Honors Chemistry Summer Assignment

One area in which chemistry students struggle is the ability to quickly write a chemical formula given the name of a chemical compound and vice versa. This summer assignment is designed to give you a head start in overcoming these difficulties. The complete assignment is due on the first day of the fall semester. Some of the expectations may be difficult without a teacher to guide you, and others will be very straightforward. You should be able to complete at least 75% of the assignment.

Background

The **Periodic Table** is an organized grouping of the elements based on chemical properties. Individual atoms of these elements are, in most cases, unstable. Nature favors stability, and therefore atoms combine in ways that allow them to achieve maximum stability. This usually involves an exchange or sharing of electrons between atoms. An exchange or sharing of electrons leads to the formation of a **chemical bond**. Elements towards the left two-thirds of the periodic table are **metals**. Atoms of these elements typically lose electrons to become stable. Elements towards the upper right third of the periodic table are **non-metals**, and atoms of these elements typically gain or share electrons to achieve stability. Individual atoms are electrically neutral (they have equal numbers of protons in their nucleus and electrons outside the nucleus). When atoms gain or lose electrons, they become charged particles we call **ions**. When an electron exchange takes place between a metallic atom (loses the electron) and a non-metallic atom (gains the electron), a chemical bond is formed due to the electrostatic interaction between the two ions formed. We refer to this as an **ionic bond**. When two non-metals interact to form a chemical bond, electrons are shared between the atoms. We refer to this as a covalent (or molecular) bond. We will not deal with the interaction of two metallic atoms in this assignment.

Assignment

This packet includes this cover sheet and several tasks, a periodic table of the elements, three charts showing symbols and charges for common stable ions, one chart showing the prefixes used in naming covalent molecules, one chart showing the stems used in naming hydrocarbons and a sheet titled "Composition of Matter," which gives rules for identifying and naming ionic compounds.

You will need to purchase a package of 3x5 index cards.

Task 1. Refer to the table titled "Prefixes for Binary Molecular Compounds." **Make flash cards for each of the ten prefixes used in naming molecular compounds. On one side of the card write the prefix and on the other side write the number it represents.**

Task 2. Prefixes are used to give names to covalently bonded molecular compounds. The prefix identifies how many atoms of a particular element are present in the molecule. When writing the name for a molecule of a binary molecular compound (two different elements), the name of the first element remains the same, but the ending of the second element is changed to
"-ide." When writing a chemical formula for a molecule the number of atoms of each element is designated by a subscript following the symbol for that atom in the molecule. For example, the correct formula for the molecule: <u>di</u>phosphorus <u>pent</u>oxide is P_2O_5.

Carbon tetrachloride would be CCl_4. **On a sheet of notebook paper, write formulas for each of these molecules: sulfur dioxide, sulfur trioxide, dinitrogen trioxide, carbon disulfide, sulfur hexafluoride, carbon dioxide, nitrogen monoxide, phosphorus trifluoride, chlorodioxide, bromotrifluoride, dihydrogen monoxide, carbon trichloride, dinitrogen tetraoxide, nitrogen trifluoride, dinitrogen monoxide and dinitrogen pentoxide.**

Task 3. Refer to the table titled "Common Monatomic Cations and Anions (Type I)." This table represents symbols and charges for atoms that have either gained or lost electrons to become stable. **Find each of these elements on the periodic table and lightly color in the box of the periodic table for that element based on the following key:**

+ or 1+	Red
2+	Orange
3+	Yellow
3-	Green
2-	Blue
1-	Violet

For example, the box for Nitrogen, N (which is 3-) should be colored Green. The box for Hydrogen, H (which can be either 1+ or 1-) should be colored half Red and half Violet.

Task 4. Refer to the table titled "Common Cations (Type II)." This table is similar to the previous table except that certain elements (known as transition metals) may carry more than one stable ionic charge. In order to indicate the charge of the ion, a roman numeral is included in the name. **Lightly color in the boxes on the periodic table for these elements. For each element that has two different stable charges, color half the box one color and half the other color. For elements whose atoms can form a stable charge of 4+, use the color brown. Add the following elements to your list and color their boxes as well: Nickel (Ni^{2+}), Silver (Ag^{1+}), Zinc (Zn^{2+}) and Cadmium (Cd^{2+}).**

