Welcome to AP Chemistry!

The exercises below have been designed to prepare you for a course that is both rewarding and challenging. If you experience great difficulty with a majority of this work, please contact the guidance department to discuss placement. Chemistry is challenging enough on its own! Make sure you are ready for this class. While this work will be demanding, it is quite possible to complete with the work ethic and knowledge-base needed for this class. This work is **required** and will be collected upon entering the class. **Do not wait until the last weeks of summer to begin this packet.**

Part I: Memorization

Memorization of material is not something that will be encouraged or emphasized in this course because this is a **problem-solving** course. **However, memorization of some topics/rules is necessary**. This information needs to be **second nature** to you to ensure your success in this course. Do whatever you need to do this summer to memorize the information below. Make flashcards, have your family and friends quiz you, or form a study group!

1. Specified Element Names and Symbols from the Periodic Table
   - Elements 1-38
   - Ag, Cd, I, Xe, Cs, Ba, W, Hg, Pb, Sn, Rn, Fr, U, Th, Pu, and Am written correctly

2. Monatomic Ions (both those with one and those with multiple oxidation states)
   An extensive list is provided in this packet.

3. Polyatomic Ions and corresponding acids
   An extensive list is provided in this packet.

4. Colors of Common Ions
   An extensive list is provided in this packet.

Ions Usually with One Oxidation State			
Symbol	Name	Symbol	Name
Li^+	lithium ion	N^{3-}	nitride
Na^+	sodium ion	O^{2-}	oxide
K^+	potassium ion	S^{2-}	sulfide
Mg^{2+}	magnesium ion	F^-	fluoride
Ca^{2+}	calcium ion	Cl^-	chloride
Sr^{2+}	strontium ion	Br^-	bromide
Ba^{2+}	barium ion	I^-	iodide
Ag^+	silver ion		
Zn^{2+}	zinc ion		
Cd^{2+}	cadmium ion		
Al^{3+}	aluminum ion		

Ions with Multiple Oxidation States			
+1		+2	
Cu^{+}	copper (I) ion	Cu^{2+}	copper (II) ion
Hg_2^{2+}	mercury (I) ion	Hg^{2+}	mercury (II) ion
+2		+3	
Fe^{2+}	iron (II) ion	Fe^{3+}	iron (III) ion
Cr^{2+}	chromium (II) ion	Cr^{3+}	chromium (III) ion
Mn^{2+}	manganese (II) ion	Mn^{3+}	manganese (III) ion
Co^{2+}	cobalt (II) ion	Co^{3+}	cobalt (III) ion
+2		+4	
Sn^{2+}	tin (II) ion	Sn^{4+}	tin (IV) ion
Pb^{2+}	lead (II) ion	Pb^{4+}	lead (IV) ion

Other Ions	
Ion	*Name*
O_2^{2-}	peroxide ion
OH^{-}	hydroxide ion
HSO_4^{-}	bisulfate ion; hydrogen sulfate ion
NH_4^{+}	ammonium ion
O_2^{-}	superoxide ion
HCO_3^{-}	bicarbonate ion; hydrogen carbonate ion
HPO_4^{2-}	hydrogen phosphate ion
$H_2PO_4^{-}$	dihydrogen phosphate ion

Polyatomic Ions and Acids			
Formula	*Name*	*Ion*	*Ion Name*
H_2SO_4	sulfuric acid	SO_4^{2-}	sulfate ion
H_2SO_3	sulfurous acid	SO_3^{2-}	sulfite ion
HNO_3	nitric acid	NO_3^-	nitrate ion
HNO_2	nitrous acid	NO_2^-	nitrite ion
H_3PO_4	phosphoric acid	PO_4^{3-}	phosphate ion
H_2CO_3	carbonic acid	CO_3^{2-}	carbonate ion
$HMnO_4$	permanganic acid	MnO_4^-	permanganate ion
HCN	hydrocyanic acid	CN^-	cyanide ion
HOCN	cyanic acid	OCN^-	cyanate ion
HSCN	thiocyanic acid	SCN^-	thiocyanate ion
$HC_2H_3O_2$	acetic acid	$C_2H_3O_2^-$	acetate ion
$H_2C_2O_4$	oxalic acid	$C_2O_4^{2-}$	oxalate ion
H_2CrO_4	chromic acid	CrO_4^{2-}	chromate ion
$H_2Cr_2O_7$	dichromic acid	$Cr_2O_7^{2-}$	dichromate ion
$H_2S_2O_3$	thiosulfuric acid	$S_2O_3^{2-}$	thiosulfate ion
H_3AsO_4	arsenic acid	AsO_4^{3-}	arsenate ion
H_3AsO_3	arsenous acid	AsO_3^{3-}	arsenite ion
HClO	hypochlorous acid	ClO^-	hypochlorite ion
$HClO_2$	chlorous acid	ClO_2^-	chlorite ion
$HClO_3$	chloric acid	ClO_3^-	chlorate ion
$HClO_4$	perchloric acid	ClO_4^-	perchlorate ion
Br and I can be substituted for Cl. F may form hypofluorous acid and the hypofluorite ion.			

