Chemical Calculations- Tutorial 3

1. 25.0 grams of sodium chloride (NaCl) is dissolved in 100 grams of solution. What is the concentration of the solution in parts per million (ppm)?

2. Suppose 17 grams of sucrose is dissolved in 183 grams of water. What is the concentration of sucrose ppm?

3. 35 grams of ethanol is dissolved in 115 grams of water. What is the concentration of ethanol in parts per million (ppm)?

4. The concentration of a $CaCl_2$ solution is 284,000 ppm. How many grams of solute is contained in 100 grams of solution?

5. Helium gas, 3.0×10^{-4} g, is dissolved in 200 g of solution. Express this concentration in parts per million.

6. What is the final molarity of a 2.75 M HCl(aq) solution if the original 2.0 L is diluted to a final volume of 3.5 L?

7. Determine the molarity concentration of a solution containing 1.67 moles of solute dissolved into 5.6 liters of solution?

8. How many moles of solute are found in 2.0 L of a 1.75 mol dm^{-3} solution?

9. A 900.0 g sample of sea water is found to contain 6.7×10^{-3} g Zn. Express this concentration in ppm.

10. A student uses 200 grams of water at a temperature of 60 °C to prepare a saturated solution of potassium chloride, KCl. If 180 g dissolved when forming the saturated solution, Calculate the concentration of KCl in ppm.

11. 25 grams of a chemical is dissolved in 75 grams of water. What is the concentration of the chemical in parts per hundred (ppm)? What is the concentration of the chemical in parts per thousand (ppt)? What is the % of solute in this solution?

12. Suppose 17 grams of sucrose is dissolved in 183 grams of water. What is the concentration of sucrose in pph ? ppm?

13. 35 grams of ethanol is dissolved in 115 grams of water. What is the concentration of ethanol in parts per billion (ppb)?

14. The solubility of NaCl is 284 grams/100 grams of water. What is this concentration in ppm?

15. The solubility of AgCl is 0.008 grams/100 grams of water. What is this concentration in ppm?

16. A certain pesticide has a toxin solubility of 5.0 grams/Kg of body weight. What is this solubility in ppm?

17. A compound with an empirical formula of C_2OH_4 and a molar mass of 88 grams per mole.

18. A compound with an empirical formula of C_4H_4O and a molar mass of 136 grams per mole.

19. A compound with an empirical formula of CFBrO and a molar mass of 254.7 grams per mole.

20. A compound with an empirical formula of C_2H_8N and a molar mass of 46 grams per mole.

21. The percentage composition of acetic acid is found to be 39.9% C, 6.7% H, and 53.4% O. Determine the empirical formula of acetic acid.

22. What's the empirical formula of a molecule containing 18.7% lithium, 16.3% carbon, and 65.0% oxygen?

23. A 50.51 g sample of a compound made from phosphorus and chlorine is decomposed. Analysis of the products showed that 11.39 g of phosphorus atoms were produced. What is the empirical formula of the compound?

24. When 2.5000 g of an oxide of mercury, (Hg_xO_y) is decomposed into the elements by heating, 2.405g of mercury are produced. Calculate the empirical formula.

25. The compound benzamide has the following percent composition. What is the empirical formula? C = 69.40 % H= 5.825 % O = 13.21 % N= 11.57 %.

26. A component of protein called serine has an approximate molar mass of 100 g/mole. If the percent composition is as follows, what is the empirical and molecular formula of serine? C = 34.95 % H= 6.844 % O = 46.56 % N= 13.59 %

IUPAC NAMING OF INORGANIC COMPOUNDS

IUPAC recommendations for nomenclature are used in the systematic way of naming compounds. IUPAC stands for International Union of Pure and Applied Chemistry. This section deals only with the inorganic nomenclature.

Trivial names (name used before the IUPAC nomenclature was introduced) are often still commonly used for some compounds in addition to the IUPAC names.