Task 5. In order to write the name for a binary ionic compound (two oppositely charged ions), we start with the name of the stable metal ion first (this is the same name as the atom), and we follow that with the name of the stable non-metal ion (also the name of the atom) only changing its ending to "-ide." For example, the name of the stable compound between lithium and sulfur is called "lithium sulfide." The stable compound between aluminum and bromine is called "aluminum bromide." Chemical formulas for ionic compounds are determined differently than molecular compounds. In order to write a chemical formula for an ionic compound, we must mathematically balance out the positive charge of the metal ion (cation) with the negative charge of the non-metal ion (anion). The overall charge must total zero, as ionic compounds are neutral in charge. The numbers of each ion present in the formula are written as subscripts. For example, in order to write the formula for lithium sulfide, we must mathematically balance the charge of lithium with that of sulfide. It would take two lithium ions (1+ each) to balance the charge of one sulfide (2-). The correct formula for the compound is Li_2S. In order to write the formula for aluminum bromide, three bromide ions (1- each) would be required to balance one aluminum (3+) ion. The correct formula for the compound is $AlBr_3$. The formula for aluminum sulfide requires that we balance aluminum (3+) with sulfide (2-). Since the least common multiple of these two values is 6, it would take two aluminum ions (total charge of

6+) and three sulfide ions (total charge of 6-) to write a formula that has a charge of zero. The correct formula is Al_2S_3. **Write the correct formulas for the following stable ionic compounds: sodium chloride, beryllium bromide, sodium sulfide, barium phosphide, potassium oxide, aluminum oxide, cesium nitride, aluminum nitride, magnesium selenide, manganese phosphide, lead (IV) oxide, tin (II) phosphide, copper (I) chloride, copper (I) selenide, chromium (III) fluoride, iron (II) sulfide, iron (II) nitride, tin (IV) hydride, cobalt (II) bromide and mercury (II) hydride.**

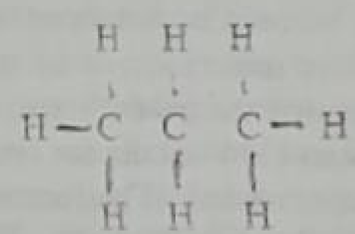
Task 6. Refer to the table titled "Common Polyatomic Ions." Polyatomic means "many atoms in the overall ion." Notice that most of these polyatomic ions carry negative charges (anions). The one major exception is ammonium, a 1+ charged cation. Also notice that in each case where oxygen is found in the polyatomic ion, the name ends in either "-ate," or "-ite." You may refer to the sheet in this packet titled "Composition of Matter," for rules in naming polyatomic ions. **Make flash cards for each of the polyatomic ions in the chart. On one side of the card write the formula and charge, and on the other side write the name.**

Task 7. We use the same rules for balancing charges as we used above when writing formulas for compounds involving polyatomic ions; however, since the charge on a polyatomic ion corresponds to the entire grouping of atoms in the polyatomic ion, we must surround the polyatomic ion with parentheses whenever its subscript is a value other than one. For example, in order to write the formula for the compound cobalt (III) nitrate, one ion of cobalt (3+) would be balanced by three ions of nitrate (1-). Since the 1- charge applies to the entire nitrate ion, we put parentheses around the nitrate ion and include a subscript of 3 outside the parentheses: $Co(NO_3)_3$. The formula for sodium sulfate requires two ions of sodium (1+) to balance one sulfate ion (2-). Since there is only one sulfate ion, no parentheses are needed. The formula is: Na_2SO_4. Notice that we did not place parentheses around the sodium ion. We only use parentheses when the charge corresponds to a grouping of more than one type of element. The formula for Lead (IV) carbonate requires two carbonate ions (2-) to balance out the charge of one lead ion (4+). Since more than one carbonate ion is required, we must use parentheses. The correct formula is: $Pb(CO_3)_2$. The correct formula for barium hydroxide is: $Ba(OH)_2$. **Write the correct formulas for the following stable ionic compounds: calcium permanganate, copper (I) sulfite, iron (III) oxalate, barium phosphate, tin (IV) hydroxide, magnesium dichromate, manganese (II) chlorite, potassium dihydrogen phosphate, tin (IV) hydroxide, aluminum cyanide, beryllium thiocyantate, sodium hydroxide, chromium (II) phosphate, lead (IV) carbonate, sodium chromate, cesium hypochlorite, potassium permanganate, manganese (III) nitrate, ammonium hydroxide and ammonium dichromate.**

