AP Chemistry **Name:**

Ch.2 – The Nuclear Atom **Date:** **Period:**

ALL of the answers to this worksheet can be **logically** figured out by looking at the **schematic diagrams for various atoms, the Periodic Table,** and **discussing** with your classmates. All of the information you need is here somewhere. Determine each answer and be able to give convincing reasons for each answer. Good luck.

1. How many **protons** are found in ^{12}C?_____ ^{13}C?_____ $^{13}C^{-1}$?_____

2. How many **neutrons** are found in ^{12}C?_____ ^{13}C?_____ $^{13}C^{-1}$?_____

3. How many **electrons** are found in ^{12}C?_____ ^{13}C?_____ $^{13}C^{-1}$?_____

4. Based on the model,
   a) what do all carbon atoms (and ions) have in common?

   b) what do all hydrogen atoms (and ions) have in common?

5. What is the significance of the atomic number, Z, above each atomic symbol in the periodic chart?

6. What do all nickel (Ni) atoms have in common?

7. How is the mass number, A, (left-hand superscript next to the atomic symbol) determined?

8. What structural feature is different in isotopes of a particular element?

9. a) What feature distinguishes a neutral atom from an ion?

   b) How is the charge on an ion determined?

10. Where is most of the mass of an atom, within the nucleus or outside of the nucleus? Explain your reasoning.

11. Complete the following table:

Isotope	Atomic Number Z	Mass Number A	Number of electrons
^{31}P	15		
^{18}O			8
	19	39	18
$^{58}Ni^{2+}$		58	

