Chapter ~~5~~ 2-7 Study Guide Answer Key

I. Mole Conversions

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

$3(40.08) + 2(30.97376) + 8(15.9994) = 310.18272 \rightarrow$ **310.18 g/mole** or amu (a)

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

$(0.123 \text{ moles})\left(\frac{310.18272 \text{ g}}{1 \text{ mole}}\right) = 38.152 \rightarrow$ **38.2 grams** (b)

c. Convert 5.0 grams of calcium phosphate into moles.

$(5.0 \text{ g})\left(\frac{1 \text{ mole}}{310.18272 \text{ g}}\right) = 0.0161195 \rightarrow$ **0.016 moles** (c)

2a. Convert 100.0 grams of copper (II) nitrate to moles.

$(100.0 \text{ g } Cu(NO_3)_2)\left(\frac{1 \text{ mole}}{187.5558 \text{ g}}\right) =$ **0.5332 moles** 2a

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

$(1.0 \times 10^{22} \text{ } Cl_2 \text{ molecules})\left(\frac{1 \text{ mole}}{6.02 \times 10^{23} \text{ molecules}}\right) = 0.01661 \rightarrow$ **0.017 moles** 2b

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

$(1.0 \times 10^{22} \text{ } Cl_2 \text{ molecules})\left(\frac{1 \text{ mole}}{6.02 \times 10^{23} \text{ molecules}}\right)\left(\frac{70.906 \text{ g}}{\text{mole}}\right) = 1.1778 \text{ g}$

1.2 g 2c

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

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

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

$(1 \text{ atom Cobalt})\left(\frac{1 \text{ mole}}{6.02 \times 10^{23} \text{ atoms}}\right)\left(\frac{58.933 \text{ g}}{1 \text{ mole}}\right) =$ **9.79×10^{-23} grams** (3)

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

$(8.4 \text{ g } SO_2)\left(\frac{1 \text{ mole}}{64.0628 \text{ g}}\right)\left(\frac{6.02 \times 10^{23} \text{ molecules}}{1 \text{ mole}}\right) =$ **7.9×10^{22} molecules** 4a

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

$(7.8935 \times 10^{22} \text{ molecules } SO_2)\left(\frac{3 \text{ atoms}}{1 \text{ molecule } SO_2}\right) = 2.3681 \rightarrow$ **2.4×10^{23} atoms** 4b

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

$(4.0 \times 10^{23} \text{ molecules})\left(\frac{1 \text{ mole}}{6.02 \times 10^{23} \text{ molecules}}\right)\left(\frac{141.94452 \text{ g}}{\text{mole}}\right) =$ **94 grams** 4c

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

$(4.0 \times 10^{23} \text{ molecules } P_2O_5)\left(\frac{7 \text{ atoms}}{1 \text{ molecule}}\right) =$ **2.8×10^{24} atoms** 4d

e. How many moles of P_2O_5 are in the above sample (in c/d)

$(4.0 \times 10^{23} \text{ molecules})\left(\frac{1 \text{ mole}}{6.02 \times 10^{23} \text{ molecules}}\right) =$ **0.66 moles** 4e

II. Protons, Neutrons, Electrons, Periodic Table

5a. What is the difference between an atom and an ion?

Atoms are neutral (so the number of protons = the number of electrons)

Ions are charged (number of protons ≠ the number of electrons)

b. How many electrons are lost/gained when a calcium atom forms an ion? 2 lost

Ca atom 20p, 20e Ca^{+2} ion 20p, 18e

c. How many electrons are lost/gained when a phosphorus atom forms an ion? 3 gained

P atom 15p, 15e P^{-3} 15p, 18e⁻

d. How many electrons must an aluminum ion gain or lose in order to become an aluminum atom? 3 gained

Al^{+3} ion 13p, 10e Al atom 13p, 13e

6a. Which column on the periodic table contains elements that don't tend to bond? VIII A (Noble gases / inert gases)

b. Which elements in column IA form ions, what is the charge on the ion? +1

What about elements in IIA? +2 IIIA? +3 VA −3 VIA −2 VIIA −1

c. What is the name of the family of elements in:

IA(except H) alkali metals IIA alkali earth metals VIIA halogens VIIIA noble gases / inert gases

8.

	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 (same style as in a-d): $^{140}La^{+3}$

140 − 83 = 57 protons

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

Pb: 82 protons 82 + 128 = 210

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

Te: # 52 52 + 73 = 125

9a. 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 nonmetal gain e⁻ | Li metal lose e⁻ | Zn metal lose e⁻ | Cl nonmetal gain e⁻ | Ca metal lose e⁻

b. Of the above elements, which one is LEAST likely to obtain a noble gas configuration when it forms an ion?

Zinc. it would have to lose 12 e⁻ or gain 6e⁻ to match a noble gas configuration. this is too many to gain/lose.

c. Find a pair of ions in 9a that could bond together to form an ionic compound.

