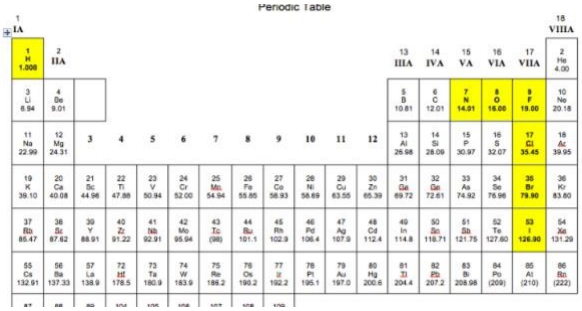
Names/Symbols of Common Elements & Their Phases

Al	aluminum
Ar	argon arsenic
As	barium
Ba	beryllium
Be	boron
B	bromine
Br	cadmium
Cd	calcium
Ca	carbon cesium
C	chlorine
Cs	chromium
Cl	cobalt
Cr	copper
Co	fluorine
Cu	francium
F	germanium
Fr	gold
Ge Au	helium
He	hydrogen
H	iodine iron
I	krypton
Fe	lead
Kr	lithium
Pb	
Li	

Mg	magnesium
Mn	manganese
Hg	mercury
Ne	neon
Ni	nickel
N	nitrogen
O	oxygen
P	phosphorous
Pt	platinum
Pu	plutonium
K	potassium
Ra	radium radon
Rn	rubidium
Rb	selenium
Se	silicon
Si	silver
Ag	sodium
Na	strontium
Sr	sulfur
S	thorium
Th	tin
Sn	uranium
U	xenon
Xe	zinc
Zn	

Phases of Matter:

- All metals are solid, except for mercury, which is a liquid.
- All metalloids are solids.
- Nonmetals: carbon, phosphorus, sulfur, & selenium are solids; bromine is a liquid; and the rest are gases.
- Diatomic elements: Br_2, I_2, N_2, Cl_2, O_2, F_2, H_2 (7-up rule) →
- Other elements with subscripts (they don't exist alone as single atoms): P_4, S_8



Common Monoatomic & Polyatomic Ions

Mastering 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, as part of your test. You will always be allowed a periodic table, which makes identifying the ions on the left "automatic." Tips on learning these ions follow.

From the Periodi	
Cations	**Ion 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	**Ion Name (-i**
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
Type II Cations	**Ion Name**
Fe^{2+}	Iron(II)
Fe^{3+}	Iron(III)
Cu^+	Copper(I)

Ions to Memorize	
Cations	**Name**
Ag^+	Silver
Zn^{2+}	Zinc
Hg_2^{2+}	Mercury(I)
Polyatomic Ions	**Name**
NH_4^+	Ammonium
NO_2^-	Nitrite
NO_3^-	Nitrate
SO_3^{2-}	Sulfite
SO_4^{2-}	Sulfate
OH^-	Hydroxide
CN^-	Cyanide
PO_4^{3-}	Phosphate
CO_3^{2-}	Carbonate
ClO^-	Hypochlorite
ClO_2^-	Chlorite
ClO_3^-	Chlorate
ClO_4^-	Perchlorate
$C_2H_3O_2^-$	Acetate
MnO_4^-	Permanganate
CrO_4^{2-}	Chromate
$Cr_2O_7^{2-}$	Dichromate
O_2^{2-}	Peroxide
$C_2O_4^{2-}$	Oxalate
NH_2^-	Amide

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

Tips for Learning the Mono/Polyatomics

"From the Periodic Table"

These ions can be organized into two groups:

1. **Main group (Group A) metals**: 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 (and satisfy the octet rule). Hopefully you recall this from first year chemistry, but if you are unsure what this means, get help or ask questions BEFORE the start of the year.
    a. All Group 1 Elements (alkali metals) lose 1 electron to form an ion with a 1+ charge
    b. All Group 2 Elements (alkaline earth metals) lose 2 electrons to form an ion with a 2+ charge
    c. Group 13 (or Group 3A) metals like aluminum lose 3 electrons to form an ion with a 3+ charge
    d. All Group 17 (Group 7A) elements (halogens) gain 1 electron to form an ion with a 1- charge
    e. All Group 16 (Group 6A) nonmetals gain 2 electrons to form an ion with a 2- charge
    f. All Group 15 (Group 5A) nonmetals gain 3 electrons to form an ion with a 3- charge

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

2. **Transition (Group B or Type II) metals**: These charges you cannot predict based on a pattern in the periodic table, so they must be memorized. Also, most can form <u>more than one</u> type of ion, so will have their positive charge denoted by a Roman numeral in parenthesis immediately next to the name of the element (eg. Iron (II) = Fe^{2+}). The possible charges of these Type II metals are noted in the "Type II Cations" section above.
    a. However, the charges of 3 monoatomic ions (or diatomic, for mercury) CAN be predicted—they have <u>only one possible charge</u>. These are: Ag^{+}, Zn^{2+}, and Hg_2^{2+}, in the rightmost table above.

