

Name: \_\_\_\_\_

Date: \_\_\_\_\_

## AP Chemistry: Unit 1 (Ch. 1, 2, 3)

Directions: Complete the following problems.

Read Ch. 1 in Textbook

1. Explain how the difference between a law and a theory is the difference between *what* and *why*.

Classify each of the following as an element, compound, homogeneous mixture, or heterogeneous mixture.

- |                    |                        |
|--------------------|------------------------|
| 2A. tossed salad   | 2B. a cup of tap water |
| a cup of green tea | distilled water        |
| zinc               | bronze                 |
| blood              | table salt (NaCl)      |
| glucose            | copper                 |
| the Atlantic Ocean | salsa                  |

Perform each conversion, showing the conversion factor(s) in each case.

3A. Convert 6.1 millimeters to kilometers.

3B. Convert  $9.1 \times 10^6$  micrometers to nanometers.

4A. Convert 72 miles per hour to meters per second. (1 mile = 1609 m)

4B. Convert 48.3 meters per second to kilometers per hour.

5A. Convert  $150 \text{ cm}^2$  to  $\text{m}^2$ .

Answers: 3A)  $6.1 \times 10^{-6} \text{ km}$  3B)  $9.1 \times 10^8 \text{ nm}$  4A) 32 m/s 4B) 174 km/h 5A)  $0.015 \text{ m}^2$

5B. An inland sea holds 15,800 km<sup>3</sup> of water. How many liters is this?

6A. A zinc-64 nuclide has a mass of about 64 atomic mass units. Convert this to kg (1 g = 6.02 x 10<sup>23</sup> amu).

6B. The mass of an electron at rest (?!?!?) is about 9.11 x 10<sup>-28</sup> grams. Convert this mass into amu.

7A. Portland cement concrete (PCC) has a density of 150 lb/ft<sup>3</sup>. How many kilograms of PCC are required to cast a cylindrical column 1.15 m in diameter and 7.8 m in height? (1 kg = 2.205 lb, 1 inch = 2.54 cm)

7B. A 30 L storage tank contains 6.85 kg of argon under pressure. If the gas is released into a 12-meter by 15-meter by 3.0-meter room, find the density of the argon, in g/L, once it has filled the room.

8A. Silver has a density of 9.32 g/cm<sup>3</sup>. Find the length of one side of a 184 g silver cube.

5B)  $1.58 \times 10^{16}$  L    6A)  $1.1 \times 10^{-25}$  kg    6B)  $5.48 \times 10^{-4}$  amu    7A) 19,000 kg    7B) 0.013 g/L  
8A)  $s = 2.70$  cm    8B)  $d = 3.35$  cm    8C) 77 microns

8B. Assume now that the silver cube above was melted and reshaped into a sphere. Find the sphere's diameter.

8C. Gold has a density of  $19.3 \text{ g/cm}^3$  and can be rolled into very thin sheets. If a  $285 \text{ mg}$  sample of gold is rolled into a "circle" of radius  $0.78 \text{ cm}$ , find the thickness of the "circle," in microns.

9. In industrial quality control, a Vernier caliper can be used to measure dimensions of machined objects to a very high degree of precision. Suppose the actual diameter of a bolt is known to be  $1.723 \text{ cm}$ . For each of the following, give three examples of measured data of this diameter that are:

A. imprecise and inaccurate

B. precise and inaccurate

C. precise and accurate

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# Unit 1 : Reintroduction to Chemistry

## Ch. 1 : Chemical Foundations

### CHAPTER 1

Multiple Choice: Choose the best option to complete the statement or answer the question.

- Which of the following statements is most true?
  - All compounds are molecules
  - All molecules are compounds
  - Some molecules are compounds
  - None of the above
- A mixture that has variable composition is considered:
  - Heterogeneous
  - Homogeneous
  - Compounds
  - Pure substances
- You have a sample of potassium chloride in lab and you dissolve it in 50 ml of distilled water. Which of the following best represents the resulting solution?
  - Element
  - Compound
  - Homogeneous mixture
  - Heterogeneous mixture
- You are in lab and you discover a new material that has astounding capabilities, including curing cancer, keep crime off the streets, and bring world peace. This new substance has an indefinite shape but a definite volume. This material is a:
  - Solid
  - Liquid
  - Gas
  - Plasma
- Which of the following is NOT an example of a chemical change?
  - Burning wood
  - Cooking a spicy grilled chicken breast with an Italian peppercorn sauce, sautéed with onions, fresh spinach and extra virgin olive oil.
  - Boiling water
  - Tarnishing silver
- Which of the following examples is not an example of physical change?
  - Boiling salt water
  - Melting wax
  - Popping a balloon
  - Rusting metal
- What is another name for a homogeneous mixture?
  - Compound
  - Element
  - Solution
  - Substance
  - None of these
- Which of the following measurements is NOT equal to all the others?
  - $3.2 \times 10^4$  mm
  - 32 000 cm
  - 0.32 km
  - 320 m
  - They are all equal

