CHEM 1411 – General Chemistry I
Practice Problems, Chapters 1–3

Chapter 1 – Chemistry: The Study of Change

1. Element, compound, homogeneous mixture (solution), or heterogeneous mixture:

a) orange juice (freshly-squeezed)	b) brass	c) 0.9% saline (NaCl) solution
d) garden soil	e) room air	f) methane gas
g) sodium metal	h) N_2 gas	i) $Cu(NO_3)_2$ crystals

2. Define (some of these terms are found in Chapters 2 and 3):

a) element
b) compound
c) solution
d) physical change
e) chemical change
f) law of conservation of mass
g) intensive properties
h) extensive properties
i) precision
j) accuracy
k) isotopes
l) stoichiometry
m) the mole
n) Avogadro's number
o) limiting reactant

3. Convert

a) 5 feet 10 inches to meters
b) 55 miles per hour to cm per second
c) 5.0 quarts to liters
d) 1.00 ft^2 to cm^2
e) 32.06 amu to g
f) 25 g of carbon to moles of carbon
g) 1.00 g of gold to number of atoms of gold
h) 25 °F to Kelvins

4. How many significant figures are in the following numbers?

a) 3.1416	b) 6.022×10^{23} atoms/mole	c) 0.000104 g
d) 6.0 g/mL	e) 1.00794 amu	f) 5000 mi

5. Perform the following operations and give the correct number of significant figures in your answers.

a) (0.031 mole)(12.011 g/mole) =

b) 4.12 g + 60.1 g + 135 g =

c) (3.258 g) / (27.8 mL – 25.0 mL) =

6. An irregularly-shaped metal object has a mass of 10.867 g. When the object was immersed in 50 mL of water in a graduated cylinder, the water level rose from 50.0 mL to 58.5 mL. What is the density of the object?

Chapter 2 – Atom, Molecules, and Ions

7. How many protons, neutrons, and electrons are in the following atoms or ions?

a) iron–56

b) the element with symbol W and 109 neutrons

c) the +3 ion with the symbol Ga and 39 neutrons

8. Name the following compounds:

a) $CuCl_2$	b) $Fe(NO_3)_3$	c) AlI_3	d) $Ca_3(PO_4)_2$
e) $NiSO_3$	f) $BaCO_3$	g) PCl_3	h) $NaNO_2$
i) XeF_4	j) H_2SO_4 (aq)	k) HNO_3 (aq)	l) LiBr
m) ZnO	n) Au_2S_3	o) N_2O_4	p) HCl (g)
q) LiCN	r) KOH	s) Li_3N	t) FeO

9. Give the formula of the following compounds:

a) copper(II) hydroxide
b) sulfurous acid
c) sodium carbonate
d) sulfur trioxide
e) lithium chloride
f) ferrous bromide
g) barium oxide
h) nitrogen triiodide
i) aluminum phosphate
j) hydrobromic acid
k) potassium bicarbonate
l) carbon monoxide
m) nickel nitrate
n) ammonium chloride
o) calcium hydride
p) sodium perchlorate

Chapter 3 – Mass Relationships in Chemical Reactions

10. Balance the following chemical equations. Classify each reaction as a combination, decomposition, single displacement, double displacement (metathesis), or combustion. (The latter topic is covered in Chapter 4 in our current textbook.)

a) ____ C_6H_{12} (l) + ____ O_2 (g) $\longrightarrow$ ____ CO_2 (g) + ____ H_2O (l)

b) ____ Zn (s) + ____ $Fe(NO_3)_3$ (aq) $\longrightarrow$ ____ Fe (s) + ____ $Zn(NO_3)_2$ (aq)

c) ____ $BaCl_2$ (aq) + ____ Na_2SO_4 (aq) $\longrightarrow$ ____ $BaSO_4$ (s) + ____ NaCl (aq)

d) ____ HgO (s) $\longrightarrow$ ____ Hg (l) + ____ O_2 (g)

e) ____ Al (s) + ____ O_2 (g) $\longrightarrow$ ____ Al_2O_3 (s)

11. Calculate the formula weight of the following compounds:

a) $Ca_3(PO_4)_2$ b) $C_{12}H_{22}O_{11}$ c) $CuSO_4 \cdot 5H_2O$

12. The element magnesium is found in nature as three isotopes with masses and abundances as follows: ^{24}Mg: 23.9924 amu, 78.70%; ^{25}Mg: 24.9938 amu, 10.13% and ^{26}Mg: 25.9898 amu, 11.17%. Calculate the average atomic weight magnesium.

13. How many moles are in the following?

a) 25.0 g of carbon b) 100 mL of water

14. How many ethyl alcohol *molecules* are in 50.0 mL of this substance? Ethyl alcohol has the molecular formula C_2H_6O and its density is 0.79 g/mL.