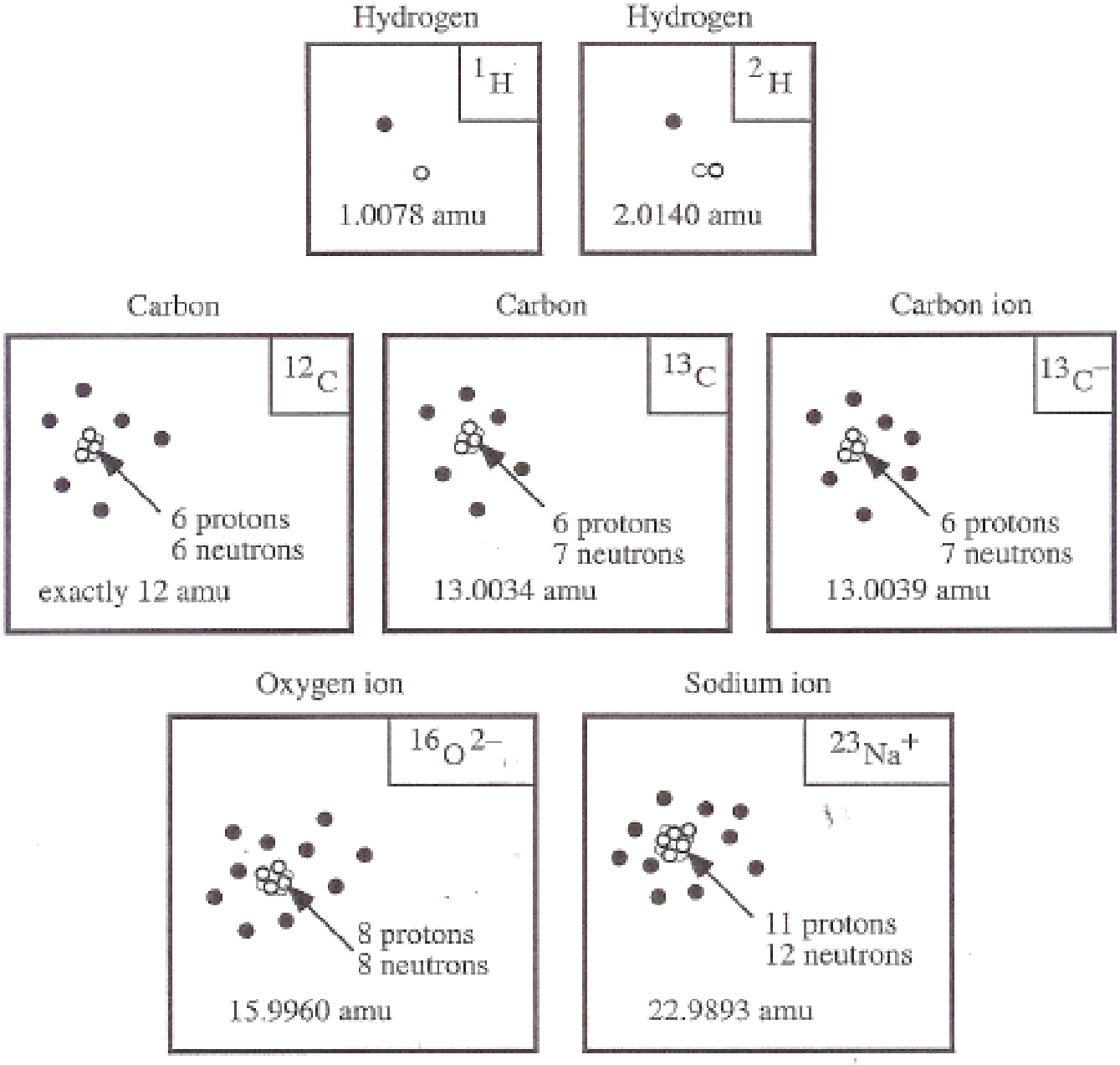
The Nuclear Atom

(What Is an Atom?)

Model: Schematic Diagrams for Various Atoms.

- ● electron (–)
- ○ proton (+)
- ○ neutron (no charge)

$1 \text{ amu} = 1.6606 \times 10^{-24} \text{ g}$



^{1}H and ^{2}H are <u>isotopes</u> of hydrogen.

^{12}C and ^{13}C are <u>isotopes</u> of carbon.

The <u>nucleus</u> of an atom contains the protons and the neutrons.

Ch.2 – Isotopes

Answer the following questions on a separate piece of paper. Show your work when necessary.

1. Give the mass number of each of the following atoms:

(a) an iron atom with 30 neutrons _____

(b) an americium atom with 148 neutrons _____

(c) a tungsten atom with 110 neutrons _____

2. Give the complete symbol (${}^{A}_{Z}X$) for each of the following atoms:

(a) nitrogen with 8 neutrons _____

(b) zinc with 34 neutrons _____

(c) xenon with 75 neutrons _____

3. How many electrons, protons, and neutrons are there in an atom of:

(a) carbon-13, ${}^{13}C$ _____

(b) copper-63, ${}^{63}Cu$ _____

(c) bismuth-205, ${}^{205}Bi$ _____

4. Fill in the blanks in the table (one column per element).

Symbol	${}^{65}Cu$	${}^{86}Kr$		
Number of protons			78	
Number of neutrons			117	46
Number of electrons in the neutral atom				36
Name of element				

5. Radioactive americium-241 is used in household smoke detectors and in bone mineral analysis. Give the number of electrons, protons, and neutrons in an atom of americium-241.

6. Circle the following symbols that are isotopes of element X, (atomic # = 9) 9: ${}^{19}_{9}X$, ${}^{20}_{9}X$, ${}^{9}_{18}X$, and ${}^{21}_{9}X$.

7. Verify through calculation, that the atomic mass of magnesium is 24.31 amu, given the following information:

${}^{24}Mg$, mass = 23.985042 amu; percent abundance = 78.99%

${}^{25}Mg$, mass = 24.985837 amu; percent abundance = 10.00%

${}^{26}Mg$, mass = 25.982593 amu; percent abundance = 11.01%

8. Copper has two stable isotopes, ${}^{63}Cu$ and ${}^{65}Cu$, with masses of 62.939598 amu and 64.927793 amu, respectively. Calculate the percent abundances of these isotopes of copper.

9. Strontium has four stable isotopes. Strontium-84 has a very low natural abundance but ${}^{86}Sr$, ${}^{87}Sr$, and ${}^{88}Sr$ are all reasonably abundant. Which of these more abundant isotopes predominates? Explain.

