Practice Problems for the Chapter 2-7 Test! Sarah

I. Mole Conversions

1a. What is the molar mass of Calcium phosphate; $Ca_3(PO_4)_2$?

$3(40.078)+2(30.9738)+8(15.9994) = 310.1768 \rightarrow$ **310.177 g/mole** 1a

b. What is the mass of 0.123 moles of calcium phosphate?

$(0.123 \text{ moles})\left(\frac{310.1768 \text{ g}}{1 \text{ mole}}\right) = 38.152 \rightarrow$ **38.2 g** 1b

c. Convert 5.0 grams of calcium phosphate into moles.

$(5.0 \text{ g})\left(\frac{1 \text{ mole}}{310.1768 \text{ g}}\right) = 0.0161 \rightarrow$ **.016 moles** 1c

2a. Convert 100.0 grams of copper (II) nitrate to moles. $Cu(NO_3)_2$

$(100.0 \text{ g})\left(\frac{1 \text{ mole}}{187.5558 \text{ g}}\right) =$ **0.5332 moles** 2a

b. Convert 1.0×10^{22} chlorine molecules into moles of chlorine gas.

$(1.0 \times 10^{22} \text{ molecules})\left(\frac{1 \text{ mole}}{6.02 \times 10^{23} \text{ molecules}}\right) =$ **0.017 moles** 2b

c. Find the mass of 1.0×10^{22} chlorine molecules. (Cl_2)

$(1.0 \times 10^{22} \text{ molecules})\left(\frac{1 \text{ mole}}{6.02 \times 10^{23} \text{ molecules}}\right)\left(\frac{70.90 \text{ g}}{1 \text{ mole}}\right) = 1.177 \rightarrow$ **1.2 g Cl_2** 2c

d. How many atoms are in 1.0×10^{22} chlorine molecules?

$(1.0 \times 10^{22} \text{ molecules } Cl_2)\left(\frac{2 \text{ atoms}}{1 \text{ molecule}}\right) =$ **2.0×10^{22} atoms** 2d

3. What is the mass of one Cobalt atom, in grams?

$(1 \text{ atom})\left(\frac{1 \text{ mole}}{6.02 \times 10^{23} \text{ atoms}}\right)\left(\frac{58.9332 \text{ g}}{1 \text{ mole}}\right) =$ **9.79×10^{-23} g** 3

4a. Convert 8.4 grams of sulfur trioxide gas into molecules.

$(SO_3)\ (8.4 \text{ g})\left(\frac{1 \text{ mole}}{80.0632 \text{ g}}\right)\left(\frac{6.02 \times 10^{23} \text{ molecules}}{1 \text{ mole}}\right) =$ **6.3×10^{22} molecules** 4a

(6.316×10^{22} before rounding ↑)

b. How many total atoms are in the 8.4 grams of sulfur trioxide?

$(6.316 \times 10^{22} \text{ molecules})\left(\frac{4 \text{ atoms}}{1 \text{ molecule}}\right) =$ **2.5×10^{23} atoms** 4b

4c. What is the mass of 4.0×10^{23} molecules of P_2O_5?

$$(4.0\times10^{23}\text{ molecules})\left(\frac{1\text{ mole}}{6.02\times10^{23}\text{ molecules}}\right)\left(\frac{141.9446\text{ g}}{1\text{ mole}}\right) = \boxed{94\text{ g}}$$ 4c

d. How many atoms are in the above sample (in c)?

$$(4.0\times10^{23}\text{ molecules})\left(\frac{7\text{ atoms}}{1\text{ molecule}}\right) = \boxed{2.8\times10^{24}\text{ atoms}}$$ 4d

e. How many moles of P_2O_5 are in the sample (in c)?

$$(4.0\times10^{23}\text{ molecules})\left(\frac{1\text{ mole}}{6.02\times10^{23}\text{ molecules}}\right) = \boxed{0.66\text{ moles}}$$ 4e

II. Percent Composition

5a. Determine the percent sulfur (by mass) in $K_2S_2O_3$.

$$\frac{2(32.065)\text{ amu}}{2(39.0983)+2(32.065)+3(15.9994)\text{ amu}}\times100 = \frac{64.130\text{ amu}}{190.3248\text{ amu}}\times100 = \boxed{33.695\ \%\ S}$$ 5a

b. What mass of $K_2S_2O_3$ would contain 75 grams of sulfur?