Polyatomic Ions

Most of the needed memorization is with these ions, but there are some 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. Sulf**ate** is SO_4^{2-} so sulf**ite** has the same charge but one less oxygen (SO_3^{2-})
    b. Nitr**ate** is NO_3^{-}, so nitr**ite** has the same charge but one less oxygen (NO_3^{-})
2. There is a relationship between –ate/ –ite suffixes, and hypo- and per- prefixes.
    a. The prefix "hypo" means "under" or "too little" (think "hypodermic" or "hypothermia")
        i. Hypochlorite is "under" chlorite, meaning it has <u>one less oxygen</u>
    b. The prefix "hyper" means "above" or "too much" (think "hyperactive" or "hypertension")
        i. The prefix "per" comes from "hyper" so perchlorate has <u>one more oxygen</u> than chlorate.
    c. Notice how this sequence increases in oxygen while retaining the same charge:

ClO^-	ClO_2^-	ClO_3^-	ClO_4^-
hypochlorite	**chlorite**	**chlorate**	**perchlorate**

Naming Molecules & Compounds

Hopefully this is review for you. Make sure you can name a molecule based on its formula, and write its formula based on its name. This is covered in section 2.8 of the Zumdahl text. Know all 3 types of naming for inorganic compounds:

1. Type I—Ionic bonding, with main group elements
2. Type II—Ionic bonding, with transition elements
3. Type III—Covalent bonding, with nonmetals only

Metric Prefixes

(All you need to know for AP Chem—there are more!)

Prefix	Symbol	Numerical	Exponential
kilo	k	1,000	10^3
no prefix (base unit):		1	10^0
deci	d	0.1	10^{-1}
centi	c	0.01	10^{-2}
milli	m	0.001	10^{-3}
micro	[?]	0.000001	10^{-6}
nano	n	0.000000001	10^{-9}

Basic Solubility Rules

Knowledge of the solubility rules is necessary to predict whether a precipitate will form in double replacement reactions. The basic rules, along with their exceptions, can be summarized as follows:

Rule	Exceptions
All compounds of alkali metals (Group 1) and ammonium (NH_4^+) are soluble.	None
All nitrates (NO_3^-), chlorates (ClO_3^-), perchlorates (ClO_4^-), and acetates (CH_3COO^- or $C_2H_3O_2^-$) are soluble.	None
Chloride (Cl^-), bromide (Br^-), and iodide (I^-) salts are soluble.	Salts of Ag^+, Pb^{2+}, and Hg_2^{2+}
Sulfate (SO_4^{2-}) compounds are soluble.	Salts of Ba^{2+}, Sr^{2+}, Ca^{2+}, Pb^{2+}, Hg_2^{2+}
Hydroxides (OH^-) and sulfides (S^{2-}) are insoluble.	Salts of NH_4, alkali metals, and Ba^{2+}, Ca^{2+}, and Sr^{2+}
All sulfites ($SO_3^=$), carbonates (CO_3^{2-}), chromates (CrO_4^{2-}), and phosphates (PO_4^{3-}) are insoluble.	Salts of NH_4^+ and alkali metals

Common Fractions → Decimals

No calculators are allowed on the multiple-choice part of the AP Chem Exam, and you should not use any time fully working out long division problems. Therefore, knowing the decimal equivalent of these fractions will let you more quickly choose the correct answer based on estimates:

Fraction	Decimal	Fraction	Decimal
1/2	0.500	3/5	0.600
1/3	0.333	4/5	0.800
2/3	0.667	1/6	0.167
1/4	0.250	5/6	0.833
3/4	0.750	1/8	0.125
1/5	0.200	3/8	0.375
2/5	0.400	5/8	0.625
7/8	0.875	7/8	0.875

Significant Figure Rules

Here are the basic rules for what digits in a number are considered significant, and how to keep the proper sig figs in your answer after doing calculations—if you need more guidance here, YouTube videos are your friend.