Names of ionic compounds derived from monoatomic ions

The way of writing the unmodified name for the monoatomic cation and then writing the modified name for the monoatomic anion with the suffix **-ide** at the end is shown in the other page.

Cation	Name	Anion	Name
H^+	hydrogen	H^-	hydride
Na^+	sodium	Cl^-	chloride
K^+	potassium	Br^-	bromide
Ca^{2+}	calcium	O^{2-}	oxide
Al^{3+}	aluminium	S^{2-}	sulfide
Zn^{2+}	zinc	N^{3-}	nitride

Rules for writing the name of ionic compounds with an element that can only form one type of cation:

Write the IUPAC names of the following compounds.

i. NaCl:_____
ii. KCl:_____
iii. CsBr:_____
iv. Al_3S_2_____
v. $ZnCl_2$_____
vi. Ca_3N_2_____

Names of ionic compounds derived from elements that form more than one type of cations

Cation	Trivial name	Systematic (IUPAC) name
Fe^{2+}	ferrous	iron(II)
Fe^{3+}	ferric	iron(III)
Cu^{+}	cuprous	copper(I)
Cu^{2+}	cupric	copper(II)
Co^{2+}	cobaltous	cobalt(II)
Co^{3+}	cobaltic	cobalt(III)
Sn^{2+}	stannous	tin(II)
Sn^{4+}	stannic	tin(IV)
Pb^{2+}	plumbous	lead(II)
Pb^{4+}	plumbic	lead(IV)
Hg_2^{2+}	mercurous	mercury(I)
Hg^{2+}	mercuric	mercury(II)

Rules for writing the name of ionic compounds composed of the elements showing variable oxidation numbers:

1. Name of the cation must always come first.
2. Name of the element is used as the name of the cation and the oxidation number (charge) is shown by capital Roman numerals in parentheses at the end of the cationic name.
3. Name of the anion is the part of its element's name which is written with the suffix –ide at the end of the anionic name.
4. Leave a space between the name of the cation and the anion.

Write the IUPAC names of the following.

i) CoS : _____

_____

ii) $FeCl_2$: _____

_____

iii) Co_2S_3 : _____

_____

iv) **FeO:** _____

_____

v) **CuCl :** _____

_____

vi) **SnO_2 :** _____

_____

vii) **$HgCl_2$:** _____

_____

viii) **Hg_2Cl_2 :** _____

_____

Write trivial names of the following

i) **$CuCl_2$** _____

ii) **$PbCl_2$** _____

iii) **FeS** _____

iv) **$PbCl_4$** _____

v) **SnO_2** _____

vi) **Fe_2S_3** _____

vii) **CuCl** _____

viii) **SnO** _____

Polyatomic ions

Some nonmetal atoms can bind covalently to form polyatomic ions. Polyatomic anions are more common than polyatomic cations.

Rules for writing the name of polyatomic ions.
The names of these ions are written using the following suffixes.

1. Names of polyatomic cations end with -ium.
2. Names of polyatomic anions end with suffixes –ide, -ite and -ate.

_____

_____

_____

Names for common polyatomic ions are given below.

Ion	Name	Ion	Name
NH_4^+	ammonium	NO_3^-	nitrate
OH^-	hydroxide	ClO_3^-	chlorate
CN^-	cyanide	MnO_4^{2-}	manganate
HS^-	hydrogen sulfide	MnO_4^-	permanganate
O_2^{2-}	peroxide	CrO_4^{2-}	chromate
O_2^-	superoxide	$Cr_2O_7^{2-}$	dichromate
SO_3^{2-}	sulfite	$C_2O_4^{2-}$	oxalate
NO_2^-	nitrite	CO_3^{2-}	carbonate
ClO_2^-	chlorite	HCO_3^-	hydrogen carbonate
HSO_3^-	hydrogen sulfite	$S_2O_3^{2-}$	thiosulfate
SO_4^{2-}	sulfate	$S_4O_6^{2-}$	tetrathionate
HSO_4^-	hydrogen sulfate	PO_4^{3-}	phosphate
AlO_2^-	aluminate	HPO_4^{2-}	hydrogen phosphate
ZnO_2^{2-}	zincate	$H_2PO_4^-$	dihydrogen phosphate

Naming compounds with polyatomic ions

Several compounds are named below by referring to the rules discussed above.