15. Hydrofluoric acid, HF (aq), cannot be stored in glass bottles because silicates in the glass are attacked by HF by the following reaction:

$$Na_2SiO_3\ (s) + 8HF\ (aq) \longrightarrow H_2SiF_6\ (aq) + 2NaF\ (aq) + 3H_2O\ (l)$$

How many moles of Na_2SiO_3 will react with 1.50 moles of HF?

16. How many grams of magnesium oxide will result when 10.0 g of magnesium ribbon is burned in air?

$$2\ Mg\ (s) + O_2\ (g) \longrightarrow 2\ MgO\ (s)$$

17. Silicon carbide, SiC, is prepared by heating SiO_2 with carbon at high temperature:

$$SiO_2\ (s) + 3\ C\ (s) \longrightarrow SiC\ (s) + 2\ CO\ (g)$$

How many grams of SiC can form when 3.00 g of SiO_2 and 4.50 g of carbon are reacted?

18. Calculate the percent carbon, hydrogen, and oxygen in aspirin, $C_9H_8O_4$.

19. A compound is analyzed and found to contain 10.4% C, 27.8% S, and 61.7% Cl by mass. What is the empirical formula of this compound?

20. Elemental analysis of a hydrocarbon determined that its empirical formula was CH_2. The molecular weight of the hydrocarbon was experimentally determined to be 168.3 g/mole. What is the molecular formula of the hydrocarbon?

Answers

Chapter 1 – Chemistry: The Study of Change

1. a) heterogeneous mixture b) solution (solid, of copper & zinc) c) solution

d) heterogeneous mixture e) solution (gaseous) f) compound

g) element h) element i) compound

2. You can find the page numbers for these and many more terms under the "Key Words" section at the end of each chapter – do review them!

3. a) 5' 10" = 60 in + 10 in = 70 in. (70 in/1)(2.54 cm/in)(1 m/100 cm) = **1.8 m**.

b) (55 mi/hr)(5280 ft/mi)(12 in/ft)(2.54 cm/in)(1 hr/60 min)(1 min/60 sec) = **2500 cm/sec**.

c) (5.0 qt/1)(1 gal/4 qt)(3.7854 L/gal) = **4.7 L**.

d) (1.00 ft^2/1)(12^2 in^2/ft^2)(2.54^2 cm^2/in^2) = **929 cm^2**.

e) (32.06 amu/1)(1 g/6.022 x 10^{23} amu) = **5.324 x 10^{-23} g**.

f) (25 g of carbon/1)(1 mole of carbon/12.011 g) = **2.1 mole of carbon**.

A note about atomic weight values: Depending on the textbook or periodic table which you use and how recent they are, you will likely find small differences in the atomic weight values. For example, our new textbook gives carbon's atomic weight as 12.0107 g/mole, while most other texts list it as 12.01115 g/mole, 12.011 g/mole, or even as 12.0 g/mole. Some of the variation is just due to the degree of rounding the authors chose to implement, but in some cases the differences are due to recent corrections when more accurate values are determined by experiment. At any rate, you should get into the habit right away of using atomic weight values with 4 or 5 significant digits in all of your calculations. In the above problem, we divided the grams of carbon by 12.011 g/mole, <u>not</u> by just 12 g/mole! Using very rounded atomic weight values is sloppy work; use good (accurate) values in your calculations, and then round your <u>final answer</u> appropriately.

g) (1.00 g of gold/1)(1 mole of gold/196.967 g)(6.022 x 10^{23} atoms of gold/mole of gold) = **3.06 x 10^{21} atoms of gold**.

h) ˚C = 5/9(25 ˚F – 32) = –3.9 ˚C. –3.9 ^{o}C + 273.15 = **269.3 K**.

4. a) 5 b) 4 c) 3 d) 2 e) 6 f) 1, 2, 3, or 4

5.
a) 0.37 g
b) 199 g
c) 1.2 g/mL

6. 10.867 g/8.5 mL = **1.3 g/mL**.

Chapter 2 – Atoms, Molecules, and Ions

7.
a) 26p, 30n, 26e
b) 74p, 109n, 74e
c) 31p, 39n, 28e

8.
a) copper(II) chloride or cupric chloride
b) iron(III) nitrate or ferric nitrate
c) aluminum iodide
d) calcium phosphate
e) nickel sulfite or nickel(II) sulfite
f) barium carbonate
g) phosphorus trichloride
h) sodium nitrite
i) xenon tetrafluoride
j) sulfuric acid (not "hydrogen sulfate")
k) nitric acid (not "hydrogen nitrate")
l) lithium bromide
m) zinc oxide
n) gold(III) sulfide or auric sulfide
o) dinitrogen tetroxide
p) hydrogen chloride (not hydrochloric acid)
q) lithium cyanide
r) potassium hydroxide
s) lithium nitride
t) iron(II) oxide or ferrous oxide

