	stannous	stannic

Fe^{2+} /Fe two plus/, iron (2+), iron (II), ferrous ion, divalent positive iron ion
Fe^{3+} /Fe three plus/, iron (3+), iron (III), ferric ion, trivalent positive iron ion

ii. homopolyatomic:

Hg_2^{2+} /h g two two plus/, mercury (I) ion, mercurous ion,

O_2^+ **di**oxygen (1+)

S_4^{2+} **tetra**sulphur (2+)

Bi_5^{4+} **penta**bismuth (4+)

H_3^+ **tri**hydrogen (1+)

Li_2^{2+} **di**lithium (1+)

N_5^+ **penta**nitrogen (1+)

Na_2^+ **di**sodium (1+)

P_2^+ **di**phosphorus (1+)

Si_2^+ **di**silicon (1+)

iii. **heteropolyatomic:** can follow rules for substitutive nomenclature, or non-systematic names; frequent suffix ***-ium***

NH_4^+ ammon**ium** (non-systematic)

H_3O^+ oxidan**ium** (substitutive) or oxon**ium** (non-systematic)

PH_4^+ phosphan**ium** (substitutive)

b. ANIONS

i. compositional nomenclature (*-ide*)

I_3^- triiodide (1-)

O_2^{2-} dioxide (2-)

ii. substitutive (anions based on the removal of hydrogen (1+), end ***in -ide***

MeNH$^-$ methanamin**ide**

iii. additive (end in ***–ate***)

PS_4^{3-} tetrasulfidophosphate (3-)

Rules for adding sufix ***–ide:***

1. added directly to the name of the element (xenon***ide***, nickel***ide***, argon***ide***…)
2. original ending in the name of the element is substituted with ***–ide:***

chlorine – chlor***ide***	carbon – carb***ide***	sodium – sod***ide***
nitrogen – nitr***ide***	boron – bor***ide***	astatine – astat***ide***
silicon – silic***ide***	sulphur – **sulphide/sulfide**	phosphorus – **phosphide**
iodine - **iodide**	calcium - **calcide**	hydrogen – **hydride**
bromine - **bromide**	arsenic - **arsenide**	helium – **helide**
tungsten - **tungstide**	mercury - **mercuride**	

3. ending ***-ide*** is added to a Latin-based word

silver – argent***ide***	gold – aur***ide***	copper – cupr***ide***
iron – ferr***ide***	lead – plumb***ide***	tin – stann***ide***

Complete these sentences.

a) The chemical symbol for the calcium ion is ___ **Ca^{2+} ; calcium (2+)**

b) The chemical symbol for the fluoride ion is _ **F^- ; fluoride (1-)** (**cation F^+ fluorine (1+))**

c) The chemical symbol for the ammonium ion is____ **NH_4^+**

d) The chemical symbol for the magnesium ion is_____ **Mg^+ ; magnesium (1+)** also **Mg^{2+} ; magnesium (2+)** (**anion: magneside**: **Mg^-** ; **magneside (1-)**)

e) The chemical symbol for the sodium ion is_ **Na^+** ; **sodium (1+)** (**anion**: **Na^-** ; **sodide (1-)**)

f) The chemical symbol for the aluminium ion is__ **Al^+ ; aluminium (1+)** also **Al^{3+} ; aluminium (3+)** (**anion Al^- aluminide (1-)**)

5. BINARY COMPOUNDS

a) METALS WITH A FIXED CHARGE (just one oxidation state)

Salts of oxo-acids, metal oxides and other binary compounds.