9. An electronic balance is precise to 0.1 g (one decimal place). The only correct measurement below that could be taken from this instrument is:
- (a) 22.000 g
  - (b) 22.00 g
  - (c) 22.0 g
  - (d) 22 g
  - (e) either (A), (B), or (C) would be correct
10. In a conversion factor:
- (a) the ratio of the numerator to the denominator is always one
  - (b) the numerator and denominator are always numerically the same
  - (c) the numerator and denominator always have the same units
  - (d) two of the above
  - (e) all of the above

**Fill in the blank:** Write the correct answer to each problem in the space provided.

11. In the space provided, write how many significant figures are in each of the following measurements.

(a) \_\_\_\_\_ 0.012000 km    (b) \_\_\_\_\_ 2,241,000 ms    (c) \_\_\_\_\_ 7,001.00 dg

12. Label each of the following as either (E) for extensive properties or (I) for Intensive properties.

- (a) \_\_\_\_\_ Temperature
- (b) \_\_\_\_\_ Mass
- (c) \_\_\_\_\_ Boiling Point
- (d) \_\_\_\_\_ Volume

13. Calculate each of the following. Round to the correct number of sig. figs. Include the correct unit.

(a) \_\_\_\_\_ 36.4 L - 32.23 L

(b) \_\_\_\_\_ 0.30 m x 4.500 m

14. Zinc has a density of 446 lb/ft<sup>3</sup>. What is the density of zinc in g/cm<sup>3</sup>?

**\* Remainder of Packet - EVEN ONLY REQUIRED ... Odd # is good Practice**  
**AP Chemistry - HW Packet (Ch. 2-3)**

**Section 2.2**

- In an exothermic (heat producing) reaction, chlorine reacts with 2.0200 g of hydrogen to form 72.926 g of hydrogen chloride gas. How many grams of chlorine reacted with hydrogen?
- Sulfur and oxygen can react to form both sulfur dioxide and sulfur trioxide. In sulfur dioxide, there are 32.06 g of sulfur and 32.00 g of oxygen. In sulfur trioxide, 32.06 g of sulfur are combined with 48.00 g of oxygen.
  - What is the ratio of the weights of oxygen that combine with 32.06 g of sulfur?
  - How do these data illustrate the law of multiple proportions?
- By experiment it has been found that 2.18 g of zinc metal combines with oxygen to yield 2.71 g of zinc oxide. How many grams of oxygen reacted with zinc metal?
- A sample of  $H_2SO_4$  contains 2.02 g of hydrogen, 32.07 g of sulfur, and 64 g of oxygen. How many grams of sulfur and grams of oxygen are present in a second sample of  $H_2SO_4$  containing 7.27 g of hydrogen?

**Section 2.3**

- Describe what part of Dalton's atomic theory each chemical statement relates to.
  - $H_2 + Cl_2 \rightarrow 2HCl$
  - There are  $3.01 \times 10^{23}$  atoms in 20.04 g of calcium.
  - Lead does not change to chromium when it forms lead hydroxide.

**Section 2.5**

- Identify each of the following elements:
 

a. ${}_{41}^{91}X$	d. ${}_{35}^{82}X$
b. ${}_{47}^{108}X$	e. ${}_{23}^{51}X$
c. ${}_{16}^{33}X$	f. ${}_{55}^{133}X$
- Identify each of the following elements:
 

a. ${}_{43}^{98}X$	d. ${}_{6}^{14}X$
b. ${}_{25}^{106}X$	e. ${}_{19}^{40}X$
c. ${}_{33}^{75}X$	f. ${}_{34}^{131}X$
- How many protons and neutrons are in each of the following elements?
 

a. ${}^{89}Y$	d. ${}^{238}U$
b. ${}^{71}Ge$	e. ${}^{35}Cl^-$
c. ${}^{24}Mg^{2+}$	f. ${}^{65}Zn$
- How many protons and neutrons are in each of the following elements?
 

a. ${}^{227}Ac$	d. ${}^{251}Cf$
b. ${}^{76}Gn$	e. ${}^{239}Pu$
c. ${}^{11}B$	f. ${}^{64}Cu$

**Section 2.6**

- How many protons, neutrons, and electrons are in each of the following ions?
 

a. ${}^{50}Fe^{3+}$	d. ${}^{31}P^{3-}$
b. ${}^{40}Ca^{2+}$	e. ${}^{127}I^-$
c. ${}^{19}F^-$	f. ${}^{127}I^{7+}$
- How many protons, neutrons, and electrons are in each of the following?
 

a. ${}^{195}Pt^4+$	d. ${}^{16}O^{2-}$	g. ${}^{184}W$
b. ${}^{93}Nb$	e. ${}^{122}Sb^{2+}$	h. ${}^{133}Cs^+$
c. ${}^{40}Ar^-$	f. ${}^{56}Fe^{2+}$	i. ${}^{28}Si^{3-}$
- Fill in the missing information in the following table:

Symbol	Protons	Neutrons	Electrons	Charge
${}_{35}^{80}Br^-$	_____	_____	_____	_____
_____ $^{5+}$	35	45	_____	+5
${}_{137}^{_____}$	56	_____	54	_____
${}_{47}^{108}Ag^+$	_____	_____	_____	_____
${}_{23}^{51}_____^{5+}$	_____	_____	_____	_____
_____ $Co^-$	_____	32	_____	+2

- Fill in the missing information in the following table:

Symbol	Protons	Neutrons	Electrons	Charge
${}_{27}^{_____}$	13	_____	10	_____
${}_{88}^{38}_____$	_____	_____	_____	+1
_____ $^{2+}$	30	35	_____	_____
${}_{35}^{_____}$	_____	18	18	_____
_____ $Te^{2-}$	_____	76	_____	_____
${}^{85}Rb^-$	_____	_____	_____	+1

## Multiple Choice Questions

34. The masses of an apple, orange, grape, and banana are 800, 750, 72, and 650 g, respectively. Determine the combined mass of 10 apples, 6 oranges, 20 grapes, and 5 bananas.  
A. 17190 g      B. 8595 g      C. 2272 g      D. 95200 g
35. A pound cake consists of 1.0 lb of butter, 1.25 lb of flour, 1.0 lb of sugar, 6 eggs (1.25 lb in mass) and 0.5 lb of milk. After the cake has baked and cooled, it weighs 5.25 lbs. Which of the following statements is true?  
A. The law of conservation of mass has been violated by a gain in 0.25 lbs.  
B. The law of conservation of mass is conserved since 0.25 lbs of gas were produced during baking.  
C. The law of conservation of mass has been violated by a gain in 12.0 oz.  
D. The law of conservation of mass has been violated by a gain in 8.0 oz.
36. The oxides of CO and CO<sub>2</sub> must have the following carbon-to-oxygen mass ratio:  
A. 12:16, 12:32      B. 12:12, 12:16      C. 12:8, 12:4      D. 12:12, 12:24
37. When silicone and oxygen combine to form silicon dioxide, silicon and oxygen  
A. Fuse together to yield a new atom  
B. Retain their identities  
C. Duplicate their mass  
D. Have some atoms that retain their individual identities, and some that do not
38. Every atom contains  
A. As many neutrons as electrons      C. As many nuclei as neutrons  
B. As many protons as neutrons      D. As many electrons as protons
39. The atomic number represents  
A. The number of nuclei in that atom      C. The number of neutrons in that atom  
B. The number of protons in that atom      D. The number of electrons in that atom
40. Which of the following elements has  $Z = 68$  and  $A = 167$ ?  
A. Erbium      B. Californium      C. Calcium      D. Dysprosium
41. The atomic number and atomic mass, respectively, for vanadium, are:  
A. 23, 51      B. 51, 23      C. 46, 102      D. 46, 51
42. Atom A has 30 protons, 32 neutrons, and 30 electrons. Atom B has 30 protons, 28 neutrons, and 30 electrons. Atoms A and B are  
A. Isotopes      B. Isobars      C. Isomers      D. Isoneutrons
43. How many electrons and protons, respectively, are there in  $Rn^{2+}$ ?  
A. 88, 88      B. 86, 88      C. 224, 226      D. 228, 224
44. How many total protons are found in two molecules of  $C_{20}H_{10}O$ ?  
A. 102      B. 316      C. 302      D. 600
45. What is the charge of an ion with 29 protons and 28 neutrons?  
A. 0      B. +1      C. +2      D. Unknown

## CHAPTER 2

Multiple Choice: Choose the best option to complete the statement or answer the question.

1. Which of the following conclusions can be drawn from J. J. Thomson's cathode ray experiments? \*\*AP Question 1989 (#33)  
(A) Atoms contain electrons.  
(B) Practically all the mass of an atom is contained in its nucleus.  
(C) Atoms contain protons, neutrons, and electrons.  
(D) Atoms have a positively charged nucleus surrounded by an electron cloud.  
(E) No two electrons in one atom can have the same four quantum numbers.
2. Of the following, the smallest and lightest subatomic particle is the \_\_\_\_\_.  
(A) neutron (B) proton (C) nucleus (D) electron
3. There are \_\_\_\_\_ electrons, \_\_\_\_\_ protons and \_\_\_\_\_ neutrons in an atom of  $^{132}_{54}Xe$ ?  
A) 78, 78, 132      (B) 132, 132, 54      (C) 54, 54, 78      (D) 78, 78, 54
4. Of the choices below, which one is not an ionic compound?  
(A)  $MoCl_6$       (B)  $PbCl_2$       (C)  $PCl_6$       (D)  $NaCl$       (E)  $RbCl$

Write the formula or the name of the following compound:

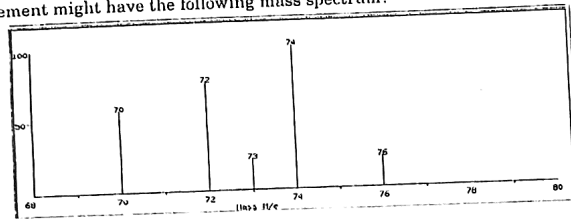
- |                                 |                             |
|---------------------------------|-----------------------------|
| 5. Magnesium carbonate _____    | 15. $Na_2O$ _____           |
| 6. Potassium perchlorate _____  | 16. $Fe(OH)_3$ _____        |
| 7. Silver bromite _____         | 17. $Al_2S_3$ _____         |
| 8. Lead (II) thiocyanate _____  | 18. $Cu(C_2H_3O_2)_2$ _____ |
| 9. Barium phosphate _____       | 19. $K_2SO_4$ _____         |
| 10. Silicon dioxide _____       | 20. $Cl_2O$ _____           |
| 11. Arsenic (III) hydride _____ | 21. $N_2H_4$ _____          |
| 12. Methane _____               | 22. $SF_6$ _____            |
| 13. Chromic acid _____          | 23. $NO_2$ _____            |
| 14. Hydrochloric acid _____     | 24. $HCl_2H_3O_2$ _____     |

## Exercises

Place the best answer in the blank:

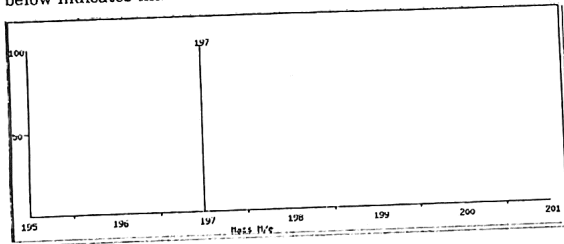
25. Which element might have the following mass spectrum?

- a. Ge  
b. Cu  
c. At  
d. K



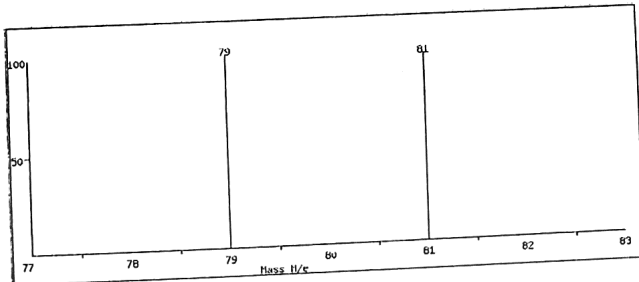
26. The data below indicates that the element gold has how many isotopes?

- a. 1  
b. 2  
c. 3  
d. 4



27. The data below suggests that the atomic mass of the element corresponding to this data is

- closest to  
a. 100  
b. 79  
c. 80  
d. 81



## Section 3.2

- An element "E" is present as  $^{10}\text{E}$  with a mass value of 10.01 amu, and as  $^{11}\text{E}$  with a mass value of 11.01 amu. The natural abundances of  $^{10}\text{E}$  and  $^{11}\text{E}$  are 19.78% and 80.22% respectively. What is the average atomic mass of the element? What is the element?
- Naturally occurring sulfur consists of four isotopes,  $^{32}\text{S}$  (95.0%),  $^{33}\text{S}$  (0.76%),  $^{34}\text{S}$  (4.22%), and  $^{36}\text{S}$  (0.014%). Using these data, calculate the atomic weight of naturally occurring sulfur. The masses of the isotopes are given in the table below.

Isotope	Atomic mass (amu)
$^{32}\text{S}$	31.97
$^{33}\text{S}$	32.97
$^{34}\text{S}$	33.97
$^{36}\text{S}$	35.97

- An unknown sample of mystery element "T" is injected into the mass spectrometer. According to the mass spectrum, 7.42% of the element is present as  $^6\text{T}$ , and 92.58% is present as  $^7\text{T}$ . The mass values are 6.02 amu for  $^6\text{T}$  and 7.02 amu for  $^7\text{T}$ . Calculate the average atomic mass, and identify the mystery element.
- A noble gas consists of three isotopes of masses 19.99 amu, 20.99 amu, and 21.99 amu. The relative abundance of these isotopes is 90.92%, 0.257%, and 8.82% respectively. What is the average atomic mass of this noble gas? What noble gas is this?
- Chlorine has two stable isotopes. The mass of one isotope is 34.97 amu. Its relative abundance is 75.53%. What is the mass of the other stable isotope?
- Complete the following table of isotopic information for the element neon (Ne).

Isotope	Mass (amu)	Abundance
$^{20}\text{Ne}$	19.99	
$^{21}\text{Ne}$	20.99	0.257%
$^{22}\text{Ne}$	21.99	

- Silicon has three stable isotopes in nature as shown in the table below. Fill in the missing information.