9.
a) $Cu(OH)_2$ b) H_2SO_3 c) Na_2CO_3 d) SO_3

e) $LiCl$ f) $FeBr_2$ g) BaO h) NI_3

i) $AlPO_4$ j) HBr (aq) k) $KHCO_3$ l) CO

m) $Ni(NO_3)_2$ n) NH_4Cl o) CaH_2 p) $NaClO_4$

Chapter 3 – Mass Relationships in Chemical Reactions

10.
- a) 1, 9, 6, 6 combustion
- b) 3, 2, 2, 3 single displacement
- c) 1, 1, 1, 2 double displacement (or "metathesis")
- d) 2, 2, 1 decomposition
- e) 4, 3, 2 combination

11. a) 310.177 g/mole b) 342.300 g/mole c) 249.686 g/mole

12. Average atomic weight = (0.7870)(23.9924 amu) + (0.1013)(24.9938 amu) + (0.1117)(25.9898 amu) = **24.317 amu**.

13. How many moles are in the following?

a) (25.0 g of carbon)(1 mole of carbon/12.011 g of carbon) = 2.08 mole of carbon.

b) (100 mL of water)(1.00 g of water/mL of water)(1 mole of water/18.0153 g of water) = **5.55 moles of water**.

(can be rounded to **6 moles** if "100 mL" is taken to have only one significant figure).

14. (50.0 mL)(0.79 g/mL)(1 mole/46.06904 g)(6.022×10^{23} molecules/mole) = **5.16×10^{23} molecules**.

15. (1.50 mole of HF)(1 mole of Na_2SiO_3/8 moles of HF) = **0.188 mole of Na_2SiO_3**.

16. (10.0 g of Mg)(1 mole of Mg/24.305 g of Mg)(2 moles of MgO/2 moles of Mg) x (40.3044 g of MgO/mole of MgO) = **16.6 g of MgO**.

17. First, we need to calculate the moles of the given amounts and determine which is the **limiting reactant**.

moles of SiO_2 = 3.00 g/60.0843 g/mole = 0.0499 mole of SiO_2

moles of C = 4.50 g/12.011 g/mole = 0.375 mole of C

At this point, there are two approaches we can take to determine which reactant is limiting. The first is to compare the ratio of the coefficients of these reactants in the balanced chemical equation with the ratios of the moles we calculated above:

From the balanced equation: moles of C/moles of SiO_2 = 3 moles/1mole = 3.

Compare to the given amounts: 0.375 mole of C/0.0499 mole of SiO_2 = 7.51.

Since 7.51 is greater than 3, we can see that carbon is in excess amount, and therefore the limiting reactant is **SiO_2**.

A second way to determine the limiting reactant is to calculate the moles of SiC product starting first with 0.375 mole of carbon, and then repeat the calculation starting with 0.0499 moles of SiO_2, and see which gives the least amount of SiC product. The reactant which gives the lesser number of moles of product will be the limiting reactant.

Since we know that SiO_2 is the limiting reactant here, we will calculate the grams of SiC product starting with moles of SiO_2:

(0.0499 mole of SiO_2)(1 mole of SiC/1mole of SiO_2)(40.0965 g of SiC/mole of SiC) = **2.00 g of SiC**.

18. Assume for simplicity that we have 1 mole of aspirin ($C_9H_8O_4$).

9 moles of C x 12.011 g/mole = 108.10 g of C
8 moles of H x 1.008 g/mole = 8.064 g of H
4 moles of O x 15.9994 g/mole = 63.9976 g of O
180.16 g total

Percent C = 108.10 g/180.16 g x 100 = **60.002 %**
Percent H = 8.064 g/180.16 g x 100 = **4.476 %**
Percent O = 63.9976 g/180.16 g x 100 = **35.523 %**
100.001 % total (☺)

19. Assume for simplicity that we have 100 g of compound. That means we have 10.4 g of carbon, 27.8 g of sulfur, and 61.7 g of chlorine in the 100 g of sample.

moles of C = 10.4 g/12.011 g/mole = 0.866 mole (Note that we are dividing, not multiplying, this time!)
moles of S = 27.8 g/32.066 g/mole = 0.867 mole
moles of Cl = 61.7 g/35.453 g/mole = 1.74 moles

At this point our formula is "$C_{0.866}S_{0.867}Cl_{1.74}$". Dividing through by the smallest subscript (0.866) gives $C_{1.00}S_{1.00}Cl_{2.01}$ indicating that the empirical formula is **$CSCl_2$**.

20. First, calculate the formula weight of the given empirical formula, which for CH_2 is 14.027 g/mole. Then, see how many times this formula weight will divide into the molecular weight: (168.3 g/mole)/(14.027 g/mole) = 12.00. Therefore, we multiply the empirical formula through by 12 to obtain the molecular formula: 12 x CH_2 → **$C_{12}H_{24}$**.