$$\frac{33.69503}{100} = \frac{75\text{ g}}{x} \qquad x = 222.58 \rightarrow \boxed{220\text{ g } K_2S_2O_3}$$ 5b

c. Determine the percent iron (by mass) in $Fe_2(CO_3)_3$.

$$\frac{2(55.845)\text{ amu}}{291.7179\text{ amu}}\times100 = \boxed{38.287\ \%\ Fe}$$ 5c

d. How many milligrams of iron are in a 250 mg sample of iron (III) carbonate?

$$\frac{38.28703}{100} = \frac{x}{250\text{ mg}} \qquad x = 95.717 \rightarrow \boxed{96\text{ g Fe}}$$ 5d

6. A chemist has a sample of gold (III) nitrate, from which she plans to extract gold.

$Au(NO_3)_3$ $\quad \%\ Au = \frac{196.9665\text{ amu}}{382.9813\text{ amu}}\times100 = 51.42982\ \%\ Au$

a. What mass of gold could she extract from 80.0 grams of gold III nitrate?

$$\frac{51.42982}{100} = \frac{x}{80.0\text{ g}} \qquad x = \boxed{41.1\text{ grams Au}}$$ 6a

b. If she plans to extract 50.0 grams of gold, what mass of gold III nitrate would she need to start with?

$$\frac{51.42982}{100} = \frac{50.0\text{ g}}{x} \qquad x = \boxed{97.2\text{ g } Au(NO_3)_3}$$ 6b

7. Another chemist did an experiment to determine the percent gold in gold (III)nitrate. Gold nitrate was added to water and dissolved, and then reacted with zinc in order to extract the gold from gold (III) nitrate.

Data was as follows: Mass of empty flask: 23.22 g
Mass of flask and gold nitrate (before adding water): 25.12 g
Mass of empty beaker: 33.30 g
Mass of beaker and dry gold crystals collected after the reaction: 34.26 g

Use the lab data to determine the percent gold (by mass) in the compound gold nitrate.

$25.12\,g - 23.22\,g = 1.90\,g$ "gold nitrate"

$34.26\,g - 33.30\,g = 0.96\,g$ gold (Au)

$$\%\,Au = \frac{\text{mass Au}}{\text{mass gold nitrate}} \times 100 = \frac{0.96\,g}{1.90\,g} \times 100 = 50.526 \rightarrow \boxed{51\,\%\,Au}$$

#7

8. Some iron powder is burning in a crucible and the following lab data is obtained.

Mass of crucible:	16.78 g
Mass of crucible and iron powder (before burning):	18.14 g
Mass of crucible and iron oxide (after burning):	18.50 g

Calculate the percent iron in the iron oxide that formed, according to this lab data.

$18.14\,g - 16.78\,g = 1.36\,g$ iron

$18.50\,g - 16.78\,g = 1.72\,g$ iron oxide

$$\%\,iron = \frac{\text{mass iron}}{\text{mass iron oxide}} \times 100 = \frac{1.36\,g}{1.72\,g} \times 100 = 79.0697 \rightarrow \boxed{79.1\,\%\,Fe}$$

#8

III. Empirical and Molecular Formula:

9. What is the empirical formula of each compound here:

C_4H_8 CH_2 C_4H_{10} C_2H_5 $C_6H_{14}O_4$ $C_3H_7O_2$ $C_6H_{12}N_6O_9$ $C_2H_4N_2O_3$

10. "Hexane" is an organic liquid that contains only carbon and hydrogen. It is 83.6% carbon by mass.

a. Calculate the the empirical formula of hexane. $100 - 83.6 = 16.4\,\%$ Hydrogen

(assume I have 100 g)

$(83.6\,g\,C)\left(\frac{1\,mole}{12.011\,g}\right) = 6.9603$ moles C $\quad \frac{6.9603}{6.9603} = 1$ $\quad (C_1H_{2\frac{1}{3}})(3) =$

$(16.4\,g\,H)\left(\frac{1\,mole}{1.0079\,g}\right) = 16.271$ moles H $\quad \frac{16.271}{6.9603} = 2.34 \approx 2\frac{1}{3}$ $\quad \boxed{C_3H_7}$

#10a

* 12.011 and 1.0079 were the atomic masses, but we only need a rough value of the empirical mass.