Li and Cl, Li and P, Zn and Cl, Zn and P (need metal + nonmetal)

d. Find a pair of ions in 9a that could bond together to form a covalent compound.

P and Cl (need two nonmetals)

B C N O Al Nonmetals

Cu Zn metals (except H)

III Isotopes.

10. Chlorine has two common isotopes. 75.77% of chlorine atoms have a mass of 34.968853 amu, and the remainder of Cl atoms have a mass of 36.965903 amu.

a. What is the "natural abundance" of the Cl-37 isotope? 100 − 75.77 = 24.23%

b. Calculate the atomic mass of chlorine.

(0.7577)(34.968853 amu) + (0.2423)(36.965903 amu) = 35.4527 → 35.45 amu

c. Write the symbol for each of these chlorine isotope, in the same style as in #8.

^{35}Cl and ^{37}Cl (could do a zero for charge..)

d. How are the two isotopes of chlorine the same? Give at least two answers.

Same number of protons in nucleus. same reactivity (forms a −1 ion, etc)

same number of electrons as an element.

e. How are the two isotopes of chlorine different? Give at least two answers.

Different number of neutrons in nucleus.

Different atomic mass. (sometimes the number of neutrons affects whether the atom is radioactive, but not in this case)

11. 99.63% of nitrogen atoms have a mass of 14.003074, and the remainder have a mass of 15.000108 amu. Calculate the atomic mass of nitrogen. 100 − 99.63 = 0.37%

(.9963)(14.003074 amu) + (.0037)(15.000108 amu) = 14.006763 → 14.01 amu

12. (This type of question would be in the extra credit section if given on a test.) Boron has only two isotopes: B-10 (10.012936 amu), and B-11 (11.009305 amu). Use these masses, along with info from the periodic table, to determine the natural abundance percents for each boron isotope.

5 B 10.811 ← mass of 10.811 amu

$X(10.012936\text{ amu}) + (1-X)(11.009305\text{ amu}) = 10.811\text{ amu}$

$10.012936x + 11.009305 - 11.009305x = 10.811$

$0.198305 = 0.996369x$

$x = \frac{.198305}{.996369} = 0.19903$

19.9% B-10
80.1% B-11

IV. Percent Composition

13a. Determine the percent composition of iron in $Fe_2(CO_3)_3$.

$\frac{2(55.847)}{2(55.847) + 3(12.011) + 9(15.9994)} \times 100 = 38.28787$ → 38.288% Fe

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

$\frac{38.2887}{100} = \frac{x}{250\text{ mg}}$ $x = 95.7197$ → 96 mg Fe

Answers to #14 and #15 are on the next page!

I would have used this extra space to tell some chemistry jokes, but unfortunately all the good ones Argon. (sorry.)

V. Empirical Formula

16. What is the empirical formula of C_4H_8 CH_2 C_4H_{10} C_2H_5 $C_6H_{14}O_4$ $C_3H_7O_2$

17. "Hexane" is an organic liquid that contains only carbon and hydrogen. It is 83.6% carbon by mass. The molar mass of the compound is between 75 and 100 amu. $100 - 83.6 = 16.4$

Determine a) the empirical formula of hexane

$(83.6\text{ g C})\left(\frac{1\text{ mole}}{12.011\text{ g}}\right) = 6.9603\text{ moles C}$

$(16.4\text{ g H})\left(\frac{1\text{ mole}}{1.0079\text{ g}}\right) = 16.271\text{ moles H}$

$\frac{16.271}{6.9603} = 2.338 \approx 2\frac{1}{3}$

$(C_1H_{2\frac{1}{3}})\times 3 = C_3H_7$ (a) empirical form.

b) the molecular formula of hexane

C_3H_7 : $3(12) + 7(1) = 43$ amu $43 \times 2 = 86$, which is between 75 and 100

$(C_3H_7)(2) = C_6H_{14}$ (b) molecular formula

c) the molar mass of hexane.

$6(12.011) + 14(1.0079) =$ 86.177 amu (c)

14. A chemist has 150.2 grams of silver nitrate ($AgNO_3$). He plans to extract the silver from the silver nitrate using a physical/chemical change (which is it?). How many grams of silver can be extracted from this silver nitrate?

$$\%\ Ag \text{ in } AgNO_3 = \frac{107.868}{107.868 + 14.0067 + 3(15.9994)} \times 100 = 63.4992\%\ Ag$$

$$\frac{63.49924}{100} = \frac{x}{150.2\,g} \qquad 100x = 63.49924(150.2\,g)$$

$$x = \frac{63.49924(150.2\,g)}{100} = \boxed{95.38\,g\ Ag}$$

15a. A different chemist has a sample of gold (III) nitrate, from which she plans to extract gold. If she plans to extract 50.0 grams of gold, what mass of gold nitrate would she need to start with?

