

AP Required Memorization – Charges of Ions

POSITIVE IONS: - periodic table connections

+1		+2		+3		+4		+5	
Group 1		Group 2		Group 13		Group 14		Group 15	
Alkali		Alkaline Earth		Boron		Carbon		Nitrogen	
Li ⁺¹	Lithium	Be ⁺²	Beryllium	Al ⁺³	Aluminum	Si ⁺⁴	Silicon(IV)	As ⁺⁵	Arsenic (V)
Na ⁺¹	Sodium	Mg ⁺²	Magnesium	Ga ⁺³	Gallium	Ge ⁺⁴	Germanium(IV)	Bi ⁺⁵	Bismuth(V)
K ⁺¹	Potassium	Ca ⁺²	Calcium						
Rb ⁺¹	Rubidium	Sr ⁺²	Strontium						
Cs ⁺¹	Cesium	Ba ⁺²	Barium						
Fr ⁺¹	Francium	Ra ⁺²	Radium						

NEGATIVE IONS: - periodic table connections

-4		-3		-2		-1	
Group 14		Group 15		Group 16		Group 17	
Carbon		Nitrogen		Oxygen		Halogens	
C ⁻⁴	Carbide	N ⁻³	Nitride	O ⁻²	Oxide	F ⁻¹	Fluoride
		P ⁻³	Phosphide	S ⁻²	Sulfide	Cl ⁻¹	Chloride
				Se ⁻²	Selenide	Br ⁻¹	Bromide
						I ⁻¹	Iodide

VARIABLE CHARGES/TRANSITION METALS:

Hydrogen	+1 or -1	Chromium (II) or (III)	+2 or +3
Iron (II) or (III)	+2 or +3	NO ROMAN NUMERALS	
Copper (I) or (II)	+1 or +2	Silver	+1
Mercury (I) or (II)	+1 or +2	Zinc	+2
Tin (II) or (IV)	+2 or +4	Cadmium	+2
Lead (II) or (IV)	+2 or +4	Nickel	+2
Cobalt (II) or (IV)	+2 or +4		
Manganese (II) or (IV)	+2 or +4		

POLYATOMICS IONS

+1

ammonium	NH ₄ ⁺¹
hydronium	H ₃ O ⁺¹

-1

Acetate	C ₂ H ₃ O ₂ ⁻¹	Hydroxide	OH ⁻¹
CH ₃ COO ⁻¹		Nitrate	NO ₃ ⁻¹
Azide	N ₃ ⁻¹	Nitrite	NO ₂ ⁻¹
Bromate	BrO ₃ ⁻¹	Perchlorate	ClO ₄ ⁻¹
Cyanide	CN ⁻¹	Chlorate	ClO ₃ ⁻¹
Dihydrogen phosphate	H ₂ PO ₄ ⁻¹	Chlorite	ClO ₂ ⁻¹
Bicarbonate or	HCO ₃ ⁻¹	Hypochlorite	ClO ⁻¹
Hydrogen carbonate		Iodate	IO ₃ ⁻¹
Bisulfate or	HSO ₄ ⁻¹	Permanganate	MnO ₄ ⁻¹
Hydrogen sulfate		Thiocyanate	SCN ⁻¹

-2

Carbonate	CO_3^{-2}	Oxalate	$\text{C}_2\text{O}_4^{-2}$
Chromate	CrO_4^{-2}	Silicate	SiO_3^{-2}
Dichromate	$\text{Cr}_2\text{O}_7^{-2}$	Tetraborate	$\text{B}_4\text{O}_7^{-2}$
Hydrogen phosphate	HPO_4^{-2}	Peroxide	O_2^{-2}
Sulfate	SO_4^{-2}	Selenate	SeO_4^{-2}
Sulfite	SO_3^{-2}	Tartrate	$\text{C}_4\text{H}_4\text{O}_6^{-2}$
Thiosulfate	$\text{S}_2\text{O}_3^{-2}$		