10b. The molar mass of hexane is between 75 and 100 amu. Determine the molecular formula of hexane.

The empirical formula (from 10a) was C_3H_7

empirical mass $\approx 3(12^*) + 7(1^*)$ or 43 amu

$\frac{75}{43} = 1.7$ $\frac{100}{43} = 2.3$ So need factor of 2

$(C_3H_7)(2) = \boxed{C_6H_{14}}$ # 10b

11. A compound is 60.9 % carbon, 4.38 % hydrogen, and 34.8 % oxygen (by mass).

a. Determine the empirical formula of the compound. (assume I have 100 g)

$(60.9\text{ g C})\left(\frac{1\text{ mole}}{12.011\text{ g}}\right) = 5.0704\text{ moles C}$ $\frac{5.0704}{2.1751} = 2.33 \approx 2\frac{1}{3}$

$(4.38\text{ g H})\left(\frac{1\text{ mole}}{1.0079\text{ g}}\right) = 4.3457\text{ moles H}$ $\frac{4.3457}{2.1751} = 1.9979 \approx 2$

$(34.8\text{ g O})\left(\frac{1\text{ mole}}{15.9994\text{ g}}\right) = 2.1751\text{ moles O}$ $\frac{2.1751}{2.1751} = 1$

$(C_{2\frac{1}{3}}H_2O_1)(3) = \boxed{C_7H_6O_3}$ 11a

b. Determine the molecular formula of the compound, if the molar mass is between 500 and 600 g/mole.

empirical mass of $C_7H_6O_3 \approx 7(12) + 6(1) + 3(16) = 138$ g/mole

$\frac{500}{138} = 3.62$ $\frac{600}{138} = 4.34$ so multiply by factor of 4

$(C_7H_6O_3)(4) = \boxed{C_{28}H_{24}O_{12}}$ 11b

12. A compound contains 11.7 grams iron per 10.1 grams sulfur and 20.2 grams oxygen.

a. Calculate the empirical formula of the compound.

$(11.7\text{ g Fe})\left(\frac{1\text{ mole}}{55.845\text{ g}}\right) = 0.20951\text{ moles Fe}$ $\frac{0.20951}{0.20951} = 1$

$(10.1\text{ g S})\left(\frac{1\text{ mole}}{32.065\text{ g}}\right) = 0.31499\text{ moles S}$ $\frac{0.31499}{0.20951} = 1.5002 \approx 1\frac{1}{2}$

$(20.2\text{ g O})\left(\frac{1\text{ mole}}{15.9994\text{ g}}\right) = 1.2625\text{ moles O}$ $\frac{1.2625}{0.20951} = 6.025 \approx 6$

$(Fe_1S_{1\frac{1}{2}}O_6)(2) = \boxed{Fe_2S_3O_{12}}$ # 12a

b. This compound has the (incomplete) name of "iron sulfate." Is it iron II sulfate or iron III sulfate?

Iron(II) sulfate is $FeSO_4$

Iron(III) sulfate is $Fe_2(SO_4)_3$ ← expands out to $Fe_2S_3O_{12}$

It is $\boxed{\text{Iron III sulfate}}$ (aka "ferric sulfate")

12b

IV. Protons, Neutrons, Electrons, Periodic Table

You should be able to do all of #13 and #14 without an ion sheet. You will need a periodic table. (Use a periodic table that doesn't show any ion charges, like the one on the yellow data sheet or the tables on our classroom walls.)

13a. What is the difference between an atom and an ion?

Atoms have no charge/are neutral/are neutrally charged. so in an atom, the number of protons is equal to the # of electrons.

Ions have a charge (can be positive or negative) so in an ion, the # protons ≠ # electrons.

b. How many electrons are lost/gained when a calcium atom forms an ion? 2 lost, to form Ca^{+2}

c. How many electrons are lost/gained when a phosphorus atom forms an ion? 3 gained, to form P^{-3}

d. How many electrons must an aluminum ion gain or lose in order to become an aluminum atom? 3 lost, to form Al^{+3}

They lost ~~of~~ gained e- to acquire the same number of e- as the nearest noble gas.