$Au(NO_3)_3$

$$\%\ Au \text{ in } Au(NO_3)_3 = \frac{196.967}{196.967 + 3(14.0067) + 9(15.9994)} \times 100 = 51.42987\%\ Au$$

$$\frac{51.42987}{100} = \frac{50.0\,g}{x} \qquad x = \frac{50.0\,g(100)}{51.42987} = \boxed{97.2\,g\ Au(NO_3)_3}$$

%

b. Another chemist did an experiment to determine the 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 [redacted] beaker and dry gold crystals collected after the reaction: 34.26 g

Use the data to determine the percent gold in the compound gold nitrate.

$$\text{Mass of gold nitrate} = 25.12\,g - 23.22\,g = 1.90\,g$$

$$\text{mass of gold collected} = 34.26\,g - 33.30\,g = 0.96\,g$$

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

c) calculate % error: $\%\ \text{error} = \left|\frac{\text{lab} - \text{book}}{\text{book}}\right|$

$$= \left|\frac{50.526 - 51.42987}{51.42987}\right| \times 100$$

$$= \frac{0.90387}{51.42987} \times 100 = 1.757\% \rightarrow \boxed{2\%\ \text{error.}}$$

18. Phenolphthalein is an acid-base indicator; it is pink in basic solutions and colorless in acidic and neutral solutions. Phenolphthalein is 75.5% carbon, 4.43 % hydrogen, and 20.1 % oxygen, by mass. It has a molar mass of roughly 300 amu. (I Assumed I had 100 g compand)
Determine a) the empirical formula, and b) the molecular formula of phenolphthalein.

$(75.5\text{ g C})\left(\frac{1\text{ mole}}{12.011\text{ g}}\right) = 6.2859\text{ moles C}$ $\quad \frac{6.2859}{1.2563} = 5.0035 \approx 5$

$(4.43\text{ g H})\left(\frac{1\text{ mole}}{1.0079\text{ g}}\right) = 4.3953\text{ moles H}$ $\quad \frac{4.3953}{1.2563} = 3.4986 \approx 3.5$

$(20.1\text{ g O})\left(\frac{1\text{ mole}}{15.9994\text{ g}}\right) = 1.2563\text{ moles O}$ $\quad \frac{1.2563}{1.2563} = 1$!!!

$C_{10}H_7O_2$: $10(12)+7(1)+2(16) = 159\ \frac{g}{mole}$ $\quad (C_5H_{3.5}O_1)\times 2 = C_{10}H_7O_2$ (a) empirical formula

$159 \times 2 = 318$ g/mole ← this is as close to 300 amu as we can get

$(C_{10}H_7O_2)(2) = C_{20}H_{14}O_4$ molecular formula (b)

VI. Formula Writing and Naming

19. 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
NO_2 nitrogen dioxide	$Ca(ClO_2)_2$ 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	Na_2O_2 Sodium peroxide
Cl_2O_7 dichlorine heptoxide	$Li_2Cr_2O_7$ lithium dichromate	ferric chromate $Fe_2(CrO_4)_3$	bromine Br_2
Aluminum thiosulfate $Al_2(S_2O_3)_3$	Br_2O dibromine monoxide	N_2O_5 dinitrogen monoxide	As_4O_6 tetraarsenic hexoxide

20. For each of the first six compounds in #19 (the compounds 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? (e⁻)

K_3N is ionic. potassium must lose electrons, nitrogen must gain electrons.
NO_2 is covalent. N and O share electrons to bond.
BaI_2 is ionic. Barium must lose e⁻; Iodine must gain e⁻
PI_3 is covalent. P and I share electrons to bond.
Al_2S_3 is ionic. Al must lose e⁻; S must gain e⁻, to bond.
Cl_2O_7 is covalent. Chlorine and Oxygen share e⁻ to bond.

VII. Significant figures and Scientific Notation:

21. Perform these operations and report the answer to the correct number of significant figures.

a. 1400 + 188 1588 → 1600

b. 1400.2 +188 1588.2 → 1588

c. 13.4 x 2111.11 28288.874 → 28300

d. 120/6.33 18.957 → 19

e. $(3622\ cm^3)(8\ g/cm^3)$ 28976 g → 30000 g

f. 13.4 + 2111.11 2124.51 → 2124.5

g. 600./6.0 100 → 1.0×10^2

h. 12.2 x 0.0011 .0134 2 → 0.013

i. 600./125 4.8 → 4.80

VIII.Density:

22. Copper has a density of 8.90 g/mL. Olive oil has a density of 0.89 g/mL

a. What is the volume of 600. grams of olive oil?