Ch.2 – Study Questions

"The one quality which sets one man apart from another — the key which lifts one to every aspiration while others are caught up in the mire of mediocrity — is not talent, formal education, nor brightness — it is self-discipline. With self-discipline, all things are possible. Without it, even the simplest goal can seem like the impossible dream."
Theodore Roosevelt (1858-1919)

1. Explain, at an atomic or molecular level, what happens when
   a) water freezes to form ice

   b) copper and tin combine to form bronze

   c) rainwater evaporates from the pavement

2. Which of the following atoms are isotopes of the same element? Identify the elements of these isotopes and describe the number of protons and neutrons in the nucleus of them all.

$^{15}_{7}X$ $^{12}_{6}X$ $^{13}_{7}X$ $^{18}_{8}X$ $^{14}_{7}X$ $^{14}_{6}X$ $^{16}_{8}X$ $^{13}_{6}X$ $^{17}_{8}X$

3. There are three naturally occurring isotopes of neon:

neon-20	mass 19.9924 amu	abundance 90.84%
neon-21	mass 20.9940 amu	abundance 0.260%
neon-22	mass 21.9914 amu	abundance 8.90%

   a) Without calculation, what is the approximate atomic mass of neon?

   b) Calculate the actual atomic mass.

4. Uranium has an atomic mass equal to 238.0289. It consists of two isotopes: uranium-235 with an isotopic mass of 235.044 amu and uranium-238 with an isotopic mass of 238.051. Calculate the % abundance of the uranium-235 isotope.

5. Identify the alkali metal, the alkaline earth metal, the transition metal, the actinide, the halogen, the noble gas, and the chalcogen (Group 6A) from the following elements: sodium, chlorine, nickel, argon, calcium, uranium, and oxygen.

6. Reorder this list to match the name of the scientist with his or her contribution to our understanding of the nature of matter:

A.	J.J. Thompson	_____developed the idea of the atomic nature of matter
B.	James Chadwick	_____ established the law of conservation of matter
C.	Robert Millikan	_____ characterized positive and negative electrical charges
D.	Henry Moseley	_____ suggested that atoms could disintegrate
E.	Michael Faraday	_____ experimented with electrolysis
F.	Dmitri Mendeleev	_____ proved the existence of the electron
G.	John Dalton	_____ developed the idea of a nuclear atom
H.	Henri Becquerel	_____ discovered the neutron
I.	Democritus	_____ developed the first periodic table of elements
J.	Joseph Proust	_____ showed that periodicity depended upon atomic number
K.	Antoine Lavoisier	_____ formulated the laws of constant composition
L.	Ernest Rutherford	_____ determined the charge on a single electron
M.	Marie Curie	_____ revived the atomic theory
N.	Benjamin Franklin	_____ discovered radioactivity

7. Identify the following elements:

A. The most abundant metal in the earth's crust _____

B. Combined with chlorine, it produces a compound essential to life. _____

C. The transition element at the center of hemoglobin. _____

D. Used in smoke detectors and named for the United States. _____

E. A component of washing powder mined in Death Valley. _____

F. The basis for the compounds that make up all living things. _____

G. Primary constituent of pencil lead. _____

H. The last element in the Periodic Table that is not radioactive. _____

I. Exists as X_4 molecules. _____

J. The element named after the sun, where it was first detected. _____

K. A metal that occurs in vast limestone deposits and combines with oxygen in a 1:1 ratio to form an oxide with a generic formula MO. _____

AP Chemistry

40 Ions to Memorize…yes, you'll get more later

aluminum	Al^{3+}	strontium	Sr^{2+}
ammonium	NH_4^+	stannous	Sn^{2+}
barium	Ba^{2+}	stannic	Sn^{4+}
calcium	Ca^{2+}	zinc	Zn^{2+}
cuprous	Cu^+	acetate	$C_2H_3O_2^-$ or CH_3COO^-
cupric	Cu^{2+}	bromide	Br^-
ferrous	Fe^{2+}	carbonate	CO_3^{2-}
ferric	Fe^{3+}	chlorate	ClO_3^-
hydrogen	H^+	chloride	Cl^-
hydronium	H_3O^+	chromate	CrO_4^{2-}
lead	Pb^{2+}	dichromate	$Cr_2O_7^{2-}$
lithium	Li^+	fluoride	F^-
magnesium	Mg^{2+}	hydroxide	OH^-
manganese	Mn^{2+}	iodide	I^-
mercurous	Hg_2^{2+}	nitrate	NO_3^-
mercuric	Hg^{2+}	oxide	O^{2-}
nickel	Ni^{2+}	permanganate	MnO_4^-
potassium	K^+	phosphate	PO_4^{3-}
silver	Ag^+	sulfate	SO_4^{2-}
sodium	Na^+	sulfide	S^{2-}