Colors of Common Ions in Aqueous Solution	
Most common ions are colorless in solution. However, some have distinctive colors. These colors have appeared in question on the AP exam.	
Fe^{2+} and Fe^{3+}	various colors
Cu^{2+}	blue to green
Cr^{2+}	blue
Cr^{3+}	green or violet
Mn^{2+}	faint pink
Ni^{2+}	green
Co^{2+}	pink
MnO_4^-	dark purple
CrO_4^{2-}	yellow
$Cr_2O_7^{2-}$	orange

Part II: Nomenclature

Upon entering AP Chemistry, it is important that you speak the "language" of the course. For now that means knowing the names, charges, and formulas of common ions and the names and formulas of ionic compounds, covalent compounds, and acids. Review the following pages of instructions and complete the work that follows.

Nomenclature Review

Forming binary ionic compounds

A. In a binary ionic compound the total positive charges must equal the total negative charges. Use the "Criss Cross Method".

B. Ex. What ionic compound would form when calcium ions combine with bromide ions? Use the steps to the Criss Cross Method:

1. Write the ions with their charges, cations are always first. Ca^{+2} Br^{-1}
2. Cross over the charges by using the absolute value of each ion's charge as the subscript for the other ion. Ca_1 Br_2
3. Check to make sure the subscripts are in the lowest whole number ratio possible. Then write the formula. $CaBr_2$

Naming binary ionic compounds

A. Combine the names of the cation and the anion.

B. Example: $BaBr_2$ is named barium bromide.

Naming binary ionic compounds that contain polyatomic ions

A. The polyatomic ions on your common ions list should be memorized.

B. The most common oxyanions – polyatomic anions that contain oxygen, end in *–ate.*

Oxyanions with one less oxygen end in *–ite*. For example:

NO_3^{-1} is nitrate	SO_4^{2-} is sulfate
NO_2^{-1} is nitrite	SO_3^{2-} is sulfite

C. Anions with one less oxygen than the *–ite* ion are given the prefix *hypo-*.

D. Anions with one more oxygen than the *–ate* ion are given the prefix *per-*.

ClO^{-1} is hypochlorite	ClO_3^{-1} is chlorate
ClO_2^{-1} is chlorite	ClO_4^{-1} is perchlorate

E. Naming compounds with polyatomics is the same as naming other compounds, just name the cation and then the anion. If there is a transition metal involved, be sure to check the charges to identify which ion (+1, +2, +3, +4….) it may be so that you can put the correct Roman numeral in the name.

Polyatomic Ions Ending in "ate"

BO_3^{-3}	CO_3^{-2}	NO_3^{-1}	O	F
	SiO_4^{-4}	PO_4^{-3}	SO_4^{-2}	ClO_3^{-1}
		AsO_4^{-3}	SeO_4^{-2}	BrO_3^{-1}
			TeO_4^{-2}	IO_3^{-1}

Notes and Observations (see above table)

1. The individual locations of the elements in the table correspond to their relative locations on the periodic table.
2. The outside edges have ions that all end in "O_3".
3. The interior area has ions that all end in "O_4".
4. The charges of the ions become more positive as you go across a "period".
5. For ions with the same root containing oxygen, the suffixes and prefixes are : *(Using chlorate as an example)*

