WKS 3-3 & 3-4

Mole Conversions

Name Answer Key

Period __________

PART I: Find the Molar Masses (MM) for the following substances. *(Look up the mass of each element on the periodic table and add them all up.)* Write all molar masses with at least 4 sig figs.

a) MM of Al = 26.98 g/mol

b) MM of PCl_3 = 30.97 + 3(35.45) = 137.3 g/mol

c) MM of Na_2SO_4 = 2(22.99) + 32.07 + 4(16.00) = 142.1 g/mol

d) MM of $Mg(NO_3)_2$ = 24.31 + 2(14.01) + 6(16.00) = 148.3 g/mol

For the Rest of the WKS: Use the dimensional analysis/factor label method. Every number must have units. Write answers with correct number of sig figs.

PART II: Conversions between grams and moles. *(All molar mass values must have at least 4 sig figs.)*

Use: $\text{grams} \xleftrightarrow{\text{Molar Mass (? g/mol)}} \text{moles}$

1) 45.0 g of Ca = ? moles of Ca

$$45.0 \text{ g Ca} \times \frac{1 \text{ mol Ca}}{40.08 \text{ g Ca}} = \boxed{1.12 \text{ mol Ca}}$$

2) 0.0190 moles MgO = ? grams of MgO

MM MgO = 24.31 + 16.00 = 40.31 g/mol

$$0.0190 \text{ mol MgO} \times \frac{40.31 \text{ g MgO}}{1 \text{ mol MgO}} = \boxed{0.766 \text{ g MgO}}$$

3) 7.32 g of $Ba(OH)_2$ = ? moles of $Ba(OH)_2$

MM $Ba(OH)_2$ = 137.33 + 2(16.00) + 2(1.008) = 171.35 g/mol

$$7.32 \text{ g Ba(OH)}_2 \times \frac{1 \text{ mol Ba(OH)}_2}{171.35 \text{ g Ba(OH)}_2} = \boxed{0.0427 \text{ mol Ba(OH)}_2}$$

PART III: Conversions between moles and atoms or molecules

REMEMBER: $\text{moles} \xleftrightarrow[(6.022\times10^{23} \text{ atoms, mlcls, f.un./mol})]{\text{Avogadro's \#}} \text{atoms, mlcls, f. un.}$

4) 4.87×10^{23} atoms of H = ? moles of H

$$4.87\times10^{23} \text{ atoms H} \times \frac{1 \text{ mol H}}{6.022\times10^{23} \text{ atoms H}} = \boxed{0.809 \text{ mol H}}$$

5) 0.56 moles of PCl_5 = ? molecules of PCl_5

$$0.56 \text{ mol PCl}_5 \times \frac{6.022\times10^{23} \text{ mlcl PCl}_5}{1 \text{ mol PCl}_5} = \boxed{3.4\times10^{23} \text{ mlcl PCl}_5}$$

<u>PART IV:</u> Combination questions. Use your flow chart!!

$$\text{grams} \xleftrightarrow{\text{Molar Mass (? g/mol)}} \text{moles} \xleftrightarrow[(6.022\times10^{23}\text{ atoms, mlcls, or f.un./mol})]{\text{Avogadro's \#}} \text{atoms, mlcls, or f.un.}$$

6) 51 g of S = ? atoms of S *(g → moles → atoms)*

$$\underbrace{51\text{ g S}\times\frac{1\text{ mol S}}{32.06\text{ g S}}}_{\substack{1.59\text{ mol S*}\\ \text{*1 extra sig fig}}}\times\frac{6.022\times10^{23}\text{ atoms S}}{1\text{ mol S}}=\boxed{9.6\times10^{23}\text{ atoms S}}$$

7) 8.34×10^{23} formula units of $Fe_2(CO_3)_3$ = ? g of $Fe_2(CO_3)_3$ *(f.un. → moles → grams)*

MM $Fe_2(CO_3)_3$ = 2(55.85) + 3(12.01) + 9(16.00) = 291.73 g/mol

$$\underbrace{8.34\times10^{23}\text{ f.un. }Fe_2(CO_3)_3\times\frac{1\text{ mol }Fe_2(CO_3)_3}{6.022\times10^{23}\text{ f.un. }Fe_2(CO_3)_3}}_{\substack{1.385\text{ mol }Fe_2(CO_3)_3\text{*}\\ \text{*1 extra sig fig}}}\times\frac{291.73\text{ g }Fe_2(CO_3)_3}{1\text{ mol }Fe_2(CO_3)_3}=\boxed{404\text{ g }Fe_2(CO_3)_3}$$

8) 3.20 g of Ag_2SO_4 = ? formula units of Ag_2SO_4

MM Ag_2SO_4 = 2(107.87) + 32.06 + 4(16.00) = 311.80 g/mol

$$\underbrace{3.20\text{ g }Ag_2SO_4\times\frac{1\text{ mol }Ag_2SO_4}{311.80\text{ g }Ag_2SO_4}}_{\substack{0.01026\text{ mol }Ag_2SO_4\text{*}\\ \text{*1 extra sig fig}}}\times\frac{6.022\times10^{23}\text{ f.un. }Ag_2SO_4}{1\text{ mol }Ag_2SO_4}=\boxed{6.18\times10^{21}\text{ f.un. }Ag_2SO_4}$$

<u>PART V:</u> Mixed review (all types of mole conversions) with a few complications.