Ch.3 - Organize Your Ions

Write the charge of each monatomic ion listed below:

I	II	III	IV	V	VI	VII	VIII
H							
Li					O	F	
Na	Mg	Al			S	Cl	
K	Ca					Br	
	Sr					I	
	Ba						

1+ ions

2+ ions

3+ ions

4+ ions

1- ions

2- ions

3- ions

"ates"

Elements with two different ion names / charges

Ch.3 - Molar Mass & Percent Composition

I. Molar Masses

Given a periodic table, you should be able to calculate the molecular mass (in u's) or the molar mass (in grams) for any element or compound.

Examples: (give answers to two decimal places)

H_2SO_4	Cl_2	$Ca(OH)_2$	$HC_2H_3O_2$
CO_2	N_2O	NaOCl	Al_2S_3

II. Fraction and Percent Composition

It is useful to determine how much of a compound's mass is made up of each element. Water, H_2O, for example has a molar mass of 18.02 g. The H's mass is 2(1.0079) = 2.02 g. The O's mass is 16.00 g.
We can set up **fractions** for each element:

$$H = \frac{2.02}{18.02} = 0.112 = 11.2\%. \qquad O = \frac{16.00}{18.02} = 0.888 = 88.8\%.$$

This is called the **percent composition** or **mass percent**. The fraction composition is a good in-between step. Determine the fraction and percent composition of each element below. Answer to 2 decimal places.

1. H_2SO_4			
2. $Ca(OH)_2$			
3. $HC_2H_3O_2$			
4. CO_2			
5. N_2O			
6. NaOCl			
7. Al_2S_3			

Mole Calculations - Difficulty Level 3

1 mole = 6.02 x 10^{23} molecules = 22.4 L (@ STP)

In each question, there is a "given" (G) and a "determine" (D). For each problem, you will need to decide what "G" and "D" are, and then you need to solve using dimensional analysis.

1. Calculate the mass of 7.23 moles CH_4. [molar mass CH_4 = 16.0 g/mol]
   G:
   D:

2. What volume will 9.35 moles of CO_2 gas occupy at STP?
   G:
   D:

3. How many molecules are there in a 0.0752 mole sample of H_2O?
   G:
   D:

4. What mass of CO_2 gas occupies a volume of 10.8 Liters at STP? [molar mass CO_2 = 44.0 g/mol]
   G:
   D:

5. How many molecules are in a 1.44 gram sample of H_2O? [molar mass H_2O = 18.0 g/mol]
   G:
   D:

6. What volume will 1.21 x 10^{24} molecules of CH_4 occupy at STP?
   G:
   D:

Ch.3 – Writing Formulas and Naming Compounds

Introduction

Writing formulas and naming compounds can be confusing because there are different types of compounds that follow different rules. Additionally, some compounds (H_2O, NH_3, CH_4, etc.) simply have ***common names*** that must be memorized. The two types of compounds we will focus on first are ***ionic compounds*** (formed from positive and negative ions) and ***binary nonmetal compounds*** (molecular compounds). Later we will add ***acids***. So… you must recognize the ***type*** of compound before you try to name it. [Note: + ion = "cation" and – ion = "anion".]

	Ionic	**Binary Nonmetal**
Formula	+ ion before – ion ex: NaCl $(NH_4)_2SO_4$ Al_2S_3	usually the less electronegative atom is first ex: CO CO_2 N_2O
Naming	Name of cation + name of anion sodium chloride ammonium sulfate aluminum sulfide	Indicate the number (mono, di, tri, and kind of atoms. First element is simply name of element. Second element name ends with "ide" carbon monoxide carbon dioxide dinitrogen monoxide

I. Writing Ionic Formulas

	Cl^-	NO_3^-	S^{2-}	CO_3^{2-}	N^{3-}	PO_4^{3-}	OH^-
Na^+							
NH_4^+							
Sn^{2+}							
Hg_2^{2+}							
Al^{3+}							
Sn^{4+}							