Example 1: $K_2Cr_2O_7$ has a simple cation and a polyatomic anion.

Name of the cationic part = potassium
Name of the anionic part = dichromate
Name of the compound = potassium dichromate

Example 2: $(NH_4)_2Cr_2O_7$ has a polyatomic cation and a polyatomic anion. Name of the cationic part = ammonium
Name of the anionic part = dichromate
Name of the compound = ammonium dichromate

KH_2PO_4 = potassium dihydrogen phosphate
FeC_2O_4 = iron(II) oxalate
$NaHCO_3$ = sodium hydrogen carbonate

Write down IUPAC names.

i) KHS =_____

ii) $KMnO_4$ =_____

iii) $FeSO_4$=_____

iv) $CaCO_3$=_____

v) NaH_2PO_4=_____

vi) $CuNO_2$_____

vii) $Cu(NO_2)_2$=_____

viii) $(NH_4)_2CrO_4$=_____

ix) $(NH_4)_2SO_3$=_____

x) Na_2ZnO_2=_____

xi) $Cu(OH)_2$=_____

xii) $Cu(HCO_3)_2$=_____

xiii) $Co(NO_3)_2$=_____

xiv) $Fe_2(CN)_3$=_____

Names of simple covalent compounds

Many elements form covalent compounds. When naming this type of compounds, the element with the positive oxidation number must be written first followed by the element with the negative oxidation number.

Rules for writing the name of simple covalent compounds:

1. First part of the name is written representing the less electronegative element and the second part of the name is written indicating the more electronegative element in the compound.
2. Write the name of the compound leaving a space between the first part and the second part.
3. Name the most electronegative atom by modifying its name with the suffix –ide.
4. Prefixes are used to represent the number of similar atoms in the compound.

   Based on the number of similar atoms prefixes are given as follows.
   1 = mono, 2 = di, 3 = tri, 4 = tetra, 5 = penta, 6 = hexa, 7 = hepta, 8 = octa However, the prefix mono is never used when naming the first element.

5. When the prefix ends in “a” or “o” and the second element name begins with “a” or “o”, the final vowel of the prefix is dropped for ease of pronunciation.

   e.g.: mono + oxide = monoxide

   tetra + oxide = teroxide

Write down the IUPAC names of the following compounds.

1. CO – _____
2. H_2S - _____
3. SO_3 - _____
4. N_2O3 -_____
5. N_2O_4 - _____
6. P_4O6 - _____
7. H_2O - _____
8. OF_2 - _____
9. N_2O_5-_____
10. CO_2-_____

Inorganic acids

Compounds with one or more ionizable protons in aqueous solutions and an anion without oxygen are named using the prefix hydro- followed by the name of the other nonmetal or group of non-metals modified with an -ic ending. The full name is composed of the term acid at the end.

Write the IUPAC names of the following.

HCl (hydrogen chloride) = _____

HBr (hydrogen bromide) = _____

HCN (hydrogen cyanide) = _____

H_2S (dihydrogen sulfide) = _____

Compounds with one or more ionizable protons in aqueous solutions and an anion with oxygen are called oxoacids. The name of the anion is written with suffix and it is used as the name of the acid.

When the anion name ends in –ate, the suffix –ic is used. H_2SO_4 (anion is SO_4^{2-} - sulfate) = sulfuric acid

When the anion name ends in –ite, the suffix –ous is used. H_2SO_3 (anion is SO_3^{2-} - sulfite) = sulfurous acid

i) H_2CO_3 _____
ii) H_2SO_3 _____
iii) HNO_3 _____
iv) HNO_2_____
v) H_3PO_4_____

Naming different oxoanions (oxyanions) formed from the same central atom

An oxyanion or oxoanion is an ion with the generic formula $A_xO_y^{z-}$.