Isotope	Mass (amu)	Abundance
$^{28}\text{Si}$	27.98	
$^{29}\text{Si}$		4.70%
$^{32}\text{Si}$	29.97	3.09%

- Gallium has two stable isotopes of masses 68.93 amu ( $^{69}\text{Ga}$ ) and 70.92 amu ( $^{71}\text{Ga}$ ). What are the relative abundances of the two isotopes?
- Magnesium exists as three isotopes in nature. One isotope ( $^{25}\text{Mg}$ ) has a mass of 24.99 amu and a relative abundance of 10.13%. The other two isotopes have masses of 23.99 amu ( $^{24}\text{Mg}$ ) and 25.98 amu ( $^{26}\text{Mg}$ ). What are their relative abundances? (atomic mass Mg = 24.305 amu)



10. An element "X" has 5 major isotopes, listed below along with their abundances. What is the element? Does the atomic mass that you calculate based on these data agree with that listed in your periodic table?

Isotope	% Natural Abundance	Atomic Mass
$^{46}\text{X}$	8.0%	45.95269
$^{47}\text{X}$	7.3%	46.951764
$^{48}\text{X}$	73.8%	47.947947
$^{49}\text{X}$	5.5%	48.947841
$^{50}\text{X}$	5.4%	49.944792

### Section 3.3

- How many moles are in a sample of 300 atoms of nitrogen? How many grams?
- How many atoms of gold does it take to make 1 gram of gold?
- If you buy 38.9 moles of M&M's<sup>®</sup>, how many M&M's<sup>®</sup> do you have? (1 mole of M&M's<sup>®</sup> =  $6.022 \times 10^{23}$  M&M's<sup>®</sup>)
- A sample of sulfur has a mass of 5.37 g. How many moles are in the sample? How many atoms?
- Give the number of moles of each element present in 1.0 mole of each of the following substances:
  - $\text{Hg}_2\text{I}_2$
  - $\text{LiH}$
  - $\text{PbCO}_3$
  - $\text{Ba}_3(\text{AsO}_4)_2$
  - $\text{RbOH} \cdot 2\text{H}_2\text{O}$
  - $\text{H}_2\text{SiF}_6$
- How many grams of zinc are in  $1.16 \times 10^{22}$  atoms of zinc?
- How many amu are in 3.68 moles of iron?

### Section 3.4

- Calculate the molar masses of each of the following:
  - $\text{Cu}_2\text{SO}_4$
  - $\text{NH}_4\text{OH}$
  - $\text{C}_{10}\text{H}_{16}\text{O}$
  - $\text{Zr}(\text{SeO}_3)_2$
  - $\text{Ca}_2\text{Fe}(\text{CN})_6 \cdot 12\text{H}_2\text{O}$
  - $\text{Cr}_2(\text{P}_2\text{O}_7)_3$
- Calculate the molar mass of
  - $\text{Zn}(\text{CN})_4$
  - $\text{Cu}(\text{NH}_3)_4 \cdot 8\text{H}_2\text{O}$
- What is the mass of  $4.28 \times 10^{22}$  molecules of water?
- What is the mass of  $4.89 \times 10^{21}$  atoms of the element "X" described in problem # 10?
- How many milligrams of  $\text{Br}_2$  are in  $4.8 \times 10^{20}$  molecules of  $\text{Br}_2$ ?
- How many sodium ions are present in each of the following:
  - 2 moles of sodium phosphate
  - 5.8 grams of sodium chloride
  - a mixture containing 14.2 grams of sodium sulfate and 2.9 grams of sodium chloride?

- How many potassium ions are present in each of the following:
  - 3 moles of potassium chloride
  - 6.2 grams of potassium nitrate
  - a mixture containing 12.6 grams of potassium phosphate and 5.4 grams of potassium chloride?
- What is the weight in grams of
  - 0.4 moles of  $\text{CH}_4$
  - 11 moles of  $\text{SO}_4^{2-}$
  - 5 moles of  $\text{Mg}(\text{OH})_2$ ?
- Determine the molar mass of  $\text{KAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$ .
- How many moles of cadmium bromide,  $\text{CdBr}_2$ , are in a 39.25 g sample?
- A sample of calcium chloride,  $\text{CaCl}_2$ , has a mass of 23.8 g. How many moles of calcium chloride is this?
- If 0.172 moles of baking soda,  $\text{NaHCO}_3$ , were used to bake a chocolate cherry cake, how many grams of baking soda would the recipe call for?
- How many moles are there in a sample of barium sulfate,  $\text{BaSO}_4$ , weighing  $9.90 \times 10^{-7}$  g?
- How many grams are there in 0.36 moles of cobalt (III) acetate,  $\text{Co}(\text{C}_2\text{H}_3\text{O}_2)_3$ ? How many grams of cobalt are in this sample? How many atoms of cobalt?
- How many milligrams of chlorine are there in a sample of  $3.9 \times 10^{19}$  molecules of chlorine gas,  $\text{Cl}_2$ ? How many atoms of chlorine?
- Bauxite, the principle ore used in the production of aluminum cans, has a molecular formula of  $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$ .
  - Determine the molar mass of bauxite.
  - How many grams of Al are in 0.58 moles of bauxite?
  - How many atoms of Al are in 0.58 moles of bauxite?
  - What is the mass in grams of  $2.1 \times 10^{24}$  formula units of bauxite?