1. Non-zero digits are always significant. Eg. **322**
2. Zeroes between non-zeroes are significant. Eg. 3**0**2
3. Zeroes at the beginning of a number are not significant—they are placeholder zeroes. Eg. 0.032
4. Final zeroes at the end of a number are significant IF there is a decimal point. Eg. 32**0**. (320 zero is not)

Addition/subtraction rule: Round answer so it has the same number of digits <u>after</u> the decimal as there are in the number with the <u>least</u> sig figs after the decimal. Eg. 35.48 + 2.4 = 37.88 → round to 37.9 (1 sig fig <u>after</u>)

Multiplication/division rules: Round answer so it has the same number of <u>total</u> sig figs as there are in the number with the least <u>total</u> sig figs. Eg. 4.82 x 2.318 = 11.17276 → round to 11.2 (3 <u>total</u> sig figs)

Practice Problems

I. Significant Figures and Metric Conversions

1. Round each of the following numbers to four significant figures. Write the answer in decimal form AND scientific notation.
    a. 300.235800
    b. 456,500
    c. 0.006543210
    d. 0.000957830
    e. – 0.035000

2. Carry out the following operations, and provide answers with the correct number of sig figs:
    a. 1.24056 + 75.80
    b. 23/67 - 75
    c. 890,000 x 112.3
    d. 78,132 / 2.50

3. Perform the following conversions. Solve each problem using dimensional analysis, SHOWING YOUR WORK! Every number must have a unit and be expressed with proper significant figures.
    a. Convert 50.0 m to mm
    b. Convert 25 cm to km
    c. Convert 400 mm to m
    d. Convert 60 kg to mg
    e. Convert 500 nm to km
    f. The average speed of helium at 25□C is 1255 m/s. Convert this speed to miles per hour (mph).

4. If a megabuck is one million dollars, and a kilobuck is one thousand dollars, how many kilobucks is 342 dollars?

5. Normally the human body can endure a temperature of 105□F for only short periods of time without permanent damage to the brain or other vital organs. What is this temperature in □C?

6. The temperature on the surface of the sun is about 6300□C. What is this temperature in degrees Fahrenheit?

II. Mental Math

7. You need practice doing mental math/paper and pencil math for the AP exam, as no calculators are allowed on the multiple-choice section. **Please do not use a calculator to do these!!** a. $1.62 \times 10^6 + 1.9 \times 10^5$
    b. $1.62 \times 10^6 - 1.9 \times 10^5$
    c. $3.72 \times 10^{-8} + 0.211 \times 10^{-7}$
    d. $3.72 \times 10^{-8} - 0.211 \times 10^{-7}$
    e. $(2.3 \times 10^4)(3.1 \times 10^4)$
    f. square root of 9.0×10^{-8}
    g. cube root of 8.0×10^{-9}
    h. (0.001)(0.001)
    i. 3.42/342

III. Structure of the Atom & Periodic Table

8. Fill in the following table, assuming each column represents a <u>neutral atom</u>:

Symbol (nuclear notation)	$_{19}^{39}K$				
Protons	19	25			82
Neutrons	20	30	64		
Electrons			48	56	
Mass #				137	207

9. Describe the contributions of the following scientists to our knowledge of atomic structure:
   a. J.J. Thomson

   b. R.A. Millikan

   c. Ernest Rutherford

   d. James Chadwick

   e. Erwin Schrödinger

10. Describe where the following element groups are located on the periodic table, and give 2 element examples:
    a. Alkaline earth metals
    b. Halogens
    c. Alkali metals
    d. Noble gases
    e. Metalloids

IV. Naming Inorganic Compounds

11. Write the formula of the common ion derived from each of the following atoms:
    a. Li d. N g. Mg
    b. S e. Al h. Xe
    c. I f. Cs

12. Give the name for each of the following ionic compounds:

a. AlF_3
b. $Fe(OH)_2$
c. $Cu(NO_3)_2$
d. $Ba(ClO_4)_2$
e. Li_3PO_4
f. Hg_2S
g. $Ca(C_2H_3O_2)_2$
h. $(NH_4)_2SO_4$

13. Write the chemical formula for each of the following compounds:

a. copper (I) oxide
b. potassium peroxide
c. aluminum hydroxide
d. zinc nitrate
e. mercury (I) bromide
f. iron (III) carbonate