Here, **A** represents a chemical element and **O** represents an oxygen atom.

Some elements are able to form more than one oxoanion each containing different number of oxygen atoms.

Series of oxoanions containing different numbers of oxygen atoms are generally named as follows.

The prefix per– is used for the anion with a higher number of oxygen atoms, and the prefix hypo– is used for the anion with a lower number of oxygen atoms.

According to the increasing order of oxidation number of the central atom of the oxoanion, their names can be derived as follows:

hypo____ite	___ite	___ate	per___ate
ClO^- = hypochlorite	ClO_2^- = chlorite	ClO_3^- = chlorate	ClO_4^- =perchlorate
(+1)	(+3)	(+5)	(+7)

These oxoanions are available in the form of oxoacids or salts.

Write down the IUPAC names of the compounds given below.

i) $NaClO$ _____

ii) $NaClO_4$ _____

iii) $Fe(ClO_4)_3$ _____

iv) $HClO$ _____

v) $FeClO_2$ _____

vi) $HClO_4$ _____

vii) $NaClO_3$ _____

viii) $HClO_2$ _____

ix) $NaClO_2$ _____

x) $HClO_3$ _____

xi) $KClO_4$ _____

xii) $Cu(ClO)_2$ _____

xiii) $Na_2Cr_2O_7$. _____

xiv) $CaCrO_4$. _____

xv) $Ba(ClO_3)_2$ _____

xvi) $MgSO_4$ _____

xvii) Li_2SO_3 _____

xviii) $Mg(ClO_4)_2$ _____

xix) CuI _____

Write down the IUPAC names of the compounds given below.

1. CO _____
2. PBr_3 _____
3. CCl_4 _____
4. NCl_3 _____
5. SeO_2 _____
6. P_2O_3 _____
7. SO_3 _____
8. P_2O_5 _____
9. CO_2 _____
10. PI_5 _____
11. SeO_3 _____
12. SiO_2 _____
13. Cl_2O_7 _____
14. SO_2 _____
15. N_2O_3 _____
16. N_3P_2 _____
17. SCl_2 _____
18. SeF_6 _____
19. N_2O_4 _____
20. CS_2 _____
21. H_2S _____
22. CF_4 _____

Write down the IUPAC names of the compounds given below.

1. $Ca(OH)_2$ _____
2. $AlCl_3$ _____
3. FeI_2 _____
4. Hg_2Cl_2 _____
5. NaH _____
6. $MgCl_2$ _____
7. $ZnBr_2$ _____
8. $MnCl_2$ _____
9. NH_4Cl _____
10. PbS _____
11. $K(CN)$ _____
12. MgO _____
13. $PbCl_2$ _____
14. $Fe(OH)_3$ _____
15. Ag_2O _____
16. HgO _____
17. $(NH_4)I$ _____
18. Cu_2O _____
19. Cs_3N _____
20. CuS _____

Write down the chemical formula for the IUPAC names of the compounds given below.