-3

Phosphate	PO_4^{-3}
Phosphite	PO_3^{-3}
Arsenate	AsO_4^{-3}
Borate	BO_3^{-3}

*Reminder NH_3 = ammonia

Prefixes for naming molecular (covalent) compounds – Greek

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

Elements that exist as diatomic molecules

Br	I	N	Cl	H	O	F	
INC	Br_2	I_2	N_2	Cl_2	H_2	O_2	F_2
HO	Other weirdos	P_4 and S_8					

Naming Acids

Binary acids – named after anion

Hydro-(element)-ic acid Ex. HBr **hydrobromic acid**

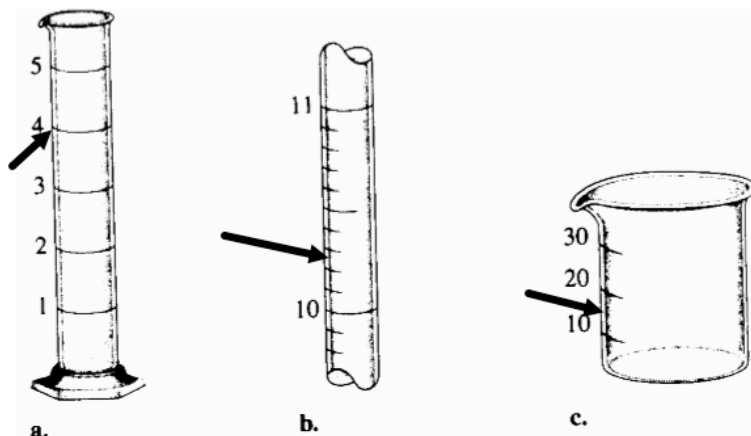
Oxyacids – named after polyatomic anion, no hydro prefix

-ate becomes -ic acid Ex. H_3PO_4 **phosphoric acid**
-ite becomes -ous acid Ex. H_2SO_3 **sulfurous acid**

Practice Problems

CHAPTER 1

1. For each of the following pieces of glassware, provide a sample measurement at arrow and discuss the number of significant figures and uncertainty.



2. A student performed an analysis of a sample for its calcium content and got the following results: 14.92%, 14.91%, 14.88%, and 14.91%. The actual amount of calcium in the sample is 15.70%. What conclusion can you draw about the accuracy and precision of these results?
3. Calculate the percent error for the following measurements.
- The density of an aluminum block determined in an experiment was 2.64 g/cm³. (Accepted value = 2.70 g/cm³)
 - The experimental determination of iron in ore was 16.48%. (Accepted value was 16.12%)
4. How many significant figures are in each of the following?
- | | |
|----------------------------|---------------------------|
| a. 12 | f. 0.0000101 |
| b. 1098 | g. 1000. |
| c. 2001 | h. 22.04030 |
| d. 2.001 x 10 ³ | i. 1.00 x 10 ³ |
| e. 100 | |
5. Round each of the following numbers to two significant figures, and write the answers in scientific notation.
- | | |
|---------------|---------------|
| a. 0.00031254 | c. 35,900 |
| b. 31,254,000 | d. 0.00000399 |
6. Use scientific notation to express the number 480 to
- One significant figure
 - Two significant figures
 - Three significant figures
7. Perform the following mathematical operations, and express each result to the correct number of significant figures.
- 97.381 + 4.2502 + 0.99195
 - 171.5 + 72.915 - 8.23
 - $\frac{0.102 \times 0.0821 \times 273.5}{1.2}$
 - $(9.04 - 8.23 + 21.954 + 81.0) / 3.1416$