9) Which of the following has a greater mass: 2 atoms of lead or 5.1×10^{-23} moles of helium? (Show work.)

$$2\text{ atoms Pb}\times\frac{1\text{ mol Pb}}{6.022\times10^{23}\text{ atoms Pb}}\times\frac{207.2\text{ g Pb}}{1\text{ mol Pb}}=\boxed{6.881\times10^{-22}\text{ g Pb}}\text{ *Greater Mass}$$

$$5.1\times10^{-23}\text{ mol He}\times\frac{4.003\text{ g He}}{1\text{ mol He}}=\boxed{2.0\times10^{-22}\text{ g He}}$$

10) A 25.0 g sample of Cu_2S, has… MM Cu_2S = 2(63.55) + 32.06 = 159.16 g/mol

a) … how many formula units of Cu_2S?

$$\underbrace{25.0\text{ g }Cu_2S\times\frac{1\text{ mol }Cu_2S}{159.16\text{ g }Cu_2S}}_{\substack{0.1571\text{ mol }Cu_2S\text{*}\\ \text{*1 extra sig fig}}}\times\frac{6.022\times10^{23}\text{ f.un. }Cu_2S}{1\text{ mol }Cu_2S}=9.459\times10^{22}=\boxed{9.46\times10^{22}\text{ f.un. }Cu_2S}$$

b) … how many atoms of copper?

Easiest way:

$$9.45\times10^{22}\text{ f.un. }Cu_2S\times\frac{2\text{ atom Cu}}{1\text{ f.un. }Cu_2S}=\boxed{1.89\times10^{23}\text{ atoms Cu}}$$

11) How many moles of Br_2 are in a 22.5 mL sample of liquid Br_2? *Density of liquid Br_2 = 3.12 g/mL*

Hint: mL → g → moles

$$\underbrace{22.5\text{ mL }Br_2\times\frac{3.12\text{ g }Br_2}{1\text{ mL }Br_2}}_{70.2\text{ g }Br_2}\times\frac{1\text{ mol }Br_2}{159.81\text{ g }Br_2}=\boxed{0.439\text{ mol }Br_2}$$

PART VI: Molar Volume of Gases

Concept:

- Avogadro's Hypothesis states that "Equal volumes of gases at the same temperature and pressure have the same number of particles.
- Thus, at any one set of temperature and pressure conditions, all gases have the same volume.
- It is conventional to define a standard set of conditions which is called **S**tandard **T**emperature and **P**ressure or STP. At STP, T= 0˚C and P = 1 atm
- It is known that at STP, 1 mole of any gas has a volume of 22.4 L

Flow chart:

grams ⟷ (Molar Mass (? g/mol)) ⟷ moles ⟷ (Avogadro's # (6.022×10^{23} atoms or mlcls/mol)) ⟷ atoms or molecules

moles ↕ Molar Volume (22.4 L/mol of any gas at STP ↕ L of gas at STP

Calculations using molar volume: *Use the dimensional analysis/factor label method to make the following conversions. Show all work. Every number written must have units and answers need correct # of sig figs.*

1) 2.5 moles of O_2 gas at STP = ? L O_2

$$2.5 \text{ mol } O_2 \times \frac{22.4 \text{ L } O_2}{1 \text{ mol } O_2} = \boxed{56 \text{ L } O_2}$$

2) 3.56 L of H_2 gas at STP = ? moles of H_2

$$3.56 \text{ L } H_2 \times \frac{1 \text{ mol } H_2}{22.4 \text{ L } H_2} = \boxed{0.159 \text{ mol } H_2}$$

3) A clown fills up his balloon with helium gas until it has a volume of 18.5 L at STP. How many atoms of helium are in his balloon?

$$\underbrace{18.5 \text{ L He} \times \frac{1 \text{ mol He}}{22.4 \text{ L He}}}_{\substack{0.8259 \text{ mol He*} \\ \text{*1 extra sig fig}}} \times \frac{6.022 \times 10^{23} \text{ atoms He}}{1 \text{ mol He}} = \boxed{4.97 \times 10^{23} \text{ atoms He}}$$

4) What would be the volume of an 84.0 g sample of nitrogen gas, N_2, at STP?

$$\underbrace{84.0 \text{ g } N_2 \times \frac{1 \text{ mol } N_2}{28.02 \text{ g } N_2}}_{\substack{2.998 \text{ mol } N_2\text{*} \\ \text{*1 extra sig fig}}} \times \frac{22.4 \text{ L } N_2}{1 \text{ mol } N_2} = \boxed{67.2 \text{ L } N_2}$$

5) What is the density of CO_2 gas at STP? *Hint: Assume you have a 1 mole sample of CO_2 gas at STP.*

$$D = \frac{\text{mass}}{\text{vol}} = \frac{44.01 \text{ g } CO_2 / \text{mol } CO_2}{22.4 \text{ L } CO_2 / \text{mol } CO_2} = \boxed{1.96 \text{ g/L}}$$

6) **Fun with trying to grasp the enormous amount of particles in a mole.** Assume that one can count 100 molecules per minute. How many years would be required to count a mole of molecules? (Assume 1 yr = 365.25 day)

$$6.022 \times 10^{23} \text{ molecules} \times \frac{1 \text{ min}}{100 \text{ mlcl}} \times \frac{1 \text{ hr}}{60 \text{ min}} \times \frac{1 \text{ day}}{24 \text{ hr}} \times \frac{1 \text{ yr}}{365.25 \text{ day}} = \boxed{1.145 \times 10^{16} \text{ yr}}$$

This is 11.45 million billion years, or over 814,000× the age of the universe!