14a. Which column on the periodic table contains elements that don't tend to bond? VIII A / Noble gases (He, Ne, Ar, Kr, Xe, Rn, Og)

b. For each column/family on the periodic table, indicate what charge of ion the elements typically form:

IA	IIA	IIIA	VA	VIA	VIIA
+1	+2	+3	-3	-2	-1
(loses 1 e-)	(loses 2e-)	(loses 3e-)	(gains 3e-)	(gains 2e-)	(gains 1e-)

15.

	Mass #	Symbol	# of protons	# of electrons	# of neutrons	Charge
a.	192	$^{192}Ir^{+3}$	77	74	115	+3
b.	80	$^{80}Se^{-2}$	34	36	46	-2
c.	193	$^{193}Pt^{+4}$	78	74	115	+4
d.	131	$^{131}I^{-1}$	53	54	78	-1

e. An ion has a mass number of 140, and has 83 neutrons and 54 electrons. Write the symbol of the ion (in the same style as in a-d, above.) $^{140}La^{+3}$

f. A lead atom lost two electrons to form an ion. It has 128 neutrons. Write the symbol of the ion. $^{210}Pb^{+2}$

g. If a tellurium atom with 73 neutrons gains 2 electrons, write the symbol for what forms. $^{125}Te^{-2}$

V. Ionic and Covalent Bonding, Formulas, Names

16a. Identify each element as a metal or a nonmetal, and indicate whether the element will be more likely to gain or lose electron(s) when it forms an ion.

P	Li	Zn	Cl	Ca
nonmetal gains e-	metal loses e-	metal loses e-	nonmetal gains e-	metal loses e-

b. When the above atoms form ions, which one will NOT form an ion with the same number of elctrons as a noble gas?

Zinc. It would need to gain 6e- (or lose 12 e-) to acquire the same # of electrons as the nearest noble gas, which is too many e- to gain or lose.

c. Identify a pair of atoms from part (a) that could bond together to form an ionic compound.

Need a metal and nonmetal Li and P, Li and Cl, Zn and P, Zn and Cl, Ca and P, Ca and Cl (any of these pairs would work)

d. Identify a pair of atoms from part (a) that could bond together to form a covalent compound.

need two nonmetals, so Cl and P

17. Determine the name (if the formula is given) or formula (if the name is given) of the following substances.

potassium nitride K_3N	lead (IV) sulfate $Pb(SO_4)_2$	NH_4NO_2 ammonium nitrite	helium He
CS_2 Carbon disulfide	$Ca(ClO_2)_2$ Calcium Chlorite	Iodine I_2	silver carbonate Ag_2CO_3
BaI_2 Barium iodide	magnesium phosphide Mg_3P_2	SnO Tin(II) oxide (Stannous oxide)	B_2Br_4 diboron tetrabromide
PI_3 phosphorus triiodide	Iron (II) peroxide FeO_2	phosphorus pentabromide PBr_5	Na_2O sodium oxide

aluminum sulfide Al_2S_3	$CuC_2H_3O_2$ copper I acetate or cuprous acetate	S_2F_{10} disulfur decafluoride	Cu_2O copper I oxide or cuprous oxide
Cl_2O_7 dichlorine heptoxide	$Li_2Cr_2O_7$ lithium dichromate	ferric chromate $Fe_2(CrO_4)_3$	bromine Br_2
aluminum thiosulfate $Al_2(S_2O_3)_3$	I_2S diiodine monosulfide	B_3P_5 triboron pentaphosphide	As_4O_6 tetraarsenic hexoxide

18. For each of the first six compounds in #17 (the first 6 in the left hand column), answer these questions:
a. Is the compound ionic or covalent?
b. When elements bond to form the compound, will the elements need to gain, lose, or share electrons to form the bond?
c. If the elements must gain or lose electrons to form the compound, which element will lose electrons in order to bond, and which will gain electrons in order to bond?

Potassium nitride (K_3N) is ionic

potassium (the metal) must lose e- to form the compound
nitrogen (the nonmetal) must gain e- to form the compound.

Carbon disulfide (CS_2) is covalent.
Carbon and Sulfur (both nonmetals) share electrons.