- Ions starting with "*per*" will have one more oxygen.
  Ex. ClO_4^{-1} = *per*chlorate
- Ions ending in "*ite*" will have one less oxygen.
  Ex. ClO_2^{-1} = chlor*ite*
- Ions starting with "*hypo*" and ending in "*ite*" will have two less oxygens.
  Ex. ClO^{-1} = hypochlor*ite*

Naming binary molecular compounds

A. With molecules, the prefix system is used.

Number	Prefix	Number	Prefix
1	mono-	7	hepta-
2	di-	8	octa-
3	tri-	9	nona-
4	tetra-	10	deca-
5	penta-	11	undeca-
6	hexa-	12	dodeca-

B. The less-electronegative element is always written first. It only gets a prefix if it has more than one atom in the molecule.
C. The second element gets the prefix and the ending *–ide*.
D. The *o or a* at the end of the prefix is dropped when the word following the prefix begins with another vowel, for example monoxide or pentoxide.

Exercise 1 - Nomenclature: Simple Inorganic Formulas and Nomenclature

I. In the first column, classify each of the following as molecular (M) or ionic (I). In the second column, name each compound:

	M or I	Name		M or I	Name
1) CaF_2			10) SrI_2		
2) P_4O_{10}			11) CO		
3) K_2S			12) Cs_2Po		
4) NaH			13) $ZnAt_2$		
5) Al_2Se_3			14) P_2S_3		
6) N_2O			15) AgCl		
7) O_2F			16) Na_3N		
8) SBr_6			17) Mg_3P_2		
9) Li_2Te			18) XeF_6		

II. In the first column, write the chemical formula (formula unit) for the compound formed between the two given elements. In the second column, write the name for the compound:

	Elements	Formula	Name
1	magnesium and iodine		
2	potassium and sulfur		
3	chlorine and aluminum		
4	zinc and bromine		
5	strontium and oxygen		
6	calcium and nitrogen		
7	calcium and oxygen		
8	copper(I) and oxygen		
9	copper(II) and chlorine		
10	mercury(II) and oxygen		

Exercise 2 – Nomenclature – Including Some Ternary Nomenclature: Salts

I. Name the following substances:

Formula	Name	Formula	Name
1) $FeSO_3$		16) Fe_2O_3	
2) $Cu(NO_3)_2$		17) $(NH_4)_2SO_3$	
3) Hg_2Cl_2		18) $Ca(MnO_4)_2$	
4) AgBr		19) PF_5	
5) $KClO_3$		20) LiH	
6) $MgCO_3$		21) HIO_3	
7) BaO_2		22) $NaBrO_2$	
8) KO_2		23) $Ca_3(PO_4)_2$	
9) SnO_2		24) HIO_4	
10) $Ni_3(PO_4)_2$		25) $Fe(IO_2)_3$	
11) $Pb(OH)_2$		26) HAt*(aq)*	
12) $CuCH_3COO$		27) C_6H_5COOH	
13) N_2O_4		28) $Hg_2(IO)_2$	
14) Rb_3P		29) H_3PO_3	
15) S_8		30) NH_4BrO_3	

II. Write formulas for the following substances:

Name	Formula	Name	Formula
1) vanadium (V) oxide		16) francium dichromate	
2) dihydrogen monoxide		17) calcium carbide	
3) ammonium oxalate		18) mercury (I) nitrate	
4) polonium (VI) thiocyanate		19) cerium (IV) benzoate	
5) tetraphosphorus decoxide		20) potassium hydrogen phthlate	
6) zinc hydroxide		21) carbonic acid	
7) potassium cyanide		22) calcium hypochlorite	
8) cesium thiosulfate		23) hydrotelluric acid	
9) oxygen molecule		24) copper (II) nitrite	
10) mercury (II) acetate		25) nitrous acid	
11) silver chromate		26) hypoiodous acid	
12) tin (II) carbonate		27) cyanic acid	
13) sodium hydrogen carbonate		28) phthalic acid	
14) manganese (VII) oxide		29) tin(IV) chromate	
15) copper(II) dihydrogen phosphate		30) hydrocyanic acid	

Exercise 3 – Nomenclature – Some Ternary Nomenclature: Acids

-IC* from *–ATE ***-OUS* from *–ITE*** ***HYDRO-, -IC* from *-IDE***

Complete the Following Table:

