Chemistry 20

Lesson 3 – Naming compounds

I. Common compounds

The following common compounds should be memorized.

O_3 .....ozone
HOH or H_2O .....water
NH_3 .....ammonia
CH_4 .....methane
$C_{12}H_{22}O_{11}$ .....sucrose
CH_3OH.....methanol
C_2H_5OH.....ethanol
H_2O_2.....hydrogen peroxide

II. Molecular elements

The following should be memorized. All metallic elements are written in the singular (Fe, K, Dy, etc.) The inert gases (He, Ne, Ar, Kr, Xe, Rn) are also monatomic. However, some nonmetals naturally occur in groups. The Group 17 elements, the halogens (F_2, Cl_2, Br_2, I_2 and As_2), occur as diatomic molecules. Other diatomic molecules are H_2, O_2 and N_2. Phosphorous occurs naturally as P_4 and sulfur occurs as S_8.

III. Molecular compounds

A molecular compound is the result of a **sharing of electrons** between a **nonmetal** and another **nonmetal**. Unlike ionic compounds, there is no balancing of charges, therefore a number of A molecular compound is the result of a **sharing of electrons** between a **nonmetal** and another **nonmetal**. Unlike ionic compounds, there is no balancing of charges, therefore a number of compounds are possible when two nonmetals form a compound. Moreover, such compounds exist as separate and distinct **molecules**. For example, at least five compounds of phosphorous and oxygen are found in nature: P_2O_3, P_2O_4, P_2O_5, P_4O_6, and P_4O_{10}. Each of these compounds must have its own, unique name.

For **molecular compounds** we use a **prefix** system to indicate the number of each type of element present:

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

The **first** element is named in full, and the **second** element is shortened and given an ***-ide*** suffix:

name → *formula*

sulphur triiodide → SI_3

nitrogen monoxide → NO

(note that the single first element often does not require a mono prefix)

formula → *name*

CO_2 → carbon dioxide

N_2O_4 → dinitrogen tetraoxide

IV. Ionic compounds

Ionic compounds form from a **cation** (metallic ion or positive polyatomic ion) and an **anion** (non-metallic ion or a negative polyatomic ion). Since the total negative and positive charges must cancel to form a neutral compound, there is only **one unique way** to write each ionic compound. Therefore, prefixes are not required **and should <u>never</u> be used** for ionic compounds.

Simple binary ionic compounds

If the compound consists of a metal and a nonmetal, first **check the metal** to see if it is capable of forming **multiple ions** (e.g. iron (II) [Fe^{2+}] and iron (III) [Fe^{3+}]). On the periodic table the preferred ion is always listed first. For example, the preferred ion for iron is iron (III).

name → *formula*

Balance the charges.

copper (II) sulfide → CuS

copper (I) sulfide → Cu_2S

formula → *name*

Indicate the ion charge using the **stock** system.

Fe_2O_3 → iron (III) oxide

FeO → iron (II) oxide

If the **metal** is capable of forming only **one ion**, the charge number is not necessary and should never be included:

name → *formula*

Balance the charges.

zinc sulfide → ZnS

calcium chloride → $CaCl_2$

formula → *name*

The **first** element (metal) is named in full and the **second** element (non-metal) is shortened and given an ***-ide*** suffix.

Al_2Te_3 → aluminium telluride

GaF_3 → gallium fluoride

Compounds involving polyatomic compounds

Your periodic table includes a **Table of Common Polyatomic Ions**. Note that there are far more polyatomic (complex) ions than are listed.

formula → *name*

Use full name of cation and the name of the complex ion.