- metal + nonmetal with -ide [aid]

Examples: **NaCl - sodium chloride** (Czech equivalent chlorid sodný – notice the difference in order of elements)

NaCl	sodium chlor***ide***
$ZnCl_2$	zinc chlor***ide***
CaC_2	calcium carb***ide***
MgS	magnesium sulph***ide***
Ca_3N_2	calcium nitr***ide***
K_2O	potassium ox***ide***
ZnO	zinc ox***ide***
CaO	calcium ox***ide***

Write the chemical formulae of the following compounds:

a) sodium fluoride **NaF**

b) silicon carbide **SiC**

c) aluminium chloride **$AlCl_3$**

d) calcium nitride **Ca_3N_2**

e) zinc oxide **ZnO**

Write the names of these compounds:

a) Na_2C _____ **sodium carbide**

b) BaS _____**barium sulphide**

c) $CaCl_2$ _____**calcium chloride**

d) Mg_3N_2 _____**magnesium nitride**

e) CaF_2 _____**calcium fluoride**

f) CaO ____**calcium oxide**

b) METALS WITH A NON-FIXED CHARGE (occur in more than one oxidation state)

Metal oxides and other binary compounds with a non-fixed charge.

2 methods of nomenclature:

- **IUPAC nomenclature,** Roman numeral expresses **oxidation state**

FeO	iron **(II)** ox***ide***
Fe_2O_3	iron **(III)** ox***ide***
Cu_2S	copper **(I)** sulf***ide***
CuS	copper **(II)** sulf***ide***
$FeCl_2$	iron **(II)** chlor***ide***
$FeCl_3$	iron **(III)** chlor***ide***

- **trivial names**

- suffix *-ous* - indicates **lower** oxidation state
- suffix *–ic* - indicates **higher** oxidation state

Example:

FeO	ferr***ous*** oxide	**(lower** oxidation state)
Fe_2O_3	ferr***ic*** oxide	**(higher** oxidation state)
Cu_2S	cupr***ous*** sulfide	
CuS	cupr***ic*** sulfide	

mercuric chloride and mercurous chloride are chlorides of mercury
arsenic oxide and arsenous oxide are oxides of arsenic
plumbic iodide and plumbous iodide are iodides of lead
stannic bromide and stannous bromide are bromides of tin, etc

Important note: These suffixes have no absolute meaning. They just indicate the lower and the higher valence. Thus e.g. -ic means a valence of 2 in the case of copper and 3 in the case of iron. It is for this reason that Roman numerals are used.

c) NON-METALS (trivial names)

Greek prefixes indicate the number of atoms of the element in the compound:

mono-, di-[dai], tri-[trai], tetra-, penta-, hexa-, hepta-, octa-, nona-, deca-

+ *-ide*

Examples:

NO_2	nitrogen **di**oxide = nitrogen (IV) oxide	(1 atom of nitrogen, 2 atoms of oxygen)
N_2O_4	**di**nitrogen **tetr**oxide = dimer of Nit. (IV) oxide	
N_2O_5	**di**nitrogen **pent**oxide = nitrogen (V) oxide	
CO	carbon **mono**xide	
CO_2	carbon **di**oxide	
P_2O_3	**(di)**phosphorus **tri**oxide	
OsO_4	osmium **tetro**xide	
P_2O_5	**di**phosphorus **pent**oxide	
PCl_3	phosphorus **tri**chloride	
CCl_4	carbon **tetra**chloride	
CS_2	carbon **di**sulfide	

c) PEROXIDES (An oxide containing more oxygen than some other oxide of the same element).

H_2O_2 hydrogen peroxide Na_2O_2 sodium peroxide

Write the formulae of the following binary molecular compounds:

nitrogen monoxide____**NO**
dinitrogen monoxide____ **N_2O**
sulfur trioxide____ **SO_3**
iron (II) sulphide____**FeS**
iron (III) sulphide ___ **Fe_2S_3**

dichlorine monoxide ___ **Cl_2O**
tetraphosphorus decoxide____ **P_4O_{10}**
oxygen difluoride _____**OF_2**
sodium peroxide ___ **Na_2O_2**

Write the names for the following formulae:

PI_3 **phosphorus triiodide, phosphorus (III) iodide**

SbF_5 **antimony pentafluoride**

P_2O_5 **diphosphorus pentoxide**

SO_3 **sulphur trioxide**

$FeCl_3$ **iron (III) chloride, ferric chloride**

CaO **calcium oxide**

$ZnCl_2$ **zinc chloride**

$FeCl_2$ **iron (II) chloride, ferrous chloride**

H_2O_2 **hydrogen peroxide**

SCl_2 **sulphur dichloride**