HANDOUT SET

GENERAL CHEMISTRY I

Periodic Table of the Elements

	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIIIB	10	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	1 **H** 1.00794																	2 **He** 4.00262
2	3 **Li** 6.941	4 **Be** 9.0122											5 **B** 10.811	6 **C** 12.011	7 **N** 14.0067	8 **O** 15.9994	9 **F** 18.9984	10 **Ne** 20.179
3	11 **Na** 22.9898	12 **Mg** 24.305											13 **Al** 26.98154	14 **Si** 28.0855	15 **P** 30.97376	16 **S** 32.066	17 **Cl** 35.453	18 **Ar** 39.948
4	19 **K** 39.0983	20 **Ca** 40.078	21 **Sc** 44.9559	22 **Ti** 47.88	23 **V** 50.9415	24 **Cr** 51.9961	25 **Mn** 54.9380	26 **Fe** 55.847	27 **Co** 58.9332	28 **Ni** 58.69	29 **Cu** 63.546	30 **Zn** 65.39	31 **Ga** 69.723	32 **Ge** 72.59	33 **As** 74.9216	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.80
5	37 **Rb** 85.4678	38 **Sr** 87.62	39 **Y** 88.9059	40 **Zr** 91.224	41 **Nb** 92.9064	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.9055	46 **Pd** 106.42	47 **Ag** 107.8682	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.710	51 **Sb** 121.75	52 **Te** 127.60	53 **I** 126.9045	54 **Xe** 131.29
6	55 **Cs** 132.9054	56 **Ba** 137.34	57 **La*** 138.91	72 **Hf** 178.49	73 **Ta** 180.9479	74 **W** 183.85	75 **Re** 186.207	76 **Os** 190.2	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.9665	80 **Hg** 200.59	81 **Tl** 204.383	82 **Pb** 207.2	83 **Bi** 208.9804	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
7	87 **Fr** (223)	88 **Ra** 226.0254	89 **Ac**** 227.0278	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (264)	108 **Hs** (265)	109 **Mt** (266)	110 (270)	111 (272)	112 *** (277)						

*Lanthanides	58 **Ce** 140.12	59 **Pr** 140.9077	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.925	66 **Dy** 162.50	67 **Ho** 164.930	68 **Er** 167.26	69 **Tm** 168.9342	70 **Yb** 173.04	71 **Lu** 174.967

**Actinides	90 **Th** 232.038	91 **Pa** 231.0659	92 **U** 238.0289	93 **Np** 237.0482	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)

Mass numbers in parenthesis are the mass numbers of the most stable isotopes. As of 1997 elements 110-112 have not been named.

***Peter Armbruster and Sigurd Hofman synthesized a single atom at the Heavy-Ion Research Center in Darmstadt, Germany in 1996. The atom survived for 280 μs after which it decayed to element 110 by loss of an α-particle

Chapter 3

Chemical Compounds
and
Formula Stoichiometry

CHEMICAL COMPOUNDS

CHAPTER 3

INTRODUCTION Chemical formulas are important because they provide us much information about the chemical compound. For example, the chemical formula can be used to identify the compound by name, calculate the molar mass and percentage composition of the compound, and mass and mole relationships of the various atoms in the compound. We learned in the laboratory how to name compounds and, in lecture, many features of the periodic table. Additionally, this chapter introduced the differences between ionic and molecular compounds.

GOALS

1. Many features of the periodic table have by now been introduced. These are important in the overall understanding of elements and molecules.
2. It is important to understand the difference between ionic and molecular compounds. As well, it is important to understand the differences between the different forms of that the "formula" can take (molecular, empirical, and structural).
3. Calculations involving the mole in regards to compounds is vital for future chapters. Percentage composition is important both experimentally (to determine the chemical formula) and theoretically.
4. The basics of nomenclature have been covered in lab. Oxidation states of simple monatomic ions is simply the ionic charge. More on oxidation states will be covered as we proceed through the book. For now, simply understanding **Section *3-5*** and **Example 3-7** will suffice.

DEFINITIONS

You should have a working knowledge of at least these terms and any others used in lecture.