$SrSO_4$ → strontium sulfate

Na_2SO_3 → sodium sulfite

name → *formula*

ammonium hydrogen carbonate → NH_4HCO_3

vanadium (IV) hydroxide → $V(OH)_4$

Hydrated Compounds

Many ionic compounds are soluble in water. When the water is allowed to evaporate, the ionic compound crystallises as a solid. For a number of ionic solids, water molecules are trapped in the crystal lattice. These ionic compounds are called **hydrates** and they will produce water when they decompose upon heating.

formula → *name*

The formula appears as an ionic formula with a number of H_2O molecules attached to it. Name the ionic compound as usual and include the number of water molecules using the same prefixes as for molecular compounds.

$CuSO_4 \cdot 5H_2O_{(s)}$ → copper (II) sulfate pentahydrate

$AlCl_3 \cdot 6H_2O_{(s)}$ → aluminum chloride hexahydrate

name → *formula*

Write the regular ionic formula followed by the indicated number of water molecules.

lithium chloride tetrahydrate → $LiCl \cdot 4H_2O_{(s)}$

barium hydroxide octahydrate → $Ba(OH)_2 \cdot 8H_2O_{(s)}$

V. Assignment

1. If the following pairs of elements were mixed and heated, they would combine into solid ionic compounds. (Note: **All ionic compounds are solids at room temperature**.) Write the name and formula of each compound formed.

	Name	**Formula**
e.g. strontium and arsenic	strontium arsenide	$Sr_3As_{2\ (s)}$
a) silver and iodine	_____	_____
b) magnesium and oxygen	_____	_____
c) magnesium and bromine	_____	_____
d) calcium and nitrogen	_____	_____
e) zinc and selenium	_____	_____
f) sodium and sulfur	_____	_____
g) barium and phosphorus	_____	_____
h) aluminium and fluorine	_____	_____
i) potassium and chlorine	_____	_____
j) silver and oxygen	_____	_____

2. If the following pairs of elements were mixed and heated, they would combine into ionic compounds. In this worksheet, use the most common ionic form of the multivalent metal ion. The most common form is listed first in the periodic table. For example, niobium exists as both 5+ and 3+ ions, with niobium (V) being the most common.

	Name	**Formula**
e.g. niobium and oxygen	niobium (V) oxide	$Nb_2O_{5\ (s)}$
a) iron and sulfur	_____	_____
b) copper and oxygen	_____	_____
c) manganese and fluorine	_____	_____
d) gold and nitrogen	_____	_____
e) chromium and chlorine	_____	_____
f) platinum and phosphorus	_____	_____
g) nickel and oxygen	_____	_____
h) cobalt and bromine	_____	_____
i) tungsten and iodine	_____	_____
j) manganese and sulfur	_____	_____

3. Complete the following table.

COMBINE	FORMULA	NAME
iron (II) & nitrate	$Fe(NO_3)_{2\ (s)}$	iron (II) nitrate
aluminium & nitrate		
sodium & sulfate		
lead (IV) & sulfate		
magnesium & carbonate		
gold (III) & sulfite		
zinc & hydrogen carbonate		
ammonium & nitrate		
copper (I) & phosphate		
silver & hydroxide		
aluminium & hydroxide		
lead (II) & phosphate		
potassium & acetate		
manganese (V) & sulfate		

4. Complete the following table.

	Formula	Description or Use [*for interest only*]		Name of Compound
	e.g., CCl_4	toxic cleaning fluid and solvent		carbon tetrachloride
1.		composition of air	78.03%	nitrogen
2.			20.99%	oxygen
3.			0.94%	argon
4.	CO_2		0.035%	
5.			0.0016%	other noble gases
6.	NO	air pollutants	in automobile exhaust	
7.	NO_2		Los Angeles-type smog	
8.			London-type smog	sulfur dioxide
9.	SO_3		becomes sulfuric acid	
10.			colorless, oderless poison	carbon monoxide
11.			good in upper atmosphere	ozone
12.		grain alcohol, ethyl alcohol		ethanol
13.		table sugar		sucrose
14.		yellow solid in Group 16		sulfur
15.	P_4O_{10}	oxides formed by burning white phosphorus in air		
16.	P_4O_6			
17.		chlorination of water		chlorine dioxide
18.		methyl alcohol, methyl hydrate		methanol
19.		a white solid		phosphorus
20.		a cleaner when dissolved in water		ammonia
21.	CH_4	85 - 95% of natural gas		
22.	HCl	a gas; in water is hydrochloric acid		
23.		laughing gas, anaesthetic		dinitrogen oxide
24.		tincture of iodine in alcohol		iodine
25.	H_2O	the most common solvent		