### Section 3.6

- Calculate the mass percent of Cl in each of the following compounds:
  - $\text{ClF}$
  - $\text{HClO}_2$
  - $\text{CuCl}_2$
  - $\text{PuOCl}$
- Calculate the mass percent of each element in  $\text{C}_3\text{H}_{10}\text{O}$ .
- Calculate the mass percent of each element in potassium ferricyanide,  $\text{K}_3\text{Fe}(\text{CN})_6$ .
- Calculate the mass percent of each element in barium sulfite,  $\text{BaSO}_3$ .
- Calculate the mass percent of each element in natural lucite,  $\text{KAlSi}_2\text{O}_6$ .
- Calculate the mass percent of silver in each of the following compounds:
  - $\text{AgCl}$
  - $\text{AgCN}$
  - $\text{AgNO}_3$

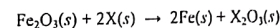
40. Chlorophyll *a* is essential for photosynthesis. It contains 2.72% magnesium by mass. What is the molar mass of chlorophyll *a* assuming there is one atom of magnesium in every molecule of chlorophyll *a*?
41. Calculate the mass percent of each of the elements in Nicotine,  $C_{10}H_{14}N_2$ .

### Section 3.7

42. Which of the following formulas can be empirical?
- |             |             |              |
|-------------|-------------|--------------|
| a. $CH_4$   | d. $N_2O_5$ | g. $Sb_2S_3$ |
| b. $CH_2$   | e. $B_3H_6$ | h. $N_2O_4$  |
| c. $KMnO_4$ | f. $NH_4Cl$ | i. $CH_2O$   |
43. Determine the empirical and molecular formulas of a compound that has a mass of 31.04 g/mole and contains the following percentages of elements by mass:  
C = 38.66%, H = 16.24%, N = 45.10%
44. The analysis of a rocket fuel showed that it contained 87.4% nitrogen and 12.6% hydrogen by weight. Mass spectral analysis showed the fuel to have a molar mass of 32.05 grams. What are the empirical and molecular formulas of the fuel?
45. A compound is found, by mass spectral analysis, to contain the following percentages of elements by mass:  
C = 49.67%, Cl = 48.92%, H = 1.39%
- The molar mass of the compound is 289.9 g/mole. Determine the empirical and molecular formula of the compound.
46. Vanillin, the pleasant smelling ingredient used to bake chocolate chip cookies, is often used in the production of vanilla extract. Vanillin has a mass of 152.08 g/mole and contains the following percentages of elements by mass:  
C = 63.18%, H = 5.26%, O = 31.56%
- Determine the empirical and molecular formula of vanillin.
47. Determine the empirical formula of a compound that contains the following percentages of elements by mass:  
Mo = 43.95%, O = 7.33%, Cl = 48.72%
48. A molecule with a molecular weight of approximately 110 g/mole is analyzed. The results show that it contains 10.05% of carbon, 0.84% of hydrogen, and 89.10% of chloride. Calculate the molecular formula of this compound.
49. Using the data provided, calculate the empirical formulas for the compounds indicated:
- an oxide of nitrogen, a sample of which contains 6.35 g of nitrogen and 3.65 g of oxygen
  - an oxide of copper, one gram of which contains 0.7989 g of copper
  - an oxide of carbon that contains 42.84% carbon
  - a compound of potassium, chloride, and oxygen containing K = 31.97%, O = 39.34%
  - a compound of hydrogen, carbon, and nitrogen containing H = 3.70%, C = 44.44%, and N = 51.85%.

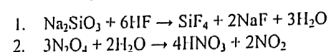
50. How many grams of product are formed in each of the following reactions?
- Two moles of  $H_2$  react with one mole of  $O_2$ .
  - One mole of silver nitrate reacts with one mole of sodium chloride.
  - Three moles of sodium hydroxide react with one mole of phosphoric acid.

51. The following reaction was performed:



It was found that 79.847 g of  $Fe_2O_3$  reacted with "X" to form 55.847 g of Fe and 50.982 g of  $X_2O_3$ . Identify element X.