Group
Family
Period
Long period
Short period
Metal
Nonmetal
Metalloid
Semiconductor
Semimetal
Element
Atom
Compound
Molecule
Anion
Cation
Binary compound
Ionic compound
Molecular compound
Molecular mass
Molar mass
Percentage composition
Law of Multiple Proportions
Empirical formula
Molecular formula
Structural formula
Oxidation state
Oxidation number
Salt
Acid
Hydrate

Formula Stoichiometry: Percentage Composition

1. What is the percent composition of CO_2?

2. What is the % composition of $(NH_4)_3PO_4$ (149.09 g/mol)?

3. By some means the percentage composition of a compound containing only Ti and O was determined to be 40.06% O and 59.94% Ti. What is the empirical formula of this compound?

4. The percent composition of an ionic compound containing only Na, S, and O is 32.37% Na and 22.57% S. What is the empirical formula of the compound?

5. A compound containing only carbon, hydrogen, an oxygen was analyzed and found to be 40.00%C and 53.28%O. The molar mass of the compound was independently determined to be 180.2 g/mol. What is the molecular formula of the compound?

An Example of Percentage Composition

Hydrated sodium stannate has the percentage composition of 44.50% Sn, 17.24% Na, 35.99% O, and 2.27% H. Determine what the correct formula is for hydrated sodium stannate. The correct order of elements is

$$Na_aSn_bO_c \bullet d\ H_2O$$

Experimental Determination of a Chemical Formula

To experimentally determine the formula of the compound formed from the reaction of magnesium and bromine, a student added 1.174 g of magnesium to a solution of hexane containing 1.142 g of bromine, Br_2. The bromine solution turned completely colorless but some magnesium metal remained. The magnesium metal was collected by filtration, washed, and dried. The mass of magnesium remaining was 1.001 g. From these data, calculate the experimentally determined formula for the magnesium-bromine compound.

Percentages in Calculations

1. When 0.100 g of magnesium reacts in air, 0.266 g of magnesium oxide is formed. What is the percentage by mass of the magnesium and oxygen in magnesium oxide?

2. The three naturally occurring isotopes of potassium are $^{39}_{19}\mathrm{K}$ (38.963707 u, 93.2581%), $^{40}_{19}\mathrm{K}$ (39.963999 u), and $^{41}_{19}\mathrm{K}$ (6.7302%) as measured in a mass spectrometer. What is the isotopic mass of $^{41}_{19}\mathrm{K}$?

3. Determine the mass percentage of water in $CuSO_4 \cdot 5\ H_2O$ (copper(II) sulfate pentahydrate).

4. Calcite, which gets its name from "*chalix*" the Greek word for lime, is one of the most common minerals on the face of the Earth, comprising about 4% by weight of the Earth's crust and is formed in many different geological environments. The formula for this ubiquitous and interesting mineral is $CaCO_3$. Calcium carbonate becomes marble from the heat and pressure of metamorphic events. What number of $^{13}_{6}C$ (1.108% abundance) atoms is present in 250.0 g of calcite?

5. Your instructor uses a “Triple-15” fertilizer. This designation represents a fertilizer that contains 15% each of nitrogen (N), P_2O_5, and K_2O. What mass of potassium is delivered to the soil when 15 lb of fertilizer are distributed?

6. Glucose contains only carbon, hydrogen, and oxygen. It has a percentage composition of 40.00% C and 6.71% H. The molecular mass as determined by mass spectrometric analysis is 180.2 u. What is the empirical and molecular formula for glucose?

Mass, Moles, and Percentages in Calculations

1. Ibuprofen, the pain-relief medication in, for example, Advil™ contains only carbon, hydrogen, and oxygen. During combustion analysis, 21.74 mg of pure ibuprofen produced 60.29 mg CO_2 and 17.09 mg H_2O. What is the empirical formula of ibuprofen?

2. Ibuprofen is an acidic compound containing a single carboxylic acid group (-COOH). Carboxylic acids react with bases in the same way that all acids react with bases. When 55.6 mg of ibuprofen is dissolved in water, 5.34 mL of 0.0505 M NaOH is required to completely neutralize the solution. What is the molar mass of the compound? Based upon the results of question 1, what is the molecular formula of ibuprofen?