5. Complete the following table.

	Chemical Formula	**Description or Use [*for Interest only*]**	**Name of Compound**
e.g.	$CaCl_{2\,(s)}$	white solid; wetting agent	calcium chloride
1.		dietary supplement for iodine	potassium iodide
2.	$MgO_{\,(s)}$	white powder; magnesium ore	
3.		antiperspirant	aluminum chloride
4.	$NaBr_{\,(s)}$	in Epsom Salts	
5.	$Al_2O_{3\,(s)}$	whiting; aluminum ore	
6.		black; lithium reacts with air	lithium nitride
7.	$CaO_{\,(s)}$	white powder; quicklime	
8.		white solid like $CaCl_2$	barium chloride
9.		white solid; table salt	sodium chloride
10.	$ZnO_{\,(s)}$	protective oxide on zinc metal	
11.		photographic emulsion	silver bromide
12.		magnesium reacts with hydrogen	magnesium hydride
13.		11 % of minerals in sea water	magnesium chloride
14.		in soldering paste	zinc chloride
15.	$Ag_2S_{\,(s)}$	argentite (silver ore)	
16.		potash (fertilizer)	potassium chloride
17.	$CaF_{2\,(s)}$	fluorite (pretty mauve crystals)	
18.		for toning pictures brown	sodium sulfide
19.	$CaH_{2\,(s)}$	preparation of hydrogen	
20.		zinc blende (zinc ore)	zinc sulfide

6. Complete the following table.

	Chemical Formula	**Description or Use** [*for interest only*]	**Name of Compound**
e.g.,	Cu_2S	copper ore (chalcocite)	copper(I) sulfide
1.		uranium ore (uraninite)	uranium(IV) oxide
2.		lead ore (galena)	lead(IV) sulfide
3.	SnO_2	tin ore (cassiterite)	
4.		manganese ore (pyrolusite)	manganese(IV) oxide
5.	Sb_2S_3	antimony ore (stibnite)	
6.	FeO	iron ore (hematite)	
7.	HgS	mercury ore (cinnabar)	
8.	MoS_2	molybdenum ore (molybdenite)	
9.		copper ore (chalcopyrite)	copper (II) sulfide
10.	FeS	also in chalcopyrite	
11.		electrode In car battery	lead (IV) oxide
12.	HgO	laboratory preparation of oxygen	
13.	V_2O_5	a common catalyst	
14.		toothpaste additive	tin (II) fluoride
15.		a green paint pigment	chromium (III) oxide
16.	TiO_2	a white paint pigment	
17.	$AuCl_3$	gold tinting of pictures	
18.		separating types of U atoms	uranium (VI) fluoride
19.	$NiBr_2$	forms a green solution	
20.		forms a pink solution	cobalt (II) chloride

7. Complete the following table.

	i or m	Chemical Formula	Name of Compound
1.		K_2CO_3	
2.		$(NH_4)_2S$	
3.			calcium hydroxide
4.			magnesium silicate
5.			iron (II) chlorite
6.		$Cr(NO_3)_3$	
7.			potassium dichromate
8.		SO_3	
9.		$NaNO_2$	
10.			ammonium sulfate
11.			sodium hydrogen carbonate
12.		K_3PO_4	
13.			potassium oxalate
14.		NH_3	
15.			sodium nitrate
16.		$KMnO_4$	
17.			sodium thlosulfate
18.		CO_2	
19.			barium perchlorate
20.			rubidium hydrogen sulfide
21.			potassium cyanide
22.		$NH_4H_2PO_4$	
23.			sodium hydrogen sulfite
24.		Na_2SO_4	
25.			potassium thiocyanate