52. Do these equations follow the conservation of matter?



### Section 3.9

53. Fill in the blanks to balance the following chemical equations:
- $AgI + Na_2S \rightarrow Ag_2S + NaI$
  - $(NH_4)_2Cr_2O_7 \rightarrow Cr_2O_3 + N_2 + H_2O$
  - $Na_3PO_4 + HCl \rightarrow NaCl + H_3PO_4$
  - $TiCl_4 + H_2O \rightarrow TiO_2 + HCl$
  - $Ba_3N_2 + H_2O \rightarrow Ba(OH)_2 + NH_3$
  - $HNO_2 \rightarrow HNO_3 + NO + H_2O$
54. Balance the following equation:  
 $NH_4OH(l) + KAl(SO_4)_2 \cdot 12H_2O \rightarrow Al(OH)_3(s) + (NH_4)_2SO_4(aq) + KOH(aq) + H_2O(l)$
55. Balance the following equation:  
 $Fe(s) + HC_2H_3O_2(aq) \rightarrow Fe(C_2H_3O_2)_3(aq) + H_2(g)$
56. Complete the following reactions (making sure they are balanced):
- $HNO_3 + \text{_____} \rightarrow H_2O + KNO_3$
  - $\text{_____} + Na_3PO_4 \rightarrow Ca_3(PO_4)_2 + NaCl$
  - $Mg(OH)_2 + HCl \rightarrow MgCl_2 + \text{_____}$
  - $\text{_____} + Cl_2 \rightarrow NaCl + Br_2$
57. Balance the following equations:
- $\text{_____} Ca + \text{_____} C + \text{_____} O_2 \rightarrow \text{_____} CaCO_3$
  - $\text{_____} FeS + \text{_____} O_2 \rightarrow \text{_____} Fe_2O_3 + \text{_____} SO_2$
  - $\text{_____} HNO_2 \rightarrow \text{_____} NO_2 + \text{_____} H_2O + \text{_____} NO$
  - $\text{_____} PCl_5 + \text{_____} H_2O \rightarrow \text{_____} H_3PO_4 + \text{_____} HCl$

## Section 3.10

58. How many grams of water vapor can be generated from the combustion of 18.74 g of ethanol?  

$$C_2H_6O(g) + O_2(g) \rightarrow CO_2(g) + H_2O(g)$$
 (unbalanced)
59. How many grams of sodium hydroxide are required to form 51.63 g of lead hydroxide?  

$$Pb(NO_3)_2(aq) + NaOH(aq) \rightarrow Pb(OH)_2(s) + NaNO_3(aq)$$
 (unbalanced)
60. How many grams of potassium iodide are necessary to completely react with 20.61 g of mercury (II) chloride?  

$$HgCl_2(aq) + KI(aq) \rightarrow HgI_2 + KCl(aq)$$
 (unbalanced)
61. How many grams of oxygen are necessary to completely react with 22.8 grams of methane,  $CH_4$ ? (Please write the entire reaction.)
62. If, in the previous problem, only 25.9 grams of water vapor were formed, how much methane actually reacted with oxygen?
63. What mass of calcium carbonate ( $CaCO_3$ ) would be formed if 248.6 g of carbon dioxide ( $CO_2$ ) were exhaled into limewater,  $Ca(OH)_2$ ? How many grams of calcium would be needed to form that amount of calcium carbonate? Assume 100% yield in each reaction.
64. The following reaction is used to form lead iodide crystals. What mass of crystal ( $PbI_2$ ) could be formed from  $1.0 \times 10^3$  g of lead (II) acetate [ $Pb(C_2H_3O_2)_2$ ]?  

$$Pb(C_2H_3O_2)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KC_2H_3O_2(aq)$$
65. How many grams of precipitate ( $Hg_2Cl_2$ ) would be formed from a solution containing 102.9 g of mercury ions that are reacted with chloride ions as follows?  

$$2Hg^+(aq) + 2Cl^-(aq) \rightarrow Hg_2Cl_2(s)$$
66. You were hired by a laboratory to recycle 6 moles of silver ions. You were given 150 g of copper. How many grams of silver can you recover? Is this enough copper to recycle 6 moles of silver ions?  

$$2Ag^+ + Cu \rightarrow 2Ag + Cu^{2+}$$
67. Fermentation converts sugar into ethanol and carbon dioxide. If you were to ferment a bushel of apples containing 235 g of sugar, what is the maximum amount of ethanol in grams that would be produced?  

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$
68. The reaction between potassium chlorate and red phosphorus is highly exothermic and takes place when you strike a match on a matchbox. If you were to react 52.9 g of potassium chlorate ( $KClO_3$ ) with red phosphorus, how many grams of tetraphosphorus decaoxide ( $P_4O_{10}$ ) would be produced?  

$$KClO_3(s) + P_4(s) \rightarrow P_4O_{10}(s) + KCl(s)$$
 (unbalanced)

## Section 3.11

69. A reaction combines 133.484 g of lead(II) nitrate with 45.010 g of sodium hydroxide (see problem 59).
- How much lead(II) hydroxide is formed?
  - Which reactant is limiting? Which is in excess?
  - How much of the excess reactant is left over?
  - If the actual yield of lead(II) hydroxide were 80.02 g, what was the percent yield?

## Stoichiometry

92. The proper set of coefficients for the following equation are  

$$C_3H_8O + O_2 \rightarrow CO_2 + H_2O$$
  
 A. 1, 3, 3, 3      B. 2, 4, 3, 3      C. 1, 2, 3, 3      D. 1, 6, 6, 6
93. The proper set of coefficients for the following equation are  

$$AgCl + HNO_3 \rightarrow AgNO_3 + HCl$$
  
 A. 1, 1, 1, 1      B. 1, 2, 2, 1      C. 2, 3, 1, 1      D. 2, 2, 2, 2
94. The proper set of coefficients for the following equation are  

$$C_3H_8 + F_2 \rightarrow C_3F_8 + HF$$
  
 A. 1, 1, 1, 1      B. 1, 3, 1, 3      C. 2, 16, 2, 16      D. 1, 8, 1, 8
95. For every liter of sea water that evaporates, 3.7 g of magnesium hydroxide are produced. How many liters of sea water must evaporate to produce 5.00 moles of magnesium hydroxide?  
 A. 78.4      B. 50      C. 143      D. 18.5
96. A solution of copper sulfate is treated with zinc metal. How many grams of copper are produced if 2.9 g of zinc are consumed?  