1) Barium sulfide 1) _____

2) Manganese (III) iodide 2) _____

3) Ammonium hydrogen phosphate 3)_____

4) Carbon disulfide 4)_____

5)Lead (II) sulfate 5)_____

6) Magnesium carbonate 6)_____

7) Potassium permanganate 7)_____

8) Silver bicarbonate 8) _____

9) Bismuth (III) bromide 9) _____

10) Tetranitrogen tetrasulfide 10) _____

11) Ferrous perchlorate 11) _____

12) Chromium (III) chlorite 12) _____

13)Tin (II) thiosulfate 13) _____

14) Cuprous sulfite 14) _____

15) Sodium bisulfate 15) _____

16) Carbon tetrachloride 16) _____

17) Sodium acetate 17) _____

18) Ferric dihydrogen phosphate 18) _____

19) Chromium (II) phosphate 19) _____

20) Mercuric perchlorate 20) _____

21) Nickel (II) borate 21) _____

22) Cadmium thiocyanate 22) _____

23) Ammonium sulfide 23) _____

24) Bismuth (III) bisulfite 24) _____

25) Strontium chlorate 25) _____

26) Aluminum bisulfide 26) _____

27) Diphosphorus trioxide 27) _____

28) Zinc hydroxide 28) _____

29) Silver chromate 29) _____

30) Copper (II) acetate 30) _____

31) Cobaltous iodide 31) _____

32) Cuprous dichromate 32) _____

33) Sodium peroxide 33) _____

34) Dinitrogen trioxide 34) _____

35) Dichlorine heptoxide 35) _____

36) Cobaltic nitrite 36) _____

37) Barium cyanide 37) _____

38) Hypochlorous acid 38) _____

39) Sulfurous acid 39) _____

40) Hydrobromic acid 40) _____

41) Nitric acid 41) _____

42) Periodic acid 42) _____

43) Bromous acid 43) _____

44) Iodic acid 44) _____

45) Hydrosulfuric acid 45)_____

46) Perbromic acid 46) _____

47) Hydrofluoric acid 47) _____

48) hypobromous acid 48) _____

49) Mercurous chloride 49) _____

50) Ferric cyanate 50) _____

Balance the following chemical equations using the trial-and-error method.

1. _____ H_2 + _____ O_2 → _____ H_2O
2. _____ N_2 + _____ H_2 → _____ NH_3
3. _____ S_8 + _____ O_2 → _____ SO_3
4. _____ N_2 + _____ O_2 → _____ N_2O
5. _____ HgO → _____ Hg + _____ O_2
6. _____ CO_2 + _____ H_2O → _____ $C_6H_{12}O_6$ + _____ O_2
7. _____ Zn + _____ HCl → _____ $ZnCl_2$ + _____ H_2
8. _____ $SiCl_4$ + _____ H_2O → _____ H_4SiO_4 + _____ HCl
9. _____ Na + _____ H_2O → _____ $NaOH$ + _____ H_2
10. _____ H_3PO_4 → _____ $H_4P_2O_7$ + _____ H_2O
11. _____ $C_{10}H_{16}$ + _____ Cl_2 → _____ C + _____ HCl
12. _____ CO_2 + _____ NH_3 → _____ $OC(NH_2)_2$ + _____ H_2O
13. _____ Si_2H_3 + _____ O_2 → _____ SiO_2 + _____ H_2O_3
14. _____ $Al(OH)_3$ + _____ H_2SO_4 → _____ $Al_2(SO_4)_3$ + _____ H_2O
15. _____ Fe + _____ O_2 → _____ Fe_2O_3
16. _____ $Fe_2(SO_4)_3$ + _____ KOH → _____ K_2SO_4 + _____ $Fe(OH)_3$
17. _____ $C_7H_6O_2$ + _____ O_2 → _____ CO_2 + _____ H_2O
18. _____ H_2SO_4 + _____ HI → _____ H_2S + _____ I_2 + _____ H_2O
19. _____ FeS_2 + _____ O_2 → _____ Fe_2O_3 + _____ SO_2
20. _____ Al + _____ FeO → _____ Al_2O_3 + _____ Fe
21. _____ Fe_2O_3 + _____ H_2 → _____ Fe + _____ H_2O
22. _____ Na_2CO_3 + _____ HCl → _____ $NaCl$ + _____ H_2O + _____ CO_2
23. _____ K + _____ Br_2 → _____ KBr
24. _____ C_7H_{16} + _____ O_2 → _____ CO_2 + _____ H_2O
25. _____ P_4 + _____ O_2 → _____ P_2O_5