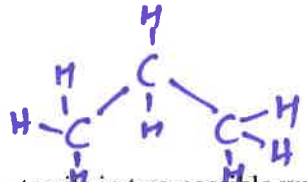
Barium iodide (BaI_2) is ionic.
Barium (the metal) must lose e- to form the compound
iodine (the nonmetal) must gain e- to form the compound

Phosphorus triiodide (PI_3) is covalent.
Phosphorus and Iodine (both nonmetals) must share e- to form the cpd.

Aluminum sulfide (Al_2S_3) is ionic
Al (the metal) loses e- to form the cpd. S (nonmetal) gains e-

Cl_2O_7 is covalent.
Cl and O (both nonmetals) share e- to form the compound.

More Mole Conversion Practice!



1. Propane has the formula C_3H_8.

a. Find the molar mass of propane. Report units in two possible ways.

$3(12.011) + 8(1.0079) = 44.0962 \rightarrow$ **44.096 g/mole** or **44.096 amu** 1a 1a

b. If a propane tank contains 13500 grams of propane, how many molecules of propane are in the tank?

$$(13500\text{ g})\left(\frac{1\text{ mole}}{44.0962\text{ g}}\right)\left(\frac{6.02\times10^{23}\text{ molecules}}{1\text{ mole}}\right) = \mathbf{1.84\times10^{26}\text{ molecules}}$$ 1b

c. Convert 4.0×10^{22} propane molecules to moles.

$$(4.0\times10^{22}\text{ molecules})\left(\frac{1\text{ mole}}{6.02\times10^{23}\text{ molecules}}\right) = \mathbf{0.066\text{ moles}}$$ 1c

d. How many total atoms are in the 4.0×10^{22} molecules of propane?

$$(4.0\times10^{22}\text{ molecules})\left(\frac{11\text{ atoms}}{1\text{ molecule}}\right) = \mathbf{4.4\times10^{23}\text{ atoms}}$$ 1d

C_3H_8: $3 + 8 = 11$

2. a. What is the mass of 3.00×10^{21} uranium atoms?

$$(3.00\times10^{21}\text{ atoms})\left(\frac{1\text{ mole}}{6.02\times10^{23}\text{ atoms}}\right)\left(\frac{238.03\text{ g}}{1\text{ mole}}\right) = \mathbf{1.19\text{ g}}$$ 2a

b. Convert 345 grams of bromine to molecules.

Br_2! $(345\text{ g})\left(\frac{1\text{ mole}}{159.8089\text{ g}}\right)\left(\frac{6.02\times10^{23}\text{ molec.}}{1\text{ mole}}\right) = \mathbf{1.30\times10^{24}\text{ molecules}}$ 2b

c. How many hydrogen peroxide molecules are in 0.0015 moles of hydrogen peroxide?

H_2O_2 $(.0015\text{ moles})\left(\frac{6.02\times10^{23}\text{ molecules}}{1\text{ mole}}\right) = 9.03\times10^{20} \rightarrow$ **9.0×10^{20} molecules** 2c

d. 1 cup of table sugar (sucrose; $C_{12}H_{22}O_{11}$) has a mass of approximately 290 grams. How many sucrose molecules are in this mass?

$$(290\text{ g})\left(\frac{1\text{ mole}}{342.2992\text{ g}}\right)\left(\frac{6.02\times10^{23}\text{ molecules}}{1\text{ mole}}\right) = \mathbf{5.1\times10^{23}\text{ molecules}}$$ 2d

$C_{12}H_{22}O_{11}$: 12 + 22 + 11 = 45 atoms in a molecule

e. How many atoms are in 1.00×10^{20} sucrose molecules?

$$(1.00\times10^{20}\ \text{molecules})\left(\frac{45\ \text{atoms}}{1\ \text{molecule}}\right) = \boxed{4.5\times10^{21}\ \text{atoms}}$$ 2e

f. What is the mass (in grams) of 1 molecule of sucrose?

$$(1\ \text{molecule})\left(\frac{1\ \text{mole}}{6.02\times10^{23}\ \text{molecules}}\right)\left(\frac{342.2992\ \text{g}}{1\ \text{mole}}\right) = \boxed{5.69\times10^{-22}\ \text{g}}$$ 2f

3. a. Determine the molar mass of copper (II) phosphate; $Cu_3(PO_4)_2$

$3(63.546) + 2(30.9738) + 8(15.9994) = 380.5808 \rightarrow \boxed{380.581\ \frac{\text{g}}{\text{mole}}}$ 3a

b. Convert 32.21 grams of copper (II) phosphate to moles.