$$CuSO_4 + Zn \rightarrow ZnSO_4 + Cu$$
  
 A. 2.9 g      B. 2.8 g      C. 5.7 g      D. 3.7 g
97. How many grams of carbon dioxide are produced from the burning of 1368 g of sucrose according to the following equation?  

$$C_{12}H_{22}O_{11} + 12O_2 \rightarrow 12CO_2 + 11H_2O$$
  
 A. 342 g      B. 176 g      C. 1056 g      D. 2111 g
98. How many grams of sulfur dioxide are produced when 90.0 g of thionyl chloride reacts with excess water according to the following equation?  

$$SOCl_2 + H_2O \rightarrow 2HCl + SO_2$$
  
 A. 96.8      B. 90.0      C. 24.2      D. 48.5
99. Calcium oxide is a basic oxide that is not very soluble in water solutions. Calcium oxide can react with carbon dioxide to form calcium carbonate (according to the equation below). Calcium carbonate is an insoluble salt that forms stalactites and stalagmites. How many moles of carbon dioxide are removed from water if a 400.0 lb stalagmite is formed?  

$$CaO + CO_2 \rightarrow CaCO_3$$
  
 A. 1813      B. 908      C. 4000      D. 2258
100. Calculate the number of grams of  $TiOCl_2$  required to react with 134 g of carbon.  

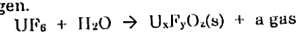
$$2TiOCl_2 + 2C \rightarrow 2Ti + CO_2 + CCl_4$$
  
 A. 134      B.  $1.51 \times 10^3$       C. 536      D. 67
101. Calculate the number of grams of methane ( $CH_4$ ) required to react with 25.0 g of chlorine according to the following equation:  

$$3CH_4 + 4Cl_2 \rightarrow 2CH_3Cl + CH_2Cl_2 + 4HCl$$
  
 A. 33.3      B. 18.8      C. 2.11      D. 4.23



**Old Stoichiometry Free Response Questions:** Try your best as you work through these problems. They can be challenging, but that is how they are supposed to be!

1. [1982B] (10) Water is added to 4.257 grams of  $\text{UF}_6$ . The only products are 3.730 grams of a solid containing only uranium, oxygen, and fluorine and 0.970 grams of a gas. The gas is 95.0% fluorine, the remainder is hydrogen.



a. From these data, determine the empirical formula of the gas.

b. Consider the fluorine in the original compound. What percent of this fluorine is in the solid product and what percent of the original fluorine is in the gaseous product?

c. What is the formula of the solid product?

2. [2008 #2] (10) Answer the following questions relating to *gravimetric analysis*. In the first of two experiments, a student is assigned the task of determining the number of moles of water in one mole of  $\text{MgCl}_2 \cdot n \text{H}_2\text{O}$ . The student collects the data shown in the following table.

Mass of empty container	22.347 g
Initial mass of sample and container	25.825 g
Mass of sample and container after first heating	23.982 g
Mass of sample and container after second heating	23.976 g
Mass of sample and container after third heating	23.977 g

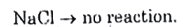
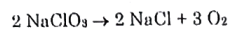
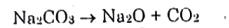
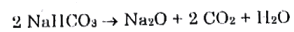
(a) Explain why the student can correctly conclude that the hydrate was heated a sufficient number of times in the experiment.

(b) Use the data above to  
(i) calculate the total number of moles of water lost when the sample was heated, and

(ii) determine the formula of the hydrated compound.

(c) A different student heats the hydrate in an uncovered crucible, and some of the solid spatters out of the crucible. This spattering will have what effect on the calculated mass of the water lost by the hydrate? Justify your answer.

**Stoich Challenge Problem:** A mixture contains NaCl, NaClO<sub>3</sub>, NaHCO<sub>3</sub>, and Na<sub>2</sub>CO<sub>3</sub>. The mixture is heated and the following reactions occur:



When 200.00 g of the mixture is heated, 5.500 g of water, 38.70 g of carbon dioxide, and 16.57 g of oxygen are produced. Assume complete decomposition of the mixture.

- How many grams of NaHCO<sub>3</sub> are in the mixture?
- How many grams of CO<sub>2</sub> are formed from the decomposition of sodium carbonate?
- How many moles of NaClO<sub>3</sub> are in the mixture?
- Calculate the percent by weight of each component in the original mixture.
- Upon heating another 200.00 g sample of the same mixture, it was found that all the sodium hydrogen carbonate decomposed but some of the sodium carbonate remained. If 9.20 g of sodium carbonate remained, how many grams of CO<sub>2</sub> would have formed in this experiment?