II. Naming Ionic Compounds

Cation	**Anion**	**Formula**	**Name**
Cu^{2+}	OH^-		
Ba^{2+}	SO_4^{2-}		
NH_4^+	$Cr_2O_7^{2-}$		
Ag^+	$C_2H_3O_2^-$		
Fe^{3+}	S^{2-}		

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

III. Writing Formulas of Binary Nonmetal Compounds

Name	**Formula**	**Name**	**Formula**
nitrogen trifluoride		phosphorus trichloride	
nitrogen monoxide		phosphorus pentachloride	
nitrogen dioxide		sulfur hexafluoride	
dinitrogen tetroxide		disulfur decafluoride	
dinitrogen monoxide		xenon tetrafluoride	

IV. Naming Binary Nonmetal Compounds

Name	Formula	Name	Formula
	CCl_4		HBr
	P_4O_{10}		N_2F_4
	ClF_3		XeF_3
	BCl_3		PI_3
	SF_4		SCl_2

V. Practice for Both Types of Compounds

Formula	Name
HCl	
PCl_5	
K_2S	
$NiSO_4$	
ClF_3	
OF_2	
$Al(OH)_3$	
NCl_3	
$(NH_4)_3PO_4$	
S_2Cl_2	

Formula	Name
	carbon dioxide
	ammonium carbonate
	sulfur dichloride
	calcium iodide
	boron trifluoride
	phosphorus triiodide
	magnesium perchlorate
	potassium permanganate
	aluminum phosphate
	dioxygen difluoride

Ch.3: Composition of Hydrates

Solve the following chemical conundrums – ***SHOW ALL YOUR WORK AND INCLUDE UNITS!***

1. Cupric chloride, $CuCl_2$, when heated to 100°C is dehydrated. If 0.235 g of $CuCl_2 \cdot x\ H_2O$ gives 0.185 g of $CuCl_2$ on heating, what is the value of *x*?

2. The "alum" used in cooking is potassium aluminum sulfate hydrate, $KAl(SO_4)_2 \cdot x\ H_2O$. To find the value of *x*, you can heat a sample of the compound to drive off all of the water and leave only $KAl(SO_4)_2$. Assume you heat 4.74 g of the hydrated compound and that the sample loses 2.16 g of water. What is the value of *x*?

3. If "Epsom salt," $MgSO_4 \cdot x\ H_2O$ is heated to 250°C, all the water of hydration is lost. On heating a 1.687-g sample of the hydrate, 0.824 g of $MgSO_4$ remains. What is the formula of Epsom salt?

4. When $CaSO_4 \cdot x\ H_2O$ is heated, all of the water is driven off. If 34.0 g of $CaSO_4$ (molar mass = 136) is formed from 43.0 g of $CaSO_4 \cdot x\ H_2O$, what is the value of *x*?

