Chem 1A Name:_____
Chapter 2 Exercises

Dalton's Atomic Theory:

(1) Matter is composed of very small units called ***atoms***. Atom is the smallest unit that possesses the chemical property of an element.
(2) An element contains only one type of atom; the masses of atoms from the same element are identical.
(3) Atoms of one element are different in properties from those of all other elements.
(4) A compound is formed when atoms of two or more elements combine in a small, whole-number ratio. A given compound always contains the same type of elements and their atoms are present in the same ratio.
(5) Atoms are neither created nor destroyed during a chemical reaction; chemical reactions only rearrange the way atoms are bound together in order to produce a new substance.

Exercise-1:

1. (a) Which of the above statements explains the *Law of Conservation of Mass*?

   (b) Which of the above statements explains the *Law of Constant Composition*?

   (c) Which *law* did Dalton propose?

2. (a) What is the *Law of Conservation of Mass?*

   (b) What is the *Law of Constant Composition*?

3. Show that the results of the following experiments illustrate the *law of conservation of mass*.

   Experiment #1: A 5.00-g sample of pure calcium carbonate is heated and the sample decomposes to produce 2.80 g calcium oxide and 2.20 g carbon dioxide.

   Experiment #2: 1.00 g of pure calcium oxide is reacted with 2.00 g carbon dioxide, which produces 1.78 g calcium carbonate and 1.22 g of carbon dioxide was unreacted.

   Experiment #3: When 2.0 g of sodium hydroxide reacts with 2.2 g carbon dioxide, 4.2 g of baking soda (sodium bicarbonate) is produced.

4. 5.00 g of copper is reacted with 5.00 g of sulfur in a crucible. A copper-sulfur compound is formed, and the mass of the compound in 6.26 g. If all of the copper were reacted, how many grams of sulfur are in the compound? How many gram of sulfur did not react with copper?

5. Three samples of pure sodium carbonate from different sources were analyzed for the elemental compositions, and the following results were obtained.
   Sample-1: 1.95 g Sodium, 0.51 g Carbon, and 2.04 g Oxygen.
   Sample-2: 1.52 g Sodium, 0.40 g Carbon, and 1.58 g Oxygen.
   Sample-3: 1.30 g Sodium, 0.34 g Carbon, and 1.36 g Oxygen.

   Show that, within experimental errors, the results illustrate the *Law of Constant Composition*.

6. Three samples, X, Y, and Z, were analyzed for their elemental compositions and the following results were obtained:
   Sample X: 1.00 g Calcium, 0.30 g Carbon, and 1.20 g Oxygen;
   Sample Y: 1.41 g Calcium, 0.84 g Carbon, and 2.25 g Oxygen;
   Sample Z: 1.60 g Calcium, 0.48 g Carbon, and 1.92 g Oxygen.

   Determine whether X, Y, and Z are samples of the same compound or samples of different compounds.

7. State the *law of multiple proportions* and explain what it means.

8. Three (different) compounds composed of only nitrogen and oxygen were analyzed and the masses of oxygen that combine with 1.000 g of nitrogen are shown below:

	Mass of Oxygen
Compound-A	0.571 g
Compound-B	1.144 g
Compound-C	2.286 g

   (a) Show that this data is consistent with the law of *multiple proportions*.

   (b) If the formula of compound-B is NO, what are the formulas of compounds A and C?

9. Chromium reacts with oxygen to form three different compounds, X, Y and Z. It was found that, for every gram of chromium in Compounds X, Y and Z, there were 0.308 g, 0.462 g and 0.924 g of oxygen, respectively.
   (a) Show that the above data illustrate Dalton's *Law of Multiple Proportions*.
   (b) Using these data, derive simple formula of compounds X, Y and Z.

Chem 1A Name:_____

Chapter 2 Exercises

Exercises #2:

1. List the fundamental characteristics of cathode-rays that were observed by J.J. Thomson.

2. Describe briefly J.J. Thomson's "plum-pudding" model and Rutherford's nuclear model for atoms.

3. Robert Millikan performed the "oil-drop" experiments that alloed him to determine the electric charges on oil-droplets. The following data were obtained on 6 oil drops were analyzed and the following charges were measured:

Oil drop #:	1	2	3	4	5	6
Charge (C x 10^{19} C):	6.4	8.0	9.6	14.4	19.2	25.6

If each oil droplet traps whole numbers of electrons, determine the charge of an electron. (Find the largest common denominator.)

4. The number of which sub-atomic particles determines the identity of the atom?

5. In a neutral atom, which two sub-atomic particles must always be equal in numbers? Where in the atom are these two particles found?

6. The number of which sub-atomic particles distinguishes the different isotopes of an element?

7. What information is provided by the letters *A*, *X* and *Z* in the isotope symbol ${}^{A}_{Z}X$?

8. Write the symbols of isotopes that contain the following:

   (a) 10 protons, 10 neutrons, and 10 electrons.