8. Precious metals and gems are measured in troy weights in the English system:
 24 grains = 1 pennyweight (EXACT)
 20 pennyweights = 1 troy ounce (EXACT)
 12 troy ounces = 1 troy pound (EXACT)
 1 grain = 0.0648 gram
 1 carat = 0.200 gram
- Diamonds are measured in carats. If a lucky girl receives a 5 carat diamond how many pennyweights is it?
 - What is the mass of 2.3 troy ounces of gold in grams?
 - The density of gold is 19.3 g/cm^3 . What is the volume of a troy pound of gold?
9. Apothecaries (druggists) use the following set of measures:
 20 grains ap = 1 scruple (EXACT)
 3 scruples = 1 dram ap (EXACT)
 8 dram ap = 1 oz. ap (EXACT)
 1 dram ap = 3.888 g
- An aspirin table contains $5.00 \times 10^2 \text{ mg}$ of active ingredient. How many grains ap of active ingredient does it contain?
 - From (a) how many scruples?
 - What is the mass of 1.00 scruple in grams?
10. The world record for the hundred meter dash is 9.79 s. What is the corresponding speed in units of m/s, km/hr, ft/s, and mi/hr?
- At this speed how long would it take to run a mile (5,820 ft)?
11. You're planning to buy a new car. One model that you're considering gets 32 miles per gallon of gasoline in highway travel. The one that your spouse likes gets 14 kilometers to the liter. Which car has the better gas mileage? (1 gal = 4 qt., 1.057 qt = 1 L)
12. You pass a road sign saying "New York – 112 km." If you drive at a constant speed of 65 mi/hr., how long should it take you to reach New York?
- If your car gets 28 miles to the gallon, how many liters of gasoline are necessary to travel 112 km?
13. You have a 1.0 cm^3 sample of lead and a 1.0 cm^3 sample of glass. You drop each in separate beakers of water. How do the volumes of water displaced by each sample compare? Explain.
 Density of lead = 11.35 g/cm^3
 Density of glass = 3.00 g/cm^3
14. A person has a temperature of 102.5 F. What is this temperature on the Celsius scale?
- On the Kelvin scale?
15. Convert the following Celsius temperatures to Kelvin and to Fahrenheit degrees.
- The boiling-point temperature of ethyl alcohol, 78.1 C
 - A cold winter day, -25 C
 - The lowest possible temperature, -273 C
 - The melting-point temperature of sodium chloride, 801 C
16. The density of diamond is 3.51 g/cm^3 . What is the volume of a 4.5 carat diamond? 1 carat = 0.200 g
17. The volume of a diamond is found to be 2.8 mL. What is the mass of the diamond in carats? (See question #16)
18. A sample containing 33.42 g of metal pellets is poured into a graduated cylinder initially containing 12.7 mL of water, causing the water level in the cylinder to rise to 21.6 mL. Calculate the density of the metal.

19. Two spherical objects have the same mass. One floats on water; the other sinks. Which object has the greater diameter? Explain your answer.
20. What are some of the differences between a solid, a liquid, and a gas?
21. What is the difference between homogeneous and heterogeneous matter?
22. Classify each of the following as homogeneous or heterogeneous.
- soil
 - the atmosphere
 - a carbonated soft drink
 - gasoline
 - gold
 - a solution of ethanol and water
23. Classify each of the following as a mixture or a pure substance. Of the pure substances, which are elements and which are compounds?
- | | |
|---------------|----------------------|
| a. Water | f. Uranium |
| b. Blood | g. Wine |
| c. The oceans | h. Leather |
| d. Iron | i. Table salt (NaCl) |
| e. Brass | |
24. Distinguish between physical and chemical changes.
25. List four indications that a chemical change (reaction) has occurred.
26. If you place a glass rod over a burning candle, the glass appears to turn black. What is happening to each of the following (physical change, chemical change, both, or neither) as the candle burns? Explain each answer
- the wax
 - the wick
 - the glass rod
27. The properties of a mixture are typically averages of the properties of its components. The properties of a compound may differ dramatically from the properties of the elements that combine to produce the compound. For each process described below, state whether the material being discussed is most likely a mixture or a compound, and state whether the process is a chemical change or a physical change.
- An orange liquid is distilled, resulting in the collection of a yellow liquid and a red solid.
 - A colorless, crystalline solid is decomposed, yielding a pale yellow-green gas and a soft, shiny metal.
 - A cup of tea becomes sweeter as sugar is added to it.