Name of Acid	Formula of Acid	Name of Anion
***hydro*chlor*ic* acid**	***HCl***	**chlor*ide***
sulfur*ic* acid	***H2SO4***	**sulf*ate***
	HI	
		sulf*ite*
chlor*ous* acid		
		nitr*ate*
	HC2H3O2 or CH3COOH	
***hydro*brom*ic* acid**		
		sulf*ide*
	HNO2	
chrom*ic* acid		
		phosph*ate*

Part III: Mathematics

You should have a scientific (graphing) calculator for this class (one that does logs and exponential notation.) However, you will not be able to use that calculator on many problems for course exams and on the multiple choice part of the AP test. The purpose of this assignment is to make sure you can do basic math operations without your calculator. Read the attached math skills worksheet. Do the practice examples and worksheets. Throughout the course, every answer must be expressed as a proper decimal or in proper scientific notation. As AP students, you are expected to have certain math skills. You should also be able to do the practice exercises on these sheets with little or no hesitation.

Operations with numbers in scientific notation.

Multiplying: (needed for moles, wavelength / frequency / energy, much more)

step 1) multiply the coefficients (the leading number parts)
step 2) multiply the powers of 10. **Hint**: to do this add the exponents to get a new exponent
step 3) combine new coefficient and exponent and adjust the answer to proper scientific notation

Example: $(4 \times 10^{-2})(3 \times 10^{5})$

step 1) $4 \times 3 = 12$; step 2) $(10^{-2})(10^{5}) = 10^{-2+5} = 10^{3}$; step 3) $12 \times 10^{3} = 1.2 \times 10^{4}$

Dividing: (similar uses as multiplying)

step 1) divide the coefficients
step 2) divide the powers of 10. **Hint**: to do this subtract the exponents to get a new exponent
step 3) combine new coefficient and exponent and adjust the answer to proper scientific notation

Example: $= ?$
step 1) $= 0.333$; step 2) $= 10^{4-7} = 10^{-3}$; step 3) $0.333 \times 10^{-3} = 3.3 \times 10^{-4}$

Solve the following without using a calculator. Round to 1 digit (significant figure, or SF)

1) $6x10^{8} / 3x10^{10}$

2) $6x10^{8} \times 3x10^{10}$

3) $6x10^{-4} / 1.8x10^{-3}$

4) $1.8x10^{8} / 3x10^{10}$

5) $7x10^{8} / 6.3x10^{10}$

6) $4x10^{8} \times 5x10^{-6}$

7) $4x10^{-3} / 5x10^{-5}$

8) $6x10^{-7} \times 9x10^{4}$

9) $8x10^{5} / 2x10^{3}$

10) $3x10^{-5} / 8x10^{-2}$

11) $5x10^{-4} \times 6x10^{-3}$

12) $6x10^{25} / 5x10^{9}$

13) $7.2x10^{8} / 1.2x10^{-4}$

14) $8x10^{-3} / 9x10^{-10}$

15) $(9x10^{3})^{2}$

16) $4*(3x10^{6})^{2}$

17) $4*(2x10^{-3})^{3}$

18) $5*(4x10^{-7})^{3}$

Adding or subtracting in scientific notation: (for equilibrium problems, especially acid-base)

Note: numbers can only be added or subtracted in scientific notation if they **have the same exponent**! If they do not have the same exponent, one must be rewritten:

step 0) (if necessary) adjust the numbers so the exponents match
step 1) add or subtract the coefficients (sig figs are often important!)
step 2) keep the same exponent
step 3) combine new coefficient with exponent and adjust the answer to proper scientific notation

Example: $8.000 \times 10^5 - 3 \times 10^2$ ---> step 0) $8.000 \times 10^5 - 0.003 \times 10^5$

step 1) $8.000 - 0.003 = 7.997$; step 2) power of ten = 10^5; step 3) 7.997×10^5

Sig figs are very important in this operation. Rule reminder: your answer can only go as far in place value as the least precise of the numbers you are adding or subtracting (the one whose last digit is "furthest left" or "has the highest place value." Subtracting numbers of greatly different exponents is usually not significant:

Example: $6.00 \times 10^{-4} + 3 \times 10^{-7}$ ---> step 0) $6.00 \times 10^{-4} + 0.003 \times 10^{-4}$

step 1) $6.00 + 0.003 = 6.00$; step 2) power of ten = 10^{-4}; step 3) 6.00×10^{-4}
(place value only to the hundredths)

Solve the following without using a calculator. Answers are given to correct sig figs.