   (b) 12 protons, 13 neutrons, and 10 electrons.

   (c) 15 protons, 16 neutrons, and 15 electrons.

   (d) 17 protons, 18 neutrons, and 18 electrons.

   (e) 24 protons, 28 neutrons, and 21 electrons.

9. Indicate the number of protons, neutrons, and electrons in each isotope with the following symbols.

   (a) ${}^{60}_{28}Ni$:

   (b) ${}^{239}_{94}Pu^{4+}$:

   (c) ${}^{79}_{34}Se^{2-}$:

Chem 1A Name:_____
Chapter 2 Exercises

Exercises #3:

1. Write formulas for the following compounds or polyatomic ions:

(a) Nitrate ion:_____: (b) Aluminum nitrate:_____

(c) Carbonate ion:_____; (d) Magnesium carbonate: _____

(e) Calcium Sulfate:_____; (f) Hydrogen phosphate ion:_____

(g) Acetate ion:_____; (h) Lead(II) acetate: _____

(*i*) Mercury(I) nitrate:_____: (j) Sodium hydrogen carbonate: _____

2. Name the following compounds or give the name of each polyatomic ion in this list:

(a) Al_2O_3:_____; (b) CrO_4^{2-} :_____

(c) Cu_2S:_____; (d) KH_2PO_4:_____;

(e) N_2O_5:_____; (f) $Cr_2O_7^{2-}$:_____;

(g) SiF_6:_____; (h) ClO_4^-: _____

(*i*) $KClO_3$:_____; (j) HNO_3:_____

(*k*) H_3PO_4:_____; (*l*) $HC_2H_3O_2$:_____

(m) $HCN_{(aq)}$: _____; (n) MnO_4^-:_____

3. Write the formula of the following compounds:

(a) Perchloric acid: _____; (b) Hydrosulfuric acid: _____

(c) Hydrobromic acid: _____; (d) Bromous acid:_____

(e) Sulfuric acid: _____; (f) Acetic acid:_____

(g) Dinitrogen tetroxide:_____; (h) Phosphorus pentachloride:_____

(*i*) Nickel(II) nitrate:_____; (j) Cobalt(II) chloride hexahydrate:_____:

(k) Titanium(IV) oxide:_____; (*l*) Iron(III) sulfate pentahydrate: _____;

4. Combine the following pairs of ions to form the correct formulas of the compounds and give their names.

Cations	Anions	Compound's Formula	Compound's Name
Ag^{+}	Br^{-}	_____	_____
Al^{3+}	SO_4^{2-}	_____	_____
Ba^{2+}	OH^{-}	_____	_____
Ca^{2+}	ClO^{-}	_____	_____
Cr^{3+}	NO_3^{-}	_____	_____
Cu^{+}	S^{2-}	_____	_____
Fe^{3+}	O^{2-}	_____	_____
Hg_2^{2+}	Cl^{-}	_____	_____
K^{+}	MnO_4^{-}	_____	_____
Li^{+}	CO_3^{2-}	_____	_____
Mg^{2+}	N^{3-}	_____	_____
Na^{+}	HPO_4^{2-}	_____	_____
Na^{+}	$Cr_2O_7^{2-}$	_____	_____
NH_4^{+}	PO_4^{3-}	_____	_____
Pb^{2+}	$C_2H_3O_2^{-}$	_____	_____
Zn^{2+}	O^{2-}	_____	_____
K^{+}	$C_2O_4^{2-}$	_____	_____

Answers:

Exercise #1:

1. (a) statement #5; (b) Statement #4; (c) The *Law of Multiple Proportions*
2. (a) In a chemical reaction, the total mass of substances before and after reaction remains constant;

   (b) A given compound always contains the same type of elements combined is a fixed ratio of their masses.
3. #1: 5.00 g = 2.80 g + 2.20 g;
   #2: 1.00 g + 2.00 g = 1.78 g + 1.22 g;
   #3: 2.0 g NaOH + 2.0 g CO_2 = 4.2 g $NaHCO_3$
   (In each experiment, the total mass of substances is conserved during reaction.)
4. Mass of product = **6.26** g; mass of sulfur reacts with copper = **1.26** g; mass of sulfur does not react with copper = **3.74** g.
5. Sample-1: Na = 43.3%; C = 11.4%; O = 45.3%;
   Sample-2: Na = 43.4%; C = 11.5%; O = 45.1%;
   Sample-3: Na = 43.3%; C = 11.4%; O = 45.3%.
   1, 2 and 3 are samples of the same compound.
6. Sample-X: Ca = 40.0%; C = 12.0%; O = 48.0%
   Sample-Y: Ca = 31.3%; C = 18.7%; O = 50.0%;
   Sampale-Z: Ca = 40.0%; C = 12.0%; O = 48.0%