CHAPTER 2

- Describe Dalton's atomic theory.
- What discoveries were made by J.J. Thomson, Henri Becquerel, and Lord Rutherford? How did Dalton's model of the atom have to be modified to account for these discoveries?
- What is the distinction between atomic number and mass number?
- What is the difference between atomic mass and average atomic mass?
- What is an isotope?

6. How many protons and neutrons are contained in the nucleus of each of the following atoms?
- | | |
|----------------------------|----------------------------|
| a. ${}_{22}\text{Ti}^{42}$ | d. ${}_{36}\text{Kr}^{86}$ |
| b. ${}_{30}\text{Zn}^{64}$ | e. ${}_{33}\text{As}^{75}$ |
| c. ${}_{32}\text{Ge}^{76}$ | f. ${}_{19}\text{K}^{41}$ |
7. Write the isotopic symbol for each of the isotopes below.
- Atomic number = 8, number of neutrons = 9
 - The isotope of chlorine in which mass = 37
 - Atomic number = 27, mass = 60
 - Number of protons = 26, number of neutrons = 31
 - The isotope of I with a mass number of 131
 - Atomic number = 3, number of neutrons = 4
8. The element copper has naturally occurring isotopes with mass number of 63 and 65. The relative abundance of the isotopes are 69.2% for mass = 62.93 amu, and 30.8% for mass = 64.93 amu. Calculate the average atomic mass of copper.
9. An element consists of 1.40% of an isotope with mass 203.973 amu, 24.10% of an isotope with mass 205.9745 amu, 22.10% of an isotope with mass 206.9759 amu, and 52.40% of an isotope with mass 207.9766 amu. Calculate the average atomic mass and identify the element.
10. Distinguish between the terms *family* and *period* in connection to the periodic table. For which of these terms is the term *group* also used?
11. In the periodic table, what is the name of the following groups
- Group (2)
 - Group (18)
12. An ion contains 50 protons, 68 neutrons, and 48 electrons. What is its symbol and charge?
13. Which of the following sets of elements are all in the same group in the periodic table?
- | | |
|--------------|-----------|
| a. N, P, O | c. Rb, Sn |
| b. C, Si, Ge | d. Mg, Ca |
14. Identify each of the following elements:
- A member of the same family as oxygen whose most stable ion contains 54 electrons
 - A member of the alkali metal family whose most stable ion contains 36 electrons
 - A noble gas with 18 protons in the nucleus
 - A halogen with 85 protons and 85 electrons
15. Would you expect each of the following atoms to gain or lose electrons when forming ions? What ion is the most likely in each case?
- | | | |
|-------|-------|-------|
| a. Na | d. Ba | g. Al |
| b. Sr | e. I | h. S |
| c. P | f. O | |
16. For each of the following ions, indicate the total number of protons and electrons in the ion. For the positive ions, predict the formula of the simplest compound formed between itself and oxide. For the negative ions predict the simplest compound formed between itself and aluminum.
- | | | |
|---------------------|---------------------|---------------------|
| a. Fe^{+2} | d. Cs^{+1} | g. Br^{-1} |
| b. Fe^{+3} | e. S^{-2} | h. N^{-3} |
| c. Ba^{+2} | f. P^{-3} | |
17. An element's most stable ion forms an ionic compound with bromine, having the formula XBr_2 . If the ion of element X has a mass number of 230 and 86 electrons, what is the identity of the element, and how many neutrons does it have?

Writing Formulas and Naming Compounds – Do WITHOUT an ion chart! You need to have these memorized.