$$(32.21\ \text{g})\left(\frac{1\ \text{mole}}{380.5808\ \text{g}}\right) = \boxed{0.08463\ \text{moles}}$$ 3b

c. What is the percent composition (by weight) of phosphorus in this compound?

$$\frac{2(30.9738)}{380.5808}\times100 = 16.27712 \rightarrow \boxed{16.2771\%\ \text{P}}$$ 3c

d. If 3.00 grams of phosphorus were extracted from copper (II) phosphate, how many grams of copper (II) phosphate were initially present?

$$\frac{16.27712}{100} = \frac{3.00\ \text{g}}{x} \qquad x = \boxed{18.4\ \text{g}\ Cu_3(PO_4)_2}$$ 3d

e. How many grams of phosphorus can be extracted from 30.0 grams of copper (II) phosphate?

$$\frac{16.27712}{100} = \frac{x}{30.0\ \text{g}} \qquad \boxed{x = 4.88\ \text{g phosphorus}}$$ 3e

4. Determine the empirical formula of $C_{20}H_{36}O_8$ (divide all by 4)

$\boxed{C_5H_9O_2}$ 4.

5. A compound is 53.31% carbon, 35.51% oxygen, and 11.12% hydrogen, by weight. Determine the empirical formula.

$(53.31\text{ g C})\left(\frac{1\text{ mole}}{12.011\text{ g}}\right) = 4.4384\text{ moles C}$ $\quad \frac{4.4384}{2.21946} = 1.9998 \approx 2$

$(35.51\text{ g O})\left(\frac{1\text{ mole}}{15.9994\text{ g}}\right) = 2.21946\text{ moles O}$ $\quad \frac{2.21946}{2.21946} = 1$

$(11.12\text{ g H})\left(\frac{1\text{ mole}}{1.0079\text{ g}}\right) = 11.0328\text{ moles H}$ $\quad \frac{11.0328}{2.21946} = 4.97 \approx 5$

$C_2O_1H_5 \rightarrow \boxed{C_2H_5O}$

6. A compund is 39.34% carbon, 8.25% hydrogen, and 52.41% oxygen by weight. The molar mass of the compound is between 225 and 250 amu.

a. Determine the empirical formula.

$(39.34\text{ g C})\left(\frac{1\text{ mole}}{12.011\text{ g}}\right) = 3.2753\text{ moles C}$ $\quad \frac{3.2753}{3.2753} = 1$

$(8.25\text{ g H})\left(\frac{1\text{ mole}}{1.0079\text{ g}}\right) = 8.1853\text{ moles H}$ $\quad \frac{8.1853}{3.2753} = 2.499 \approx 2\frac{1}{2}$

$(52.41\text{ g O})\left(\frac{1\text{ mole}}{15.9994\text{ g}}\right) = 3.2757\text{ moles O}$ $\quad \frac{3.2757}{3.2753} = 1.0001 \approx 1$

$(C_1H_{2\frac{1}{2}}O_1)(2) = \boxed{C_2H_5O_2}$

b. Determine the molecular formula.

empirical mass of $C_2H_5O_2 = 2(12) + 5(1) + 2(16) = 61\ \frac{g}{mole}$

$\frac{225}{61} = 3.69$ $\quad \frac{250}{61} = 4.1$ $\quad$ so multiply by $\underline{4}$

$(C_2H_5O_2)(4) = \boxed{C_8H_{20}O_8}$

Answers to the mole conversion practice:

1a. 44.096. amu or 44.096 g/mole <---- notice it is g/mole, not just g.
1b. 1.84×10^{26} molecules c. 0.066 moles d. 4.4×10^{23} atoms
2. a. 1.19 g b. 1.30×10^{24} molecules c. 9.0×10^{20} molecules d. 5.1×10^{23} molecules.
2e. 4.5×10^{21} atoms 2f. 5.69×10^{-22} g
3. a. 380.581 amu or g/mole b. 0.08463 moles c. 16.2771% P d. 18.4 g e. 4.88 g
4. $C_5H_9O_2$ 5. C_2H_5O 6a. $C_2H_5O_2$ b. $C_8H_{20}O_8$