AP Chemistry Summer Assignment

There are **THREE** parts to the AP Chemistry Summer Assignment.

- Part 1 deals with the memorization of common ions used in the course
- Part 2 provides information and practice on the use of significant figures rules in calculations
- Part 3 provides rules and practice for writing the names and formulas for ionic compounds, binary molecular compounds, and acids

There is a website, ***sciencegeek.net***, that I use that has links to videos and review activities to help with the summer assignment. Please make use of them.

PART 1: COMMON IONS

This part of the summer assignment for AP Chemistry is quite simple (but not easy). You need to master the formulas, charges, and names of the common ions. **On the first day of the school year, you will be given a quiz on these ions.** You will be asked to:

- write the names of these ions when given the formula and charge
- write the formula and charge when given the names

There are several resources in this packet. First, there is a list of the ions that you must know on the first day. This list also has some suggestions for making the process of memorization easier. For instance, many of you will remember that most of the monatomic ions have charges that are directly related to their placement on the periodic table. There are naming patterns that greatly simplify the learning of the polyatomic ions as well.

Also included is a copy of the periodic table used in AP Chemistry. This table is the same that the College Board allows you to use on the AP Chemistry test. Notice that it has the symbols of the elements but *not* the written names. You need to take that fact into consideration when studying for the aforementioned quiz!

Also included is a sheet of flashcards for the polyatomic ions that you must learn. I strongly suggest that you cut them out and begin memorizing them immediately. Use the hints on the common ions sheet to help you reduce the amount of memorizing that you must do.

Do not let the fact that there are no flashcards for monatomic ions suggest to you that the monatomic ions are not important. They are every bit as important as the polyatomic ions. If you have trouble identifying the charge of monatomic ions (or the naming system) then I suggest that you make yourself some flashcards for those as well.

Doubtless, there will be some of you who will procrastinate and try to do all of this studying just before the start of school. Those students may even cram well enough to do well on the initial quiz. However, they will quickly forget the ions, and struggle every time that these formulas are used in lecture, homework, quizzes, tests and labs. All research on human memory shows us that frequent, short periods of study, spread over long periods of time will produce much greater retention than long periods of study of a short period of time. I could wait and throw these at you on the first day of school, but I don't think that would be fair to you. Use every modality possible as you try to learn these – speak them, write them, visualize them.

PART 2: SIGNIFICANT FIGURES IN CALCULATIONS

Unless you have been exposed to significant figure rules in another course, this topic will take a bit of study. Attached you will find a two-sided page with explanations of the rules, and examples of problem solving in addition, subtraction, multiplication and division.

There is also a page of problems for you to complete: this page is due at the beginning of class on the first day of the new school year.

There are some excellent videos and practice activities produced by Khan Academy for this subject. Links to videos, practice activities, and other review activities can also be found on sciencegeek.net.

PART 3: NOMENCLATURE

You will be putting together what you mastered from **PART 1** to complete this section. You will get much practice naming and writing the formulas for ionic and molecular compounds along with acids. **For this part, please complete the tables with the correct name or formula: this page is due at the beginning of class on the first day of the new school year.**

There are some excellent videos and practice activities produced by Khan Academy for this subject. Links to videos, practice activities, and other review activities can also be found on sciencegeek.net.

Common Ions and Their Charges

A mastery of the common ions, their formulas and their charges, is essential to success in AP Chemistry. You are expected to know all of these ions on the first day of class, when I will give you a quiz on them. You will always be allowed a periodic table, which makes indentifying the ions on the left "automatic." For tips on learning these ions, see the opposite side of this page.

From the table:	
Cations	**Name**
H^+	Hydrogen
Li^+	Lithium
Na^+	Sodium
K^+	Potassium
Rb^+	Rubidium
Cs^+	Cesium
Be^{2+}	Beryllium
Mg^{2+}	Magnesium
Ca^{2+}	Calcium
Ba^{2+}	Barium
Sr^{2+}	Strontium
Al^{3+}	Aluminum

Anions	**Name**
H^-	Hydride
F^-	Fluoride
Cl^-	Chloride
Br^-	Bromide
I^-	Iodide
O^{2-}	Oxide
S^{2-}	Sulfide
Se^{2-}	Selenide
N^{3-}	Nitride
P^{3-}	Phosphide
As^{3-}	Arsenide
Type II Cations	**Name**
Fe^{3+}	Iron(III)
Fe^{2+}	Iron(II)