1. Name each of the following compounds:

- | | | |
|----------------------------|---------------------------------|--------------------------------------|
| a. NaCl | h. AlI_3 | o. BaSO_3 |
| b. Rb_2O | i. Al_2O_3 | p. KMnO_4 |
| c. FeBr_3 | j. ZnCl_2 | q. Sr_3P_2 |
| d. Cr_2O_3 | k. Li_3N | r. $\text{Ca}_3(\text{PO}_4)_2$ |
| e. CaBr_2 | l. Ag_2S | s. $\text{Pb}(\text{NO}_3)_2$ |
| f. CsF | m. KClO_4 | t. NaNO_2 |
| g. CaS | n. $\text{Al}_2(\text{SO}_4)_3$ | u. $\text{K}_2\text{Cr}_2\text{O}_7$ |

2. Name each of the following compounds:

- | | | |
|-------------------|---------------------------|---------------------------|
| a. NI_3 | d. ICl_3 | g. P_2S_5 |
| b. PCl_3 | e. SF_2 | h. N_2O_4 |
| c. SO_2 | f. N_2F_4 | |

3. Name each of the following compounds:

- | | |
|----------------------------|----------------------------|
| a. HCl | d. HNO_2 |
| b. H_3PO_4 | e. HI |
| c. HIO_3 | f. H_2SO_3 |

4. Name each of the following compounds:

- | | | |
|--------------------------------------|---------------------------------|---------------------------------|
| a. HgO | j. ICl | s. NH_4NO_3 |
| b. CuI | k. $\text{Pb}_3(\text{PO}_4)_2$ | t. H_2SO_4 |
| c. CuI_2 | l. KIO_3 | u. Sr_3N_2 |
| d. CoI_2 | m. $\text{Ca}(\text{OH})_2$ | v. $\text{Al}_2(\text{SO}_3)_3$ |
| e. Na_2CO_3 | n. CoS | w. SnO_2 |
| f. NaHCO_3 | o. S_3N_4 | x. Na_2CrO_4 |
| g. $\text{HC}_2\text{H}_3\text{O}_2$ | p. SF_6 | y. HClO |
| h. NH_4NO_2 | q. NaClO | z. NO |
| i. Co_2S_3 | r. BaCrO_4 | |

5. Write the formula for each of the following compounds:

- | | |
|--------------------------------|------------------------------|
| a. Cesium bromide | k. Silicon tetrachloride |
| b. Barium sulfate | l. Lithium nitride |
| c. Chlorine trifluoride | m. Chromium (III) carbonate |
| d. Ammonium chloride | n. Tin (II) fluoride |
| e. Beryllium oxide | o. Ammonium acetate |
| f. Chlorine monoxide | p. Ammonium hydrogen sulfate |
| g. Magnesium fluoride | q. Cobalt (III) nitrate |
| h. Sulfur difluoride | r. Copper (I) sulfide |
| i. Sulfur hexafluoride | s. Potassium chlorate |
| j. Sodium dihydrogen phosphate | t. Lithium tartrate |

6. Write the formula for each of the following compounds:

- | | |
|--------------------------|--------------------------------|
| a. Sodium oxide | j. Zinc sulfide |
| b. Sodium peroxide | k. Ammonium hydrogen phosphate |
| c. Potassium cyanide | l. Hydrobromic acid |
| d. Copper (II) nitrate | m. Bromous acid |
| e. Silicon tetrafluoride | n. Perchloric acid |
| f. Lead (II) sulfide | o. Silicon dioxide |
| g. Lead (IV) sulfide | p. Sodium sulfate |
| h. Copper (I) chloride | q. Aluminum hydrogen sulfate |
| i. Cadmium selenide | |