Ch. 3 – Chemical Equations & Stoichiometry

1. Balance the following equations:

a. $\_C_4H_6(g) + \_O_2(g) \rightarrow \_CO_2(g) + \_H_2O(l)$

b. $\_NH_3(g) + \_O_2(g) \rightarrow \_NO_2(g) + \_H_2O(l)$

c. $\_PCl_3(l) + \_H_2O(l) \rightarrow \_H_3PO_3(aq) + \_HCl(aq)$

d. $\_Ca_3P_2(s) + \_H_2O(l) \rightarrow \_Ca(OH)_2(aq) + \_PH_3(g)$

e. $\_C_4H_8(OH)_2(l) + \_O_2(g) \rightarrow \_CO_2(g) + \_H_2O(l)$

f. $\_NH_3(g) + \_NO(g) \rightarrow \_N_2(g) + \_H_2O(l)$

g. $\_KClO_3(s) \rightarrow \_KCl(s) + \_O_2(g)$

h. $\_Ca(OH)_2(s) + \_H_3PO_4(aq) \rightarrow \_Ca_3(PO_4)_2(s) + \_H_2O(l)$

i. $\_C_3H_8(g) + \_O_2(g) \rightarrow \_CO_2(g) + \_H_2O(l)$

j. $\_N_2O(g) + \_O_2(g) \rightarrow \_NO_2(g)$

k. $\_Al_4C_3(s) + \_H_2O(l) \rightarrow \_Al(OH)_3(aq) + \_CH_4(g)$

l. $\_CS_2(l) + \_Cl_2(g) \rightarrow \_CCl_4(l) + \_S_2Cl_2(l)$

m. $\_C_2H_5OH(l) + \_PCl_3(l) \rightarrow \_C_2H_5Cl(l) + \_H_3PO_3(l)$

n. $\_ZnS(s) + \_O_2(g) \rightarrow \_ZnO(s) + \_SO_2(g)$

o. $\_Ag(s) + \_H_2S(g) + \_O_2(g) \rightarrow \_Ag_2S(s) + \_H_2O(l)$

2. When asked to balance the equation:

$$C_2H_6(g) + O_2(g) \rightarrow CO_2(g) + H_2O(g)$$

the following suggestions were made:

$$C_2H_6(g) + 5O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$$

$$C_2H_6(g) + 5O(g) \rightarrow 2CO(g) + 3H_2O(g)$$

$$2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(g)$$

Which answer is correct and what is wrong with the others?

3. Write balanced chemical equations for the following reactions:

a. the decomposition of ammonium nitrate to nitrogen gas, oxygen gas, and water vapor.

b. the reaction of sodium bicarbonate with sulfuric acid to produce sodium sulfate, water, and carbon dioxide.

c. the treatment of phosphorus pentachloride with water to produce phosphoric acid and hydrogen chloride.

For questions 4-11, use dimensional analysis to determine the answer to the question.

4. If the maximum amount of product possible is formed in the following reactions, what mass of the specified product would you obtain?

a. 10 grams of sodium chloride is treated with excess silver nitrate:

$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$

How much silver chloride is precipitated?

b. 12 grams copper metal is treated with excess dilute nitric acid:

$3Cu(s) + 8HNO_3(aq) \rightarrow 3Cu(NO_3)_2(aq) + 2NO(g) + 4H_2O(l)$

How much nitric oxide gas (NO) is produced?

c. 60 grams propane gas is burned in excess oxygen:

$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$

How much water is produced?

5. A furniture dealer put together a special deal for the annual sale—an entire dining room set comprising a table, six dining chairs, two bookshelves, a china cabinet, and a sideboard for $999. The dealer had in stock 280 tables, 1750 chairs, 550 bookshelves, 300 china cabinets, and 325 sideboards. He asked his assistant to figure out how many dining room sets they could sell, how much money they would make if they sold all the sets possible, and what they would have left that could not be sold as part of the deal.

6. Hydrazine reacts with dinitrogen tetroxide according to the equation:

$2N_2H_4(g) + N_2O_4(g) \rightarrow 3N_2(g) + 4H_2O(g)$

50.0 grams of hydrazine is mixed with 100.0 grams of dinitrogen tetroxide. How much nitrogen gas was produced?

7. 7.321 mg of an organic compound containing carbon, hydrogen, and oxygen was analyzed by combustion. The amount of carbon dioxide produced was 17.873 mg and the amount of water produced was 7.316 mg. Determine the empirical formula of the compound.

8. 0.1101 gram of an organic compound containing carbon, hydrogen, and oxygen was analyzed by combustion. The amount of carbon dioxide produced was 0.2503 gram and the amount of water produced was 0.1025 gram. A determination of the molar mass of the compound indicated a value of approximately 115 grams/mol. Determine the empirical formula and the molecular formula of the compound.

9. Sodium metal reacts vigorously with water to produce a solution of sodium hydroxide and hydrogen gas:

$$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$$

What mass of hydrogen gas can be produced when 10 grams of sodium is added to 15 grams of water?

10. Nitrous oxide reacts with oxygen to produce nitrogen dioxide according to the equation:

$$2N_2O(g) + 3O_2(g) \rightarrow 4NO_2(g)$$

What mass of nitrogen dioxide can be made from 42 grams of nitrous oxide and 42 grams of oxygen?

11. If only 75 grams of nitrogen dioxide was produced in the reaction described in the previous question, what was the % yield?