14. Fill in the blanks in the following table:

Cation	**Anion**	**Formula**	**Name**
			Magnesium bicarbonate
		$SrCl_2$	
Fe^{3+}	NO_2^-		
			Manganese (II) chlorate
		$SnBr_4$	
Co^{2+}	PO_4^{3-}		
Hg_2^{2+}	I^-		
		$CuCO_3$	
			Lithium nitride
Al^{3+}	S^{2-}		

15. Give the name or chemical formula, as appropriate, for each of the following acids:

a. $HBrO_3$
b. HBr
c. H_3PO_4
d. hypochlorous acid
e. iodic acid
f. sulfurous acid

16. Give the name or chemical formula, as appropriate, for each of the following molecular substances:

a. dinitrogen tetroxide
b. SF_6
c. IF_5
d. XeO_3
e. hydrogen cyanide
f. tetraphosphorous hexasulfide

17. Give the name or chemical formula, as appropriate, for the following (types of naming are mixed up here! Make sure you can determine how to name each when the type is not specifi):

a. sodium hypochlorite
d. Iron(III) oxide

b. $Cr_2(CO_3)_3$
c. CO
e. nitrogen dioxide
f. K_2CrO_4

V. Molecular Masses

18. Determine the molar mass of each of the following compounds. For extra math practice, don't use a calculator—remember you can't use one on the multiple-choice section of the exam.
    a. N_2O_5
    b. $FeCO_3$
    c. disilicon hexabromide

19. Calculate the percentage by mass of <u>oxygen</u> in the following compounds.
    a. NO_2
    b. $Cr(NO_3)_3$
    c. H_2CO_3

20. The empirical formula of a compound is CH. If the molar mass of this compound is about 78 g, what is the molecular formula?

21. Find the empirical formulas of the compounds with the following compositions:
    a. 40.1% C, 6.6% H, 53.3% O

    b. 18.4% C, 21.5% N, 60.1% K

VI. Balancing Equations

22. Balance the following equations:
    a. $NaH_2PO_4 \rightarrow NaPO_3 + H_2O$
    b. $Ca(OH)_2 + CO_2 \rightarrow Ca(HCO_3)_2$
    c. $SrBr_2 + (NH_4)_2CO_3 \rightarrow SrCO_3 + NH_4Br$
    d. $Mn_2O_3 + Al \rightarrow Al_2O_3 + Mn$
    e. $S + N_2O \rightarrow SO_2 + N_2$
    f. $N_2 + H_2 \rightarrow NH_3$

g. $AgNO_3 + FeCl_3 \rightarrow Fe(NO_3)_3 + AgCl$

h. $Fe_2(SO_4)_3 + KOH \rightarrow K_2SO_4 + Fe(OH)_3$

i. $Al_2(SO_4)_3 + KOH \rightarrow Al(OH)_3 + K_2SO_4$

j. $C_7H_{16} + O_2 \rightarrow CO_2 + H_2O$

VII. Stoichiometry

Show your work, and box/circle in your final answer please. Keep in mind that your first step with stoichiometry is always to make sure your equation is balanced (if there is an equation)!! (See 3.10 in Zumdahl)

23. How many molecules of ethane (C_2H_6) are present in 0.334 g of ethane?

24. How many moles of cobalt (Co) atoms are there in 6.00×10^9 cobalt atoms?

25. How many moles of calcium (Ca) atoms are in 77.4 g of calcium?

26. How many atoms are present in 3.14 g of copper (Cu)?

27. How many moles of oxygen are necessary to react completely with four moles of propane (C_3H_8)?

$C_3H_8 + O_2 \rightarrow CO_2 + H_2O$

28. The fermentation of glucose, $C_6H_{12}O_6$, produces ethyl alcohol, C_2H_5OH, and CO_2 as shown here:

$C_6H_{12}O_6\,(aq) \rightarrow 2\,C_2H_5OH(aq) + 2\,CO_2\,(g)$

a. How many moles of CO_2 are produced when 0.300 mol of $C_6H_{12}O_6$ fully reacts?

b. How many grams of $C_6H_{12}O_6$ are needed to form 2.00 g of C_2H_5OH?

c. How many molecules of CO_2 form when 2.00 g of C_2H_5OH are produced?

29. How many grams of $Al(OH)_3$ (molar mass = 78.0 g/mol) can be produced from the reaction of 48.6 mL of .15 M KOH with excess $Al_2(SO_4)_3$?

$$Al_2(SO_4)_3 + 6KOH \rightarrow 2Al(OH)_3 + 3K_2SO_4$$

30. Nitrogen gas and hydrogen gas react to produce ammonia (NH_3).
    a. What volume of hydrogen gas is necessary to react completely with 5 L of nitrogen gas to produce ammonia at STP? (Hint: What is the conversion factor for moles to L of a gas at STP?)
    b. What volume (in L) of ammonia is produced in this reaction?