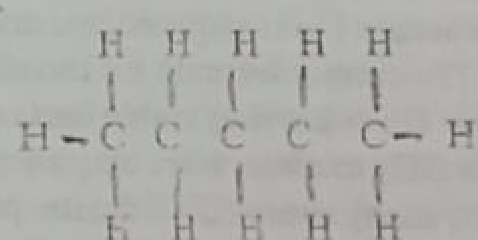
Task 8. Refer to the "Composition of Matter" sheet for rules on writing names and formulas for inorganic acids. Notice the rules state that inorganic acid formulas begin with hydrogen followed by an anion (negative ion). The acid name comes from the anion ending of the formulas. For example, the chemical name for HCl would be hydrogen chloride based on the rules you have already seen. Since it begins with "H," it is an acid. Referring to the rules for naming acids, hydrogen chloride becomes hydrochloric acid. H_2SO_4 would be named hydrogen sulfate. It is in an acid (beginning with "H") and is called sulfuric acid. H_2SO_3 (hydrogen sulfite) would be called sulfurous acid. **Write the correct formulas for these acids: carbonic acid, nitric acid, nitrous acid, phosphoric acid, chromic acid, chlorous acid, chloric acid, perchloric acid, hypochlorous acid, hydrocyanic acid, hydrofluoric acid, acetic acid, hydroiodic acid, hydrobromic acid, oxalic acid and hydrosulfuric acid.**

Task 9. The chemicals you have studied thus far in this packet are known as **inorganic compounds** (they generally do not contain covalently bonded carbon atoms). You should go back and review what covalent means. The next two tasks deal with **organic compounds** (covalently bonded carbon compounds). The simplest organic compounds contain just carbon and hydrogen. They are appropriately referred to as hydrocarbons. Refer to the table titled "Stems for Naming Hydrocarbons." **Make flash cards for each of the ten stems used in naming hydrocarbons. On one side of the card write the stem and on the other side write the number it represents.**

Task 10. Stems are used to give names to hydrocarbons. The stem identifies how many atoms of carbon are present in the molecule. The simplest hydrocarbons are the **alkanes**. When writing the name for these simple hydrocarbons, count the number of carbon atoms, use the appropriate stem and finish with the suffix "–ane." For example, the hydrocarbon with the chemical formula C_3H_8 contains 3 carbon atoms. The appropriate prefix is therefore "prop-." The correct name for the hydrocarbon would then be "propane." A more diagrammatic way to show a molecule is to write its structural formula. The structural formula for propane is written as:



The simple hydrocarbon with the chemical formula C_5H_{12} is named "pentane," as it contains 5 carbons. Its structural formula is:



Notice that the general formula for an alkane is "$C_nH_{(2n+2)}$." We have now written the chemical and structural formulas for two hydrocarbon alkanes. **On a sheet of notebook paper, write the name, chemical formula and structural formula for each of the remaining eight alkanes.**

(1-) charge	
Formula	**Name**
$H_2PO_4^-$	Dihydrogen phosphate
$C_2H_3O_2^-$	**Acetate***
SCN^-	Thiocyanate
HSO_4^-	Hydrogen sulfate
HCO_3^-	**Hydrogen carbonate (bicarbonate)**
NO_2^-	**Nitrite**
NO_3^-	**Nitrate**
CN^-	**Cyanide**
OH^-	**Hydroxide**
MnO_4^-	Permanganate
ClO^-	Hypochlorite
ClO_2^-	Chlorite
ClO_3^-	**Chlorate**
ClO_4^-	Perchlorate

(2-) charge	
Formula	**Name**
HPO_4^{2-}	Hydrogen phosphate
$C_2O_4^{2-}$	Oxalate
SO_3^{2-}	**Sulfite**
SO_4^{2-}	**Sulfate**
CO_3^{2-}	**Carbonate**
CrO_4^{2-}	**Chromate**
$Cr_2O_7^{2-}$	Dichromate
SiO_3^{2-}	Silicate
$S_2O_3^{2-}$	**Thiosulfate**

*The formula for the **acetate** ion can also be written as $CH_3CO_2^-$ or CH_3COO^-.

(3-) charge	
Formula	**Name**
PO_3^{3-}	**Phosphite**
PO_4^{3-}	**Phosphate**

(1+) charge	
Formula	**Name**
NH_4^+	**Ammonium**

Note: Memorize the bold face names and formulas

Common Monatomic Cations and Anions (Type I)						
1A	2A	3A	4A	5A	6A	7A
[illegible]						[illegible]
Li^+	Be^{2+}			N^{3-}	O^{2-}	F^-
Na^+	Mg^{2+}	Al^{3+}		P^{3-}	S^{2-}	Cl^-
K^+	Ca^{2+}					Br^-
Rb^+	Sr^{2+}					I^-
Cs^+	Ba^{2+}					