   X and Z are same compound, but Y is a different compound.
7. If two elements form more than one compounds, and if we fix the mass of one of the elements in all the compounds, the masses of the second element in all the compounds show simple whole number ratio, such as 1:2, 1:3, 2:3, 3:4, 3:5, etc.
8. Determine the ratios of masses of oxygen in A, B and C, which yields 1:2:4. Simple ratios illustrate the *Law of Multiple Proportion*.
   (b) Formula: if B = NO, then A = N_2O, and C = NO_2.
9. (a) To determine whether the data illustrate the *Law of Multiple Proportions*, determine the ratio of the masses of oxygen that combine with a fixed mass of chromium, which yields the following ratios:

   $\frac{\text{Mass of O in Y}}{\text{Mass of O in X}}$ = 0.462/0.308 = 1.5:1 or 3:2; $\frac{\text{Mass of O in Z}}{\text{Mass of O in X}}$ = 0.924/0.308 = 3:1;

   $\frac{\text{Mass of O in Z}}{\text{Mass of O in Y}}$ = 0.924/0.462 = 2:1

   Masses of oxygen in X, Y and Z that combined with a fixed mass of chromium show simple ratios. Therefore, data illustrates *Law of Multiple Proportions*.
   (b) If we assume X, which contains the least oxygen to have the formula CrO, then compounds Y and Z would be Cr_2O_3 and CrO_3, respectively. (Dalton assumed that the compound with the lowest mass combination to have an atomic number ratio of 1:1)

Chem 1A Name:_____

Chapter 2 Exercises

Exercise #2:

1. (read lecture note)
2. (read lecture note)
3. Find a common denominator that represents the charge of one electron, which is 1.6×10^{-19} C.
4. A neutral atom contains same number of protons & electrons - protons in nucleus and electron outside.
5. The number of proton, called the "atomic number" (Z), represents the identity of the element.
6. Different isotopes of a given element have different number of neutrons in the atoms.
7. A = # of protons + # of neutron; Z = # of protons. (# of neutrons = A – Z)
8. (a) $^{20}_{10}Ne$ (b) $^{25}_{12}Mg$ (c) $^{31}_{15}P$ (d) $^{35}_{17}Cl^{-}$ (e) $^{52}_{24}Cr^{3+}$
9. (a) 28 p, 32 n, and 28 e; (b) 94 p, 145 n, and 90 e; (c) 34 p, 45 n, and 36 e.

Exercise #3

1. (a) NO_3^- (b) $Al(NO_3)_3$ (c) CO_3^{2-} (d) $MgCO_3$ (e) $CaSO_4$
   (f) HPO_4^{2-} (g) $C_2H_3O_2^-$ (h) $Pb(C_2H_5O_2)_2$ (*i*) Hg_2Cl_2 (j) $NaHCO_3$

2. (a) Aluminum oxide (b) Chromate ion (c) Copper(I) sulfide
   (d) Potassium dihydrogen phosphate (e) dinitrogen pentoxide (f) Dichromate ion
   (g) Sulfur hexafluoride (h) Perchlorate ion (*i*) Potassium chlorate
   (j) Nitric acid (k) Phosphoric acid (*l*) Acetic acid
   (m) Hydrocyanic acid (n) Permanganate ion

3. (a) $HClO_4$ (b) H_2S (c) HBr (d) $HBrO_2$ (e) H_2SO_4 (f) $HC_2H_3O_2$
   (g) N_2O_4 (h) PCl_5 (*i*) $Ni(OH)_2$ (j) $CoCl_2 \cdot 6H_2O$ (k) TiO_2 (*l*) $Fe_2(SO_4)_3 \cdot 5H_2O$

4. AgBr = Silver bromide
   $Ba(OH)_2$ = barium hydroxide
   $Cr(NO_3)_3$ = Chromium(III) nitrate
   Fe_2O_3 = Iron(III) oxide
   $KMnO_4$ = Potassium permanganate
   Mg_3N_2 = Magnesium nitride
   $Na_2Cr_2O_7$ = Sodium dichromate
   $Pb(C_2H_3O_2)_2$ = lead(II) acetate
   $K_2C_2O_4$ = Zinc oxalate
   $Al_2(SO_4)_3$ = Aluminum sulfate
   $Ca(ClO)_2$ = calcium hypochlorite
   Cu_2S = Copper(I) sulfide
   Hg_2Cl_2 = Mercury(I) chloride
   Li_2CO_3 = Lithium carbonate
   NaH_2PO_4 = Sodium dihydrogen phosphate
   $(NH_4)_3PO_4$ = Ammonium phosphate
   ZnO = Zinc oxide