$D = \frac{m}{V}$ $VD = m$ $V = \frac{m}{D} = \frac{600.\ g}{0.89\ g/mL} = 674.16 \rightarrow$ 670 mL

b. What is the mass of a piece of copper that is 2.0 cm by 3.4 inches by 6.2 inches?

$V = l \cdot w \cdot h = (2.0\ cm)(3.4\ in)(6.2\ in)\left(\frac{2.54\ cm}{1\ inch}\right)^2 = 271.999\ cm^3$

$D = \frac{m}{V}$ $m = VD = (271.999\ cm^3)\left(8.90\ \frac{g}{cm^3}\right) = 2421\ g \rightarrow$ 2400 g

c. Determine the density of a rock, if the following data was collected:

Mass of the piece of rock: 2.40 grams

Initial level of water in a graduated cylinder: 6.1 mL

Volume of water and rock together in the grad. cylinder: 6.9 mL

6.9 mL − 6.1 mL = 0.8 mL

$D = \frac{m}{V} = \frac{2.40\ g}{0.8\ mL} = 3\ g/mL$ or $3\ g/cm^3$

23. Gold has a density of 19.3 g/cm^3. A piece of gold foil has a length of 5.00 inches and a width of 10.21 centimeters, and a mass of 20.52 grams.

a. Determine the ~~mass~~ Volume of the piece of foil.

$V = \frac{m}{D} = \frac{20.52\ g}{19.3\ \frac{g}{cm^3}} = 1.0632\ cm^3 \rightarrow$ 1.06 cm^3

b. Determine the thickness of this piece of foil.

$V = l \cdot w \cdot t$ $t = \frac{V}{l \cdot w} = \frac{(1.0632\ cm^3)}{(5.00\ in)\left(\frac{2.54\ cm}{inch}\right)(10.21\ cm)}$

$= 0.00819956\ cm \rightarrow$ 0.00820 cm

IX. Unit conversions 2.3

24. Make the following conversions. (See chart at the top of WS 4.0. A similar chart will be given on the test)

a. 340 nm to cm

$(340\,nm)\left(\frac{1\,cm}{10^7\,nm}\right) = 0.000034\,cm$ or $3.4\times10^{-5}\,cm$

b. 1.6×10^{-2} kilometers (km) to cm

$(1.6\times10^{-2}\,km)\left(\frac{10^5\,cm}{1\,km}\right) = 1.6\times10^3\,cm$ or $1600\,cm$

c. 0.872 m^3 to cm^3

$(0.872\,m^3)\left(\frac{100\,cm}{1\,m}\right)^3 = 0.872\,m^3\left(\frac{10^6\,cm^3}{1\,m^3}\right) = 8.72\times10^5\,cm^3$ or $872000\,cm^3$

d. 3650 inches to km

$(3650\,in)\left(\frac{2.54\,cm}{1\,inch}\right)\left(\frac{1\,km}{10^5\,cm}\right) = 0.0927\,km$

e. 0.00040micrograms per second to grams per hour.

$\left(\frac{0.00040\,\mu g}{s}\right)\left(\frac{1\,g}{10^6\,\mu g}\right)\left(\frac{60\,s}{min}\right)\left(\frac{60\,min}{hr}\right) = 1.44\times10^{-6} \rightarrow 1.4\times10^{-6}\,g/hr$ or $.0000014\,g/hr$

f. 0.55 liters of liquid to cm^3

$(0.55\,L)\left(\frac{1000\,mL}{1\,L}\right)\left(\frac{1\,cm^3}{1\,mL}\right) = 550\,cm^3$

g. 30.0 miles per hour to meters per second

$\left(\frac{30.0\,mile}{hr}\right)\left(\frac{1.61\,km}{mi}\right)\left(\frac{1000\,m}{1\,km}\right)\left(\frac{1\,hr}{60\,min}\right)\left(\frac{1\,min}{60\,s}\right) = 13.4\,m/s$

i. 0.500 kg copper to cm^3, if the density is 8.90 g/cm^3

$(0.500\,kg)\left(\frac{1000\,g}{1\,kg}\right)\left(\frac{1\,cm^3}{8.90\,g}\right) = 56.2\,cm^3$

j. 8450 cm^3 to ft^3

$(8450\,cm^3)\left(\frac{1\,inch}{2.54\,cm}\right)^3\left(\frac{1\,ft}{12\,in}\right)^3 = 0.298\,ft^3$

k. 4.4 liters of saltwater to grams, if the density is 1.1 g/mL

$(4.4\,L)\left(\frac{1000\,mL}{L}\right)\left(\frac{1.1\,g}{mL}\right) = 4840 \rightarrow 4800\,g$

l. 0.300 ~~cubic~~ square feet to cm^2.

$(.300\,ft^2)\left(\frac{12\,in}{1\,ft}\right)^2\left(\frac{2.54\,cm}{1\,inch}\right)^2 = 279\,cm^2$