19) $2.00 - 3.00 \times 10^{-2}$

20) $2.00 - 9.00 \times 10^{-6}$

21) $6.00 \times 10^{-7} + 9.00 \times 10^{-6}$

22) $0.0100 - 2.00 \times 10^{-4}$

23) $3.00 \times 10^{-5} + 1.00 \times 10^{-7}$

24) $8.45 \times 10^{9} + 3.00 \times 10^{3}$

25) $4.5 \times 10^{-7} + 9.00 \times 10^{-8}$

26) $7.56 \times 10^{23} + 9.0 \times 10^{22}$

27) $6.0 \times 10^{-8} - 6 \times 10^{-10}$

28) $2.4 \times 10^{-5} + 1.0 \times 10^{-7}$

Estimating roots of numbers in scientific notation: (needed for equilibrium problems)

The root of a number in scientific notation is equal to the root of the coefficient times the root of the power of 10.

example: $\sqrt{(4 \times 10^{-10})} = (\sqrt{4}) \times (\sqrt{10^{-10}}) = 2 \times 10^{-5}$

The root of the power of 10 can be found easily only if the exponent is divisible evenly by the root being taken (in the example above, the exponent, (-10) was divisible by the root, which is 2 for "square root"). If the exponent is not evenly divisible (as in $\sqrt{4 \times 10^{-7}}$), the number is adjusted so the exponent is lower but now divisible by the root...

example: $\sqrt{(4 \times 10^{-7})} = \sqrt{(40 \times 10^{-8})} = (\sqrt{40}) \times (\sqrt{10^{-8}}) = 6.3 \times 10^{-4}$

You should be able to estimate the value of a square root to within a tenth or two... the value for $\sqrt{40}$ in this case must lie between 6 and 7 ($6^2 = 36$ and $7^2 = 49$), but somewhat closer to 6.

Cubed roots are treated similarly:

example: $\sqrt[3]{(4\times10^{-7})} = \sqrt[3]{(400\times10^{-9})} = (\sqrt[3]{400}) \times (\sqrt[3]{10^{-9}}) = 7.4\times10^{-3}$

Here the exponent is made divisible by the root, 3. $\sqrt[3]{400}$ is estimated as described above... it must lie between 7 and 8 ($7^3 = 343$ and $8^3 = 512$), but somewhat closer to 7. Obviously an estimate of a cubed root is a bit harder mathematically than that of a square root (the numbers can approach 1000 instead of just 100), but since an exact estimate is not critical, this is still very doable. Any guess between 7 and 8×10^{-3} is acceptable for this problem.

Practice: solve for x without a calculator (1SF)

29) $x^2 = 9\times10^{10}$

30) $x^3 = 8\times10^{-15}$

31) $x^2 = 5\times10^{-8}$

32) $x^2 = 6\times10^{5}$

33) $x^2 = 4\times10^{-15}$

34) $x^3 = 5\times10^{-10}$

35) $4x^3 = 1.08\times10^{-4}$

36) $2x^2 = 8\times10^{-9}$

37) $x^3 = 5\times10^{-11}$

38) $4x^3 = 3\times10^{-23}$

39) $3x^2 = 4\times10^{-15}$

Estimating with logs (use mainly for pH's).
You will only be expected to estimate with base 10 logs. Natural logs (ln) will also be used in this course, but they will generally not appear on the AP exam and you will not need to estimate their values. Since log functions are non-linear, you are primarily expected to recognize that a value lies within the proper order of magnitude (i.e., the pH is between 6 and 7, not between 7 and 8). However, within reason, you should also be able to distinguish between two possible choices that are in the same order, but only one of which makes sense (see below)