Common Cations (Type II)		
Formula	**Stock Name**	**Classical Name**
Cu^{1+}	Copper(I) ion	Cuprous ion
Cu^{2+}	**Copper(II) ion**	Cupric ion
Fe^{2+}	Iron(II) ion	Ferrous ion
Fe^{3+}	**Iron(III) ion**	Ferric ion
Hg_2^{2+} *	Mercury(I) ion	Mercurous ion
Hg^{2+}	**Mercury(II) ion**	Mercuric ion
Pb^{2+}	**Lead(II) ion**	Plumbous ion
Pb^{4+}	Lead(IV) ion	Plumbic ion
Sn^{2+}	Tin(II) ion	Stannous ion
Sn^{4+}	Tin(IV) ion	Stannic ion
Cr^{2+}	Chromium(II) ion	Chromous ion
Cr^{3+}	Chromium(III) ion	Chromic ion
Mn^{2+}	Manganese(II) ion	Manganous ion
Mn^{3+}	Manganese(III) ion	Manganic ion
Co^{2+}	**Cobalt(II) ion**	Cobaltous ion
Co^{3+}	Cobalt(III) ion	Cobaltic ion

Prefixes for Binary Molecular Compounds	
Number	**Prefix**
1	mono-
2	di-
3	tri-
4	tetra-
5	penta-
6	hexa-
7	hepta-
8	octa-
9	nona-
10	deca-

Stems for Naming Hydrocarbons	
Number of Carbon Atoms	**St**
1	meth-
2	eth-
3	prop-
4	but-
5	pent-
6	hex-
7	hept-
8	oct-
9	non-
10	dec-

COMPOSITION OF MATTER

GENERAL RULES FOR IDENTIFYING IONS

Most elements are not chemically stable as single atoms and may gain or lose electrons to become stable. They are then referred to as ions.

Cations (+Ions)

- Typically metals
- For the representative elements, they carry the same charge within a group
- For transition metals, the charge is identified by a roman numeral

Anions (- Ions)

- Typically non-metals
- Single atoms that become ions have their ending changed to "ide"
- For the representative elements, they carry the same charge within a group
- polyatomic ions containing oxygen may follow these rules

Most Common Form:		**Root Name** -ate
1 less oxygen:		**Root Name** -ite
2 less oxygen:	Hypo	**Root Name** -ite
1 more oxygen:	Hyper	**Root Name** -ate

GENERAL RULES FOR FORMULAS OF IONIC SALTS

- Cations and anions combine in ratios such that the overall charge is zero
- Use the least common multiple of the two ions to determine the quantity of each io

GENERAL RULES FOR IDENTIFYING ACIDS

- Formulas for acids begin with hydrogen
- Acid names are based on their anions and may follow these rules:

ANION ENDING	ACID NAME	Example
-ide	Hydro **Root Name** -ic acid	Hydro**chlor**ic acid
-ate	**Root Name** -ic acid	Chloric acid
-ite	**Root Name** -ous acid	Chlorous acid
per...ate	Per **Root Name** -ic acid	Perchloric acid
hypo...ite	Hypo **Root Name** -ous acid	Hypochlorous acid

Chemistry Reference Sheet

Key

11 — Atomic number
Na — Element symbol
Sodium — Element name
22.99 — Average atomic mass*

	1 (1A)	2 (2A)	3 (3B)	4 (4B)	5 (5B)	6 (6B)	7 (7B)	8	9 (8B)	10	11 (1B)	12 (2B)	13 (3A)	14 (4A)	15 (5A)	16 (6A)	17 (7A)	18 (8A)
1	1 H Hydrogen 1.01																	2 He Helium 4.00
2	3 Li Lithium 6.94	4 Be Beryllium 9.01											5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 19.00	10 Ne Neon 20.18
3	11 Na Sodium 22.99	12 Mg Magnesium 24.31											13 Al Aluminum 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.97	16 S Sulfur 32.07	17 Cl Chlorine 35.45	18 Ar Argon 39.95
4	19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.87	23 V Vanadium 50.94	24 Cr Chromium 52.00	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.39	31 Ga Gallium 69.72	32 Ge Germanium 72.61	33 As Arsenic 74.92	34 Se Selenium 78.96	35 Br Bromine 79.90	36 Kr Krypton 83.80
5	37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.60	53 I Iodine 126.90	54 Xe Xenon 131.29
6	55 Cs Cesium 132.91	56 Ba Barium 137.33	57 La Lanthanum 138.91	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.84	75 Re Rhenium 186.21	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
7	87 Fr Francium (223)	88 Ra Radium (226)	89 Ac Actinium (227)	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (266)	107 Bh Bohrium (264)	108 Hs Hassium (269)	109 Mt Meitnerium (268)									

58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.97
90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)

* If this number is in parentheses, then it refers to the atomic mass of the most stable isotope.