CHAPTER 3 – Stoichiometry

1. Balance the following equations:

- $\text{CO} + \text{O}_2 \rightarrow \text{CO}_2$
- $\text{N}_2\text{O}_5 + \text{H}_2\text{O} \rightarrow \text{HNO}_3$
- $\text{PCl}_5 + \text{H}_2\text{O} \rightarrow \text{H}_3\text{PO}_4 + \text{HCl}$
- $\text{CH}_4 + \text{Br}_2 \rightarrow \text{CBr}_4 + \text{HBr}$
- $\text{C}_5\text{H}_{10}\text{O}_2 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$
- $\text{Cr}(\text{OH})_3 + \text{HClO}_4 \rightarrow \text{Cr}(\text{ClO}_4)_3 + \text{H}_2\text{O}$
- $\text{KNO}_3 \rightarrow \text{KNO}_2 + \text{O}_2$
- $\text{La}_2\text{O}_3 + \text{H}_2\text{O} \rightarrow \text{La}(\text{OH})_3$
- $\text{NCl}_3 + \text{H}_2\text{O} \rightarrow \text{NH}_3 + \text{HOCl}$
- $\text{Mg}_3\text{N}_2 + \text{HCl} \rightarrow \text{MgCl}_2 + \text{NH}_4\text{Cl}$
- $\text{AgNO}_3 + \text{K}_2\text{SO}_4 \rightarrow \text{Ag}_2\text{SO}_4 + \text{KNO}_3$
- $\text{Al}(\text{OH})_3 + \text{H}_2\text{SO}_4 \rightarrow \text{Al}_2(\text{SO}_4)_3 + \text{H}_2\text{O}$
- $\text{CH}_3\text{NH}_2 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} + \text{N}_2$
- $(\text{NH}_4)_2\text{Cr}_2\text{O}_7 \rightarrow \text{Cr}_2\text{O}_3 + \text{N}_2 + \text{H}_2\text{O}$

2. Write balanced chemical equations to correspond to each of the following descriptions.

- When solid potassium chlorate is heated it decomposes to form solid potassium chloride and oxygen.
- Solid zinc metal reacts with sulfuric acid to form hydrogen gas and an aqueous solution of zinc sulfate.
- When liquid phosphorous trichloride is added to water, it reacts to form aqueous phosphorous acid, and hydrochloric acid.
- When hydrogen sulfide gas is passed over solid hot iron (III) hydroxide, the resultant reaction produces solid iron (III) sulfide and water vapor.

3. The molecular formula of aspartame, the artificial sweetener marketed as Nutrasweet, is $\text{C}_{14}\text{H}_{18}\text{N}_2\text{O}_5$.

- What is the molar mass of aspartame?
- How many moles of aspartame are present in 3769.4 grams of aspartame?
- How many molecules of aspartame are present in 345.9 grams of aspartame?
- How many oxygen atoms are present in 23.6 grams of aspartame?

4. How many moles of ammonium ions are in 0.557 g of ammonium carbonate?

5. What is the mass, in grams, of 0.0438 moles of iron (III) phosphate?

6. What is the mass, in grams, of 2.69×10^{23} molecules of aspirin, $\text{C}_9\text{H}_8\text{O}_4$?

7. What is the molar mass of diazepam (Valium) if 0.05570 mol has a mass of 15.86 g?

8. Determine the empirical formulas of the following compounds.

- 10.4 % C, 27.8 % S, and 61.7% Cl
- Monosodium glutamate (MSG), a flavor enhancer in certain foods, 35.51 g C, 4.77 g H, 37.85 g O, 8.29 g N, 13.60 g Na

9. Find the molecular formulas of the following compounds.

- 73.8% carbon, 8.7% hydrogen, 17.5% nitrogen, molar mass = 166.0 g/mol
- 80.0% carbon, 20.0% hydrogen, molar mass = 30.0 g/mol

10. $4 \text{FeCr}_2\text{O}_7 + 8 \text{K}_2\text{CO}_3 + \text{O}_2 \rightarrow 2 \text{Fe}_2\text{O}_3 + 8 \text{K}_2\text{CrO}_4 + 8 \text{CO}_2$

- How many grams of FeCr_2O_7 are required to produce 44.0 g of CO_2 ?
- How many grams of O_2 are required to produce 100.0 g of Fe_2O_3 ?
- If 300.0 g of FeCr_2O_7 react, how many grams of O_2 will be consumed?
- How many grams of Fe_2O_3 will be produced from 300.0 g of FeCr_2O_7 ?
- How many grams of K_2CrO_4 are formed per gram of K_2CO_3 used?