Cu^{2+}	Copper(II)
Cu^{+}	Copper(I)
Co^{3+}	Cobalt(III)
Co^{2+}	Cobalt(II)
Sn^{4+}	Tin(IV)
Sn^{2+}	Tin(II)
Pb^{4+}	Lead(IV)
Pb^{2+}	Lead(II)
Hg^{2+}	Mercury(II)

CN^{-}	Cya
PO_4^{3-}	Pho
HPO_4^{2-}	Hy
$H_2PO_4^{-}$	Dih
NCS^{-}	Thi
CO_3^{2-}	Ca
HCO_3^{-}	Hy
ClO^{-}	Hyp
ClO_2^{-}	Ch
ClO_3^{-}	Ch
ClO_4^{-}	Per
BrO^{-}	Hyp
BrO_2^{-}	Bro
BrO_3^{-}	Bro
BrO_4^{-}	Per
IO^{-}	Hyp
IO_2^{-}	iod
IO_3^{-}	iod
IO_4^{-}	Per
$C_2H_3O_2^{-}$	Ace
MnO_4^{-}	Per
$Cr_2O_7^{2-}$	Dic
CrO_4^{2-}	Ch
O_2^{2-}	Per
$C_2O_4^{2-}$	Ox
NH_2^{-}	Am
BO_3^{3-}	Bor
$S_2O_3^{2-}$	Thi

Ions to Memorize	
Cations	**Name**
Ag^{+}	Silver
Zn^{2+}	Zinc
Hg_2^{2+}	Mercury(I)
NH_4^{+}	Ammonium
Anions	**Name**
NO_2^{-}	Nitrite
NO_3^{-}	Nitrate
SO_3^{2-}	Sulfite
SO_4^{2-}	Sulfate
HSO_4^{-}	Hydrogen sulfate (bisulfate)
OH^{-}	Hydroxide

Tips for Learning the Ions

<u>"From the Table"</u>

These are ions can be organized into two groups.

1. Their place on the table suggests the charge on the ion, since the neutral atom gains or loses a

predictable number of electrons in order to obtain a noble gas configuration. This was a focus in first year chemistry, so if you are unsure what this means, get help BEFORE the start of the year.

a. All Group 1 Elements (alkali metals) lose one electron to form an ion with a 1+ charge b. All Group 2 Elements (alkaline earth metals) lose two electrons to form an ion with a 2+ charge c. Group 13 metals like aluminum lose three electrons to form an ion with a 3+ charge d. All Group 17 Elements (halogens) gain one electron to form an ion with a 1- charge e. All Group 16 nonmetals gain two electrons to form an ion with a 2- charge

f. All Group 15 nonmetals gain three electrons to form an ion with a 3- charge

Notice that cations keep their name (sodium ion, calcium ion) while anions get an "-ide" ending (chloride ion, oxide ion).

2. Metals that can form more than one ion will have their positive charge denoted by a roman numeral in parenthesis immediately next to the name of the

Polyatomic Anions

Most of the work on memorization occurs with these ions, but there are a number of patterns that can greatly reduce the amount of memorizing that one must do.

1. "ate" anions have one more oxygen then the "ite" ion, but the same charge. If you memorize the "ate" ions, then you should be able to derive the formula for the "ite" ion and vice-versa. a. sulfate is SO_4^{2-}, so sulfite has the same charge but one less oxygen (SO_3^{2-})

b. nitrate is NO_3^-, so nitrite has the same charge but one less oxygen (NO_2^-)

2. If you know that a sufate ion is SO_4^{2-} then to get the formula for hydrogen sulfate ion, you add a hydrogen ion to the front of the formula. Since a hydrogen ion has a 1+ charge, the net charge on the new ion is less negative by one.

a. Example:

PO_4^{3-} → HPO_4^{2-} → $H_2PO_4^-$

phosphate hydrogen phosphate dihydrogen phosphate

3. Learn the hypochlorite → chlorite → chlorate → perchlorate series, and you also know the series containing iodite/iodate as well as bromite/bromate.

a. The relationship between the "ite" and "ate" ion is predictable, as always. Learn one and you know the other.