31. If 20 L of oxygen are consumed in this reaction, how many liters of carbon dioxide are produced?

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$$

32. How many grams of silver chloride are produced from 5.0 g of barium chloride reacting with an excess of silver nitrate?

$$AgNO_3 + BaCl_2 \rightarrow AgCl + Ba(NO_3)_2$$

VIII. Limiting Reactants

Show your work, and box/circle your final answer please. Again, remember to make sure you have a balanced equation first!

33. The fizz produced when an Alka-Seltzer tablet is dissolved in water is due to the reaction between sodium bicarbonate, $NaHCO_3$, and citric acid, $H_3C_6H_5O_7$:

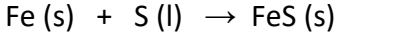
$$3\ NaHCO_3\ (aq) + H_3C_6H_5O_7\ (aq) \rightarrow 3\ CO_2\ (g) + 3\ H_2O(l) + Na_3C_6H_5O_7\ (aq)$$

In an experiment, 2.50 g of sodium bicarbonate and 5.00 g of citric acid are allowed to react.

    a. Which reactant is the limiting reactant? You must show work to support your answer.
    b. How many grams of carbon dioxide are formed? How many liters is this if we assume STP conditions?

c. How much of the limiting reactant is left when the reaction is complete?
d. How much of the excess reactant remains after the reaction is complete?

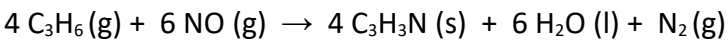
34. At high temperatures, sulfur combines with iron to form the brown-black iron (II) sulfide. In an experiment, 7.62 g of Fe are allowed to react with 8.67 g of S.



$$Fe\,(s) + S\,(l) \rightarrow FeS\,(s)$$

a. What is the limiting reagent, and what is the reactant in excess?
b. Calculate the mass of FeS formed.

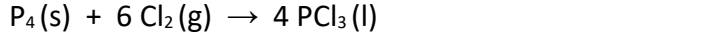
35. Acrylonitrile, C_3H_3N, is the starting material for the production of a kind of synthetic fiber acrylics) and can be made from propylene, C_3H_6 by a reaction with nitric oxide, NO, as follows:



$$4\,C_3H_6\,(g) + 6\,NO\,(g) \rightarrow 4\,C_3H_3N\,(s) + 6\,H_2O\,(l) + N_2\,(g)$$

What mass of C_3H_3N can be made when 21.6 g of C_3H_6 react with 21.6 g of nitric oxide?

36. Calculate the percent yield for the reaction below, if 75.0 g of phosphorus reacts with excess chlorine gas to produce 111.0 g of phosphorus trichloride. (See page 121 in Zumdahl if you need assistance with percent yield.)



$$P_4\,(s) + 6\,Cl_2\,(g) \rightarrow 4\,PCl_3\,(l)$$

IX. Solutions, Replacement Reactions, & Solubility

37. Calculate the molarity of each of the following solutions:
    a. 29.0 g of ethanol (C_2H_5OH) in 545 mL of solution
    b. 15.4 g of sucrose ($C_{12}H_{22}O_{11}$) in 74.0 mL of solution
    c. 9.00 g of sodium chloride (NaCl) in 86.4 mL of solution

38. Predict the outcomes of the single replacement reactions below by using the activity series (you'll have to look up the activity series online). Then balance the equations.
    a. Cu (s) + HCl (aq) →
    b. I_2 (s) + NaBr (aq)→
    c. Mg (s) + $CuSO_4$ (aq) →
    d. Cl_2 (g) + KBr (aq)→

39. Characterize the following compounds as soluble or insoluble in water:

a. $Ca_3(PO_4)_2$	d. K_2S	g. $Hg(NO_3)_2$
b. $Mn(OH)_2$	e. $CaCO_3$	h. $HgSO_4$
c. $AgClO_3$	f. $ZnSO_4$	i. NH_4ClO_4

40. Write the net ionic equations for the following reactions:
    a. $AgNO_3$ (aq) + Na_2SO_4 (aq) →
    b. $BaCl_2$ (aq) + $ZnSO_4$ (aq) →
    c. $(NH_4)_2CO_3$ (aq) + $CaCl_2$ (aq) →