Number to log: finding logs or "log(x)" ([H⁺] to pH):
What is the pH of a solution with $[H^+]=4\times10^{-3}$ M? The pH is the negative log of $[H^+]$, in this case $-\log(4\times10^{-3})$. To find a pH, you just find the log of the number representing $[H^+]$, then take the opposite. Since 4×10^{-3} lies between 10^{-3} and 10^{-2}, the log is between -3 and -2 (meaning pH is between 3 and 2.) Note... since the log function is not linear, even though 4×10^{-3} is closer in value to 10^{-3}, the log is closer to -2 (actually equaling -2.4). However, if the concentration is 9×10^{-10}, since the value is very close to 10^{-9}, the log will be very close to -9 (actual log = -9.05)

Log to number: powers of 10 or "10^x" (pH to $[H^+]$):
What is the $[H^+]$= of a solution with pH = 8.5? The answer is $10^{-8.5}$ M, however this answer is not in acceptable form. Since $10^{-8.5}$ lies between 10^{-8} and 10^{-9}, it is bigger than 10^{-9}. The actual value is 3.2×10^{-9} Note... since the log function is not linear, even though 8.5 is half-way between 8 and 9, in scientific notation $10^{-8.5}$ is closer to 10^{-9}. A log of -7.1 (pH=7.1), however,

should obviously correspond to a number closer to 10^{-7} than 10^{-8} (actual number or $[H^+] = 7.9 \times 10^{-8}$).

Practice: Without using a calculator, circle the correct answer (check with a calculator)

What is the log of 9×10^{-4} M? -3.05, -3.95, -4.05, or -4.95

What number has log = 2.2? 9.3×10^{1}, 1.6×10^{2}, 9.3×10^{2}, or 1.6×10^{3}

What is the log of 2×10^{8} M 7.7, 8.3, 8.7, or 9.3

What number has log = -10.1? 7.9×10^{-9}, 2.1×10^{-10}, 7.9×10^{-10}, 2.1×10^{-11}, or 7.9×10^{-11}

What is the pH of a solution with $[H^+] = 7 \times 10^{-9}$ M? 8.2, 8.8, 9.2, or 9.8

What is the $[H^+]$= of a solution with pH = 2.9? 1.3×10^{-3}, 9.3×10^{-3}, 1.3×10^{-2}, or 9.3×10^{-2}

Estimate the following values. Answers below. Make up your own practice if you want!

a) log (8.7×10^{12} M)

b) log (1.4×10^{-5} M)

c) $10^{-6.9}$

d) $10^{4.8}$

Estimate the following values. Answers below.

e) pH = 3.4. What is $[H^+]$?

f) $[H^+] = 6.13 \times 10^{-6}$ M. What is the pH?

g) pH = 11.80. What is $[H^+]$?

h) $[H^+] = 0.5$ M. What is the pH?

Math Answers:

Answers: 1) $2x10^{-2}$ 2) $2x10^{19}$ 3) $3x10^{-1}$ 4) $6x10^{-3}$ 5) $1x10^{-2}$ 6) $2x10^{3}$ 7) $8x10^{1}$ 8) $5x10^{-2}$ 9) $4x10^{2}$ 10) $4x10^{-4}$ 11) $3x10^{-6}$ 12) $1x10^{16}$ 13) $6x10^{12}$ 14) $9x10^{6}$ 15) $8x10^{7}$ 16) $4x10^{13}$ 17) $3x10^{-8}$ 18) $3x10^{-19}$

Answers: 19) 1.97 20) 2.00 21) $9.60x10^{-6}$ 22) $9.8x10^{-3}$ 23) $3.01x10^{-5}$ 24) $8.45x10^{9}$ 25) $5.4x10^{-7}$ 26) $8.65x10^{23}$ 27) $5.9x10^{-8}$ 28) $2.4x10^{-5}$

Answers: 29) $3x10^{5}$ 30) $2x10^{-5}$ 31) $2x10^{-4}$ 32) $8x10^{2}$ 33) $6x10^{-8}$ 34) $8x10^{-4}$ 35) $3x10^{-2}$ 36) $6x10^{-5}$ 37)

a) 12.9 b) -4.9 c) $1.3x10^{-7}$ d) $6x10^{4}$ e) $4x10^{-4}$ M f) 5.2 g) $2x10^{-12}$ M h) 0.3

Visit https://www.khanacademy.org/science/ap-chemistry to review concepts outlined in this course.