b. The prefix "hypo" means "under" or "too little" (think "hypodermic", "hypothermic" or "hypoglycemia")

i. Hypochlorite is "under" chlorite, meaning it has one less oxygen

c. The prefix "hyper" means "above" or "too much" (think "hyperkinetic")

i. the prefix "per" is derived from "hyper" so perchlorate (hyperchlorate) has one more oxygen than chlorate.

d. Notice how this sequence increases in oxygen while retaining the same charge:

ClO^- → ClO_2^- → ClO_3^- → ClO_4^-

hypochlorite chlorite chlorate perchlorate

Sulfite	**Sulfate**	**Hydrogen sulfate**
Phosphate	**Dihydrogen Phosphate**	**Hydrogen Phosphate**

Nitrite	**Nitrate**	**Ammonium**
Thiocyanate	**Carbonate**	**Hydrogen carbonate**
Borate	**Chromate**	**Dichromate**
Permanganate	**Oxalate**	**Amide**
Hydroxide	**Cyanide**	**Acetate**
Peroxide	**Hypochlorite**	**Chlorite**
Chlorate	**Perchlorate**	**Thiosulfate**

HSO_4^- SO_4^{2-} SO_3^{2-} HPO_4^{2-} $H_2PO_4^-$ PO_4^{3-}

NH_4^+ NO_3^- NO_2^- HCO_3^- CO_3^{2-} NCS SCN $Cr_2O_7^{2-}$

CrO_4^{2-} BO_{33-}

NH_2^- $C_2O_4^{2-}$ MnO_{4-} CH_3COO^- CN^- OH $C_2H_3O_{2-}$

ClO_2^- ClO^- O_{22-} $S_2O_3^{2-}$ ClO_4^- ClO_{3-}

Significant Figures in Measurement and Calculations

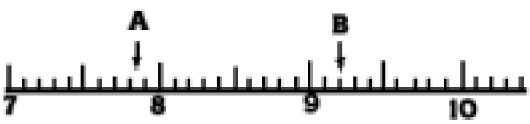
A successful chemistry student habitually labels all numbers, because the unit is important. Also of great importance is the number itself. Any number used in a calculation should contain only figures that are considered reliable; otherwise, time and effort are wasted. Figures that are considered reliable are called *significant figures*. Chemical calculations involve numbers representing actual measurements. In a measurement, significant figures in a number consist of:

Figures (digits) definitely known + One estimated figure (digit)

In class you will hear this expressed as "all of the digits known for certain plus one that is a guess."

Recording Measurements

When one reads an instrument (ruler, thermometer, graduate, buret, barometer, balance), he expresses the reading as one which is reasonably reliable. For example, in the accompanying illustration, note the reading marked *A*. This reading is definitely beyond the 7 cm mark and also beyond the 0.8 cm mark. We read the 7.8 with certainty. We further *estimate* that the reading is five-tenths the distance from the 7.8 mark to the 7.9 mark. So, we estimate the length as 0.05 cm more than 7.8 cm. All of these have meaning and are therefore significant. We express the reading as 7.85 cm, accurate to three significant figures. All of these figures, *7.85*, can be used in calculations. In reading B we see that 9.2 cm is definitely known. We can include one estimated digit in our reading, and we estimate the next digit to be zero. Our reading is reported as 9.20 cm. It is accurate to three significant figures.



Rules for Zeros

If a zero represents a measured quantity, it is a significant figure. If it merely locates the decimal point, it is not a significant figure.

Zero Within a Number. In reading the measurement 9.04 cm, the zero represents a measured quantity, just as 9 and 4, and is, therefore, a significant number. A zero between any of the other digits in a number is a significant figure.

Zero at the Front of a Number. In reading the measurement 0.46 cm, the zero does not represent a measured quantity, but merely locates the decimal point. It is not a significant figure. Also, in the measurement 0.07 kg, the zeros are used merely to locate the decimal point and are, therefore, not significant. Zeros at the first (left) of a number are not significant figures.

Zero at the End of a Number. In reading the measurement 11.30 cm, the zero is an estimate and represents a measured quantity. It is therefore significant. Another way to look at this: The zero is not needed as a placeholder, and yet it was included by the person recording the measurement. It must have been recorded as a part of the measurement, making it significant. Zeros to the right of the decimal point, and at the end of the number, are significant figures.