8. Complete the following table.

	Name of Hydrate	**Common Name, Use or Description**	**Formula**
e.g.,	copper(II) sulfate pentahydrate	blue vitriol, bluestone, copper plating, blue solid	$CuSO_4 \cdot 5H_2O$
1.		Epsom salts, white solid explosives, matches	$MgSO_4 \cdot 7H_2O$
2.	sodium carbonate decahydrate	washing soda, soda ash, water softener, white solid	
3.		white solid, fireproofing wood, disinfectants, parchment paper	$MgCl_2 \cdot 6H_2O$
4.	barium chloride dihydrate	white solid, pigments, dyeing fabrics, tanning leather	
5.		white solid, photographic emulsions	$Cd(NO_3)_2 \cdot 4H_2O$
6.		white solid, embalming material, fireproofing lumber, vulcanizing	$ZnCl_2 \cdot 6H_2O$
7.	zinc sulfate heptahydrate	white solid, clarifying glue, preserving wood and skins	
8.	lithium chloride tetrahydrate	white solid, soldering aluminum, in fireworks	
9.		photographic hypo, antichlor, white solid	$Na_2S_2O_3 \cdot 5H_2O$
10.	cobalt(II) chloride hexahydrate	pink solid, humidity and water indicator, foam stabilizer in beer	
11.		white solid, antiperspirant	$AlCl_3 \cdot 6H_2O$
12.		de-icer used on icy highways, added to cement mixtures to prevent freezing	$CaCl_2 \cdot 2H_2O$
13.	barium hydroxide octahydrate	white solid, manufacture of glass, water softener	
14.	nickel(II) chloride hexahydrate	green solid, absorbent for ammonia in gas masks	
15.		Glauber's salt (a medicine), white solid, drying agent	$Na_2SO_4 \cdot 10H_2O$

9. Complete the following table. Classify the substance as ionic or molecular (i or m) in the first column. Use a subscript to indicate the state of matter of each substance (s, l, or g at room temperature).

	i or m	Chemical Formula	Name of Compound		i or m	Chemical Formula	Name of Compound
1.		$Al(OH)_3$		26.			magnesium sulfate heptahydrate
2.			sodium sulfate decahydrate	27.		$Ca(OH)_2$	
3.			sodium nitrate hexahydrate	28.			sodium thiosulfate
4.		$Al_3(SO_4)_3$		29.		CaO	
5.			calcium chloride hexahydrate	30.			copper (II) sulfate pentahydrate
6.		NH_4NO_3		31.			sulfur
7.			phosphorus trihydride	32.		$BrH_{6\ (g)}$	
8.		$N_2O_{4\ (g)}$		33.			potassium dichromate
9.			methane	34.			phosphorus
10.		K_2SO_4		35.		SO_3	
11.		Fr_3PO_4		36.			sodium chlorate
12.			bismuth (V) borate	37.		Na_2SiO_3	
13.		$(NH_4)_2SO_4$		38.			methanol
14.		SnF_4		39.			chlorine
15.			xenon hexabromide	40.			lead (II) sulfate
16.		PbO_2		41.		$Ca(HCO_3)_2$	
17.			silicon dioxide	42.			nitrogen trichloride
18.		NaClO		43.			sodium hydrogen sulfite
19.			potassium permanganate	44.		CO	
20.		KNO_3		45.		H_2Se	
21.		$K_2CO_3 \bullet 2H_2O$		46.			silicon carbide
22.			hydrogen fluoride	47.			aluminum phosphate
23.		$H_2S_{(g\ )}$		48.			lithium nitrate
24.			sodium hydroxide	49.		SF_2	
25.		$NaHSO_4$		50.		$H_2O_{2\ (aq)}$	