

Chemistry Worksheet

Mass-Moles-Particles

Name Key Date _____ Period _____

Concept Questions:

- One mole is defined as The quantity of things as there are atoms in exactly 12.00g of the C-12 isotope (= 6.022×10^{23})
- The mole only applies to chemistry, in other words you couldn't have a mole of cars or a mole of stars. (Circle one) True / False
- The mole is a Counting unit, whereas grams is a mass unit.
- The coefficients in a balanced chemical equation can be used with which of the following for setting up ratios (Circle all that apply)
 Moles Grams Molecules/Atoms
- To convert from grams to moles of a substance you must Divide by the molar mass
- To convert from moles to grams of a substance you must Multiply by the molar mass
- To convert from moles to molecules of a substance you must Multiply by Avogadro's Number
- To convert from molecules to atoms of a substance you must Multiply the number of molecules by the subscript of the element in question
- The molar mass of a compound is found by Summing the molar masses of the elements in the compound
- The mole has the numerical value of 6.022×10^{23} and is known as Avogadro's Number (N_A).

Problem Solving: Perform the following calculations using the example below as a guide:

Example Problem: Convert 20.0g of HCl to moles of HCl

Answer: $20.0\text{gHCl} \frac{1\text{molHCl}}{36.46\text{g}} = .55\text{mol HCl}$ Molar mass of HCl

Convert to moles:

1. $15.5\text{g of H}_2\text{O} \left[\frac{1 \text{ mol}}{18.016 \text{ g}} \right] = .860\text{mol}$ 2. $125.0\text{g of H}_2\text{SO}_4 \left[\frac{1 \text{ mol}}{98.078 \text{ g}} \right] = 1.274\text{mol}$

3. 16.10g of lithium nitrate

$$16.10\text{g (1mol LiNO}_3 / 68.946\text{g)} \\ = .2335\text{mol LiNO}_3$$

4. 100.0g of dinitrogen tetraoxide

$$100.0\text{g N}_2\text{O}_4 \text{ (1mol N}_2\text{O}_4 / 92.011\text{g)} \\ = 1.087\text{mol N}_2\text{O}_4$$

Convert to grams:

$$1. .0024\text{mol NH}_3 \left[\frac{17.03 \text{ g}}{1 \text{ mol}} \right] = .041\text{g}$$

$$2. 6.5 \times 10^{-4} \text{ mol CO} \left[\frac{28.01 \text{ g}}{1 \text{ mol}} \right] = .018\text{g}$$

3. 4.0mol carbon tetrachloride

$$4.0\text{mol CCl}_4 (153.823\text{g/mol}) \\ = 615.3 = \boxed{620\text{g}}$$

4. 2.5mol nitrogen gas

$$2.5\text{mol N}_2 (28.02\text{g/mol}) \\ = 70.03 = \boxed{70\text{g}}$$

Synthesis Questions:

1. How many grams of HCl contain the same number of units as there are in 60.0g of CaCl₂?
 $60.0\text{g CaCl}_2 (1\text{mol}/110.984)(36.461\text{g HCl}/1\text{mol}) = \boxed{19.7\text{g}}$

2. How many moles of HCl contain the same number of grams as there are in .45mol of CaCl₂?
 $.45\text{mol CaCl}_2 (110.984\text{g CaCl}_2/1\text{mol})(1\text{mol HCl}/36.461\text{g}) = \boxed{1.4\text{mol HCl}}$

3. How many times more particles are there in 10.0g of H₂O than in 10.0g of CO₂?
 $\text{Mol CO}_2 = (10.0\text{g})(1\text{mol CO}_2/44.01\text{g}) = .227\text{mol}$ $\text{H}_2\text{O}/\text{CO}_2 = .555/.227 = \boxed{2.44\text{x}}$
 $\text{Mol H}_2\text{O} = (10.0\text{g})(1\text{mol H}_2\text{O}/18.016\text{g}) = .555\text{mol}$

4. If you wanted a 2 to 1 ratio of H₂O molecules to CO₂ molecules and you had 50.0g of H₂O, how many grams of CO₂ would you need (Hint: It isn't 25!)?
 $(50.0\text{g H}_2\text{O}/18.016\text{g/mol})(1\text{mol CO}_2/2\text{mol H}_2\text{O})(44.01\text{g CO}_2/1\text{mol}) = \boxed{61.1\text{g CO}_2}$

5. Which element has a molar mass of 126.9g/mol?

Iodine, I

6. For which element does 2.5 moles have a mass of 518g?

Molar mass is in grams per mole $518\text{g}/2.5\text{mol} = \boxed{207.2\text{g/mol, lead (Pb)}}$

7. You performed an experiment on a diatomic element and found that .25g of the substance contained 6.58×10^{-3} moles. What is the element?

$.25\text{g} / 6.58 \times 10^{-3}\text{mol} = 37.99\text{g/mol}$, since the element is diatomic you must divide by 2 to get the single atom mass $37.99/2 = \boxed{19.0\text{g/mol} = \text{Fluorine (F)}}$

Accelerated Chemistry

Stoichiometry and Percent Composition Practice

Name Key Period _____
Date _____

1. Silicon is found in nature combined with oxygen to give sand, quartz, agate and similar materials. The element has three stable isotopes.

Exact Mass	Relative abundance (%)
27.97693	92.23
28.97649	4.67
29.97376	3.10

Calculate the average atomic weight of silicon from the data above.

$$27.97693(.9223) + 28.97649(.0467) + 29.97376(.0310)$$

Answer 28.09 amu

2. Antimony, one of the elements known to the ancient alchemists, has two stable isotopes: ^{121}Sb (mass 120.90) and ^{123}Sb (mass, 122.90). Calculate the relative abundances of the two isotopes. *✓ table*

$$120.90(x) + 122.90(1-x) = 121.80$$

$$120.90x + 122.90 - 122.90x = 121.8$$

Answer:

$$x = .55$$

^{121}Sb 55 %

^{123}Sb 45 %

3. Calculate the number of moles represented by each of the following:

127.08g ($\frac{1 \text{ mol}}{63.55 \text{ g}}$) a. 127.08g of Cu 2.000 mol

20.0g ($\frac{1 \text{ mol}}{40.08 \text{ g}}$) b. 20.0g of calcium 0.499 mol

0.012g ($\frac{1 \text{ mol}}{39.10 \text{ g}}$) c. 0.012g of potassium 3.07×10^{-4} mol

4. Calculate the number of grams in each of the following:

a. 0.10 mol iron 5.6 g

$$0.10 \text{ mol} \left(\frac{55.85 \text{ g}}{\text{mol}} \right) = 5.585$$

2.31 mol Si ($\frac{28.09 \text{ g}}{1 \text{ mol}}$) = 64.8879
b. 2.31 mol Si 64.9 g
c. 0.0023 mol carbon .028 g
 $0.0023 \text{ mol C} \left(\frac{12.01 \text{ g}}{1 \text{ mol}} \right) = .027623$

5. Black gunpowder contains several chemicals, among them sulfur and carbon. A typical powder is about 10.09% S (by mass) and 14.29% C. If you have 1.00 pound (454g) of gunpowder, how many grams of sulfur and how many grams of carbon are present? How many moles of each?

a. grams of S 45.8 g moles of S 1.43 mol

b. grams of C 64.9 g moles of C 5.40 mol

6. Determine the mass of one copper atom?

Answer 1.055×10^{-22} g 63.55 g ($\frac{1 \text{ mol}}{6.022 \times 10^{23} \text{ atoms}}$)
 $= 1.0553 \times 10^{-22} \text{ g/atom}$

7. The average mass of one gold atom in a sample of naturally occurring gold is 3.2702×10^{-22} g. What is the molar mass of gold?

Answer 196.9 g/mol $\frac{3.2702 \times 10^{-22} \text{ g}}{\text{atom}} \left(\frac{6.022 \times 10^{23} \text{ atoms}}{1 \text{ mol}} \right)$

8. Calculate the molar mass:

a. Fe_2O_3 , iron(III)oxide

159.69 g/mol

b. N_2O , dinitrogen monoxide (laughing gas)

44.01 g/mol

c. $\text{MnCl}_2 \cdot 4\text{H}_2\text{O}$, manganese(II)chloride tetrahydrate

197.91 g/mol

9. Calculate the number of moles in 1.00g of each compound.

$\frac{1.00 \text{ g}}{32.04 \text{ g/mol}}$

a. CH_3OH , methyl alcohol

.0312 mol

b. Cl_2CO , phosgene, a poisonous gas

$\frac{1.00 \text{ g}}{98.92 \text{ g/mol}} = .0101$
.0101 mol

c. $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$, magnesium sulfate heptahydrate (Epsom salt)

$\frac{1.00 \text{ g}}{246.475 \text{ g/mol}}$
.00406 mol
 $= .00406$



10. Tin(II) fluoride is used in some brands of toothpaste to prevent tooth decay.

a. How many moles of SnF₂ are there in 0.050g of SnF₂?

$.050 / 156.707 = 3.19 \times 10^{-4}$ mol

b. How many F⁻ ions and how many Sn²⁺ ions are present in 0.050g

$(6.38 \times 10^{-4}) \times (6.022 \times 10^{23}) = 3.84 \times 10^{20}$ F⁻ ions

$(1.9 \times 10^{-4}) \times (6.022 \times 10^{23}) = 1.14 \times 10^{20}$ Sn²⁺ ions

11. Arrange the following in order of increasing mass (label 1 to 5 in the blanks)

a. 3.0×10^{23} molecules of C₄H₁₀ 5

b. 1 penny (about 3 grams) 2

c. 6.0×10^{23} molecules of CO 4

d. 1.0 mol of B₂H₆ (1.0 × 27.670) 3

e. 1 molecule of N₂ 1

12. An Alka-Seltzer® tablet contains 324mg of aspirin (C₉H₈O₄), 1904mg of sodium bicarbonate (NaHCO₃), and 1,000. mg of citric acid (C₆H₈O₇). The last two compounds react with each other to provide the "fizz" bubbles of CO₂ when the tablet is dissolved in water.

a. Calculate the number of moles of each substance in the tablet.

$324 / 180.1574 = 1.798 \times 10^{-3}$ mol aspirin

$1904 / 84.0066 = 2.266 \times 10^{-2}$ mol sodium bicarbonate

$1000 / 192.1235 = 5.205 \times 10^{-3}$ mol citric acid

b. If you take one tablet, how many molecules of aspirin are you consuming?

Answer 1.083×10^{21} molecules of aspirin

$1.798 \times 10^{-3} \text{ mol} \times (6.022 \times 10^{23})$

13. Boron hydrides, compounds containing only boron and hydrogen, form a large class of compounds. One consists of 78.3% B and 21.7% H. Its molar mass is 27.6g/mol. What are the empirical and molecular formulas for this compound?

$78.3\% \text{ B}$
 $21.7\% \text{ H}$
 $78.3 / 10.811 = 7.24$
 $21.7 / 1.0079 = 21.53$

Empirical formula BH₃

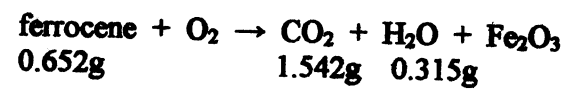
Molecular formula B₂H₆

14. Compounds consisting of carbon, hydrogen, and metals are called "organometallic" compounds. One of the best known is called "ferrocene", a molecule containing C, H, and Fe. If 0.652g of ferrocene is burned in oxygen, 1.542g of CO₂ and 0.315g of H₂O are produced. The iron is converted to Fe₂O₃. What is the empirical formula of ferrocene and what is its empirical formula weight?

13.835 g/mol
 $27.6 = 2$
 13.835
 $= \text{B}_2\text{H}_6$

Empirical formula FeC₁₀H₁₀

Empirical weight 186.031 g/mol



mass % C in CO₂ = 12.01/44.01 = 27.29%

mass % of H in H₂O = 2.016/18.016 = 11.19%

mass of C in ferrocene = (1.542g)(.2729) = .4208g C

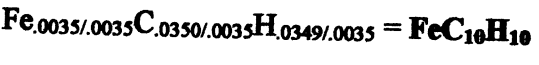
mass of H in ferrocene = (0.315g)(.1119) = .0352g H

mass of Fe = 0.652 - .4208 - .0352 = .196g Fe

moles of C = .4208 / 12.01g/mol = .0350mol

moles of H = .0352g / 1.008g/mol = .0349mol

moles of Fe = .196g / 55.85g/mol = .0035mol