Zeros at the End of a Whole Number. Zeros at the end of a whole number may or may not be significant. If a distance is reported as 1600 feet, one assumes two sig figs. Reporting measurements in scientific notation removes all doubt, since all numbers written in scientific notation are considered significant. 1 600 feet 1.6×10^3 feet Two significant figures

1 600 feet 1.60×10^3 feet Three significant figures

1 600 feet 1.600×10^3 feet Four significant figures

Sample Problem #1: Underline the significant figures in the following numbers.

(a) 0.0420 cm answer = 0.0420 cm (e) 2 403 ft. answer = 2 403 ft. (b) 5.320 in. answer = 5.320 in. (f) 80.5300 m answer = 80.5300 m (c) 10 lb. answer = 10 lb. (g) 200. g answer = 200 g (d) 0.020 ml answer = 0.020 ml (h) 2.4×10^3 kg answer = 2.4×10^3 kg

Rounding Off Numbers

In reporting a numerical answer, one needs to know how to "round off" a number to include the correct number of significant figures. Even in a series of operations leading to the final answer, one must "round off" numbers. The rules are well accepted rules:

1. If the figure to be dropped is less than 5, simply eliminate it.

2. If the figure to be dropped is greater than 5, eliminate it and raise the preceding figure by 1. 3. If the figure is 5, followed by nonzero digits, raise the preceding figure by 1

4. If the figure is 5, not followed by nonzero digit(s), and preceded by an odd digit, raise the preceding digit by one

5. If the figure is 5, not followed by nonzero digit(s), and the preceding significant digit is even, the preceding digit remains unchanged

Sample Problem #2: Round off the following to three significant figures.

(a) 3.478 m answer = 3.48 m (c) 5.333 g answer = 5.33 g (b) 4.8055 cm answer = 4.81 cm (d) 7.999 in. answer = 8.00 in.

Multiplication

In multiplying two numbers, when you wish to determine the number of significant figures you should have in your answer (the product), you should inspect the numbers multiplied and find which has the least number of significant figures. This is the number of significant figures you should have in your answer (the product). Thus the answer to 0.024 x 1244 would be rounded off to contain two significant figures since the factor with the lesser number of significant figures (0.024) has only *two* such figures.

Sample Problem #3: Find the area of a rectangle 2.1 cm by 3.24 cm.

Solution: Area = 2.1 cm x 3.24 cm = 6.804 cm^2

We note that 2.1 contains two significant figures, while 3.24 contains three significant figures. Our product should contain no more than *two* significant figures. Therefore, our answer would be recorded as 6.8 cm^2

Sample Problem #4: Find the volume of a rectangular solid 10.2 cm x 8.24 cm x 1.8 cm Solution: Volume = 10.2 cm x 8.24 cm x 1.8 cm = 151.2864 cm^3

We observe that the factor having the least number of significant figures is 1.8 cm. It contains two significant figures. Therefore, the answer is rounded off to 150 cm^3.

Division

In dividing two numbers, the answer (quotient) should contain the same number of significant figures as are contained in the number (divisor or dividend) with the least number of significant figures. Thus the answer to 528 ψ 0.14 would be rounded off to contain *two* significant figures. The answer to 0.340 ψ 3242 would be rounded off to contain three significant figures.

Sample Problem #5: Calculate 20.45 ψ 2.4

Solution: 20.45 ψ 2.4 = 8.52083

We note that the 2.4 has fewer significant figures than the 20.45. It has only *two* significant figures. Therefore, our answer should have no more than two significant figures and should be reported as 8.5.

Addition and Subtraction

In adding (or subtracting), set down the numbers, being sure to keep like decimal places under each other, and add (or subtract). Next, note which column contains the first estimated figure. This column determines the last decimal place of the answer. After the answer is obtained, it should be rounded off in this column. In other words, round to the least number of decimal places in you data.

Sample Problem #6: Add 42.56 g + 39.460 g + 4.1g

Solution:

42.56 g
39.460 g
4.1 g

Sum = 86.120 g

Since the number 4.1 only extends to the first decimal place, the answer must be rounded to the first decimal place, yielding the answer 86.1 g.

Average Readings

The average of a number of successive readings will have the same number of decimal places that are in their sum.

Sample Problem #7: A graduated cylinder was weighed three times and the recorded weighings were 12.523 g, 12.497 g, 12.515 g. Calculate the average weight.

Solution:

12.523 g
12.497 g
12.515 g
37.535 g

In order to find the average, the sum is divided by 3 to give an answer of 12.51167. Since each number extends to three decimal places, the final answer is rounded to three decimal places, yielding a final answer of 12.512 g. Notice that the divisor of 3 does not effect the rounding of the final answer. This is because 3 is an exact number - known to an infinite number of decimal places.

Name______________________________

Give the number of significant figures in each of the following:

____ 402 m ____ 34.20 lbs ____ 0.03 sec ____ 0.00420 g ____ 3 200 liters
____ 0.0300 ft. ____ 5.1 x 10^4 kg ____ 0.48 m ____ 1 400.0 m ____ 78 323.01 g
____ 1.10 torr ____ 760 mm Hg

Multiply each of the following, observing significant figure rules:

17 m x 324 m = ________________ 1.7 mm x 4 294 mm = __________________

0.005 in x 8 888 in = _____________ 0.050 m x 102 m = ____________________

0.424 in x .090 in = ______________ 324 000 cm x 12.00 cm = _______________

Divide each of the following, observing significant figure rules:

23.4 m ψ 0.50 sec = ______________ 12 miles ψ 3.20 hours = ________________

0.960 g ψ 1.51 moles = ____________ 1 200 m ψ 12.12 sec = __________________

Add each of the following, observing significant figure rules:

3.40 m 102.45 g 102. cm 0.022 m 2.44 g 3.14 cm 0.5 m 1.9999 g 5.9 cm

Subtract each of the following, observing signigicant figure rules:

42.306 m 14.33 g 234.1 cm 1.22 m 3.468 g 62.04 cm

Work each of the following problems, observing significant figure rules:

Three determinations were made of the percentage of oxygen in mercuric oxide. The results were 7.40%, 7.43%, and 7.35%. What was the average percentage?

A rectangular solid measures 13.4 cm x 11.0 cm x 2.2 cm. Calculate the volume of the solid.

If the density of mercury is 13.6 g/ml, what is the mass in grams of 3426 ml of the liquid?

A copper cylinder, 12.0 cm in radius, is 44.0 cm long. If the density of copper is 8.90 g/cm^3, calculate the mass in grams of the cylinder. (assume pi = 3.14)

Ionic Nomenclature

Ionic nomenclature is the simplest of the three types of nomenclature here. Of course, the presumption is that you completed the summer assignment and remember the names of the common ions.

First identify the cation (positive ion) by name. Second, identify the anion by name. Then, put the two names together.

Examples:

$AlCl_3$ – The cation is aluminum. The anion is chloride. The compound is *aluminum chloride*.

Na_2SO_4 – The cation is sodium. The anion is sulfate. The compound is *sodium sulfate*.

Notice that there is no use of prefixes to denote the quantity of each ion. That is because the charge of the ions guarantees that there is only one proportion in which they can combine, so prefixes are unnecessary.

For metals that can have more than one oxidation state, it is important to identify the oxidation state in the name, using Roman numerals.

Examples:

$FeCl_3$ – Because the three chloride ions have a TOTAL charge of -3, so the iron must have a +3 charge. Therefore, the compound is *iron(III) chloride*.

$Cr(NO_3)_3$ – Three nitrate ions have a TOTAL charge of -3, so the chromium must have a +3 charge. Therefore, the compound is *chromium(III) nitrate*.

When writing formulas from names:

1. Write the formula of the cation
2. Write the formula of the anion
3. Balance the formula electrostatically, using subscripts
   a. If you need more than one of a polyatomic ion, you must place the subscript outside of a set of parentheses that surround the polyatomic ion.

Examples:
Calcium phosphide – Calcium is Ca^{2+} and phosphide is P^{3-}. The balanced formula is Ca_3P_2.
Aluminum nitrite – Aluminum is Al^{3+} and nitrite is NO_2^-. The balanced formula is $Al(NO_2)_3$.

Write the name		**Write the formula**	
$PbCl_2$		Iron(III) nitride	
$Na_2C_2O_4$		Calcium thiocyanate	
KCN		Sodium sulfite	
$(NH_4)_2CO_3$		Copper(I) phosphate	
$Cu(NO_3)_2$		Cesium nitrite	
MgO_2		Cobalt(III) oxide	
SnF_2		Aluminum sulfate	
$FeBr_3$		Lithium sulfide	
$Ca(C_2H_3O_2)_2$		Ammonium phosphate	

Binary Molecular Nomenclature

Rules for Binary Molecular Compounds	**Prefixes**
1. The naming system is for compounds composed of two nonmetallic elements. 2. The first element keeps its name a. The first element gets a prefix if it has a subscript in the formula 3. The second element gets the *–ide* suffix (ending) a. The second element ALWAYS gets a prefix	1 – mono 2 – di 3 – tri 4 – tetra 5 – penta 6 – hexa 7 – hepta 8 – octa 9 – nona 10 - deca

Compound Name	***Compound Formula***
Carbon dioxide	
Carbon monoxide	

Diphosphorus pentoxide	
Dinitrogen monoxide	
Silicon dioxide	
Carbon tetrafluoride	
Sulfur dioxide	
Phosphorus pentafluoride	
Oxygen difluoride	
Nitrogen dioxide	
Dinitrogen trioxide	

Compound Formula	***Compound Name***
N_2O_4	
SO_3	
NO	
NO_2	
As_2O_5	
PF_3	
CS_2	
H_2O	
SeF_6	
N_2O_4	
CH_4	

Naming Acids

Acids are divided into two groups: Binary and Oxyacids. Binary acids consist of two elements. Oxyacids consist of 3 elements, one of which is oxygen.

1. NAMING BINARY ACIDS: The name of the binary acid consists of two words. The first word has three parts:

the "hydro" prefix

the root of the nonmetal element

the "ic" ending

The second word is always "acid"

Examples:

HCl = hydro chlor ic acid = hydrochloric acid

HBr = hydro brom ic acid = hydrobromic acid

HF = hydro fluor ic acid = hydrofluoric acid

2. **NAMING OXYACIDS**: These are more difficult to name because these acids have hydrogen, a nonmetal, and may have varying numbers of oxygen atoms. For example, H_2SO_5, H_2SO_4, H_2SO_3, and H_2SO_2 are all acids. How do we name them? To begin, we need a point of reference. Our reference point is this:

The "ate" ions (sulfate, nitrate, etc) make the "ic" acids (sulfuric acid, nitric acid) Examples:

SO_4^{2-} = sulfate ion H_2SO_4 = sulfuric acid

NO_3^- = nitrate ion HNO_3 = nitric acid

Once we have our point of reference, the acid with one more oxygen than the -ic acid is called the per-__________-ic acid. The acid with one less oxygen then the -ic acid is called the ____________-ous acid. If the acid has one less oxygen than the -ous acid, it is called the hypo-_____________-ous acid.

Examples:

H_2SO_5 = persulfuric acid HNO_4 = pernitric acid H_2SO_4 = sulfuric acid HNO_3 = nitric acid H_2SO_3 = sulfurous acid HNO_2 = nitrous acid H_2SO_2 = hyposulfurous acid HNO = hyponitrous acid

The KEY: All you really need to know are the "ate" ions. After that, you can use the above scheme to name any oxyacid. To refresh your memory, here are some of the common "ate" ions:

sulfate = SO_4^{2-} nitrate = NO_3^-

chlorate = ClO_3^- bromate = BrO_3^-

phosphate = PO_4^{3-} carbonate = CO_3^{2-}

Naming Acids - Problems

Name these binary acids:

HF________________________________ HCl________________________________

H_2S________________________________ HBr________________________________

HI________________________________

Name these oxyacids:

H_2CO_4____

H_2CO_3____

H_2CO_2____

H_2CO ____

$HClO_4$____

$HClO_3$____

$HClO_2$____

HClO ____

H_3PO_5____
H_3PO_4____
H_3PO_3____
H_3PO_2____

Write the formulas for these acids (they may or may not actually exist!):

perbromic acid____
nitrous acid____
hypobromous acid____
chromic acid____
chromous acid____
pernitric acid____
sulfurous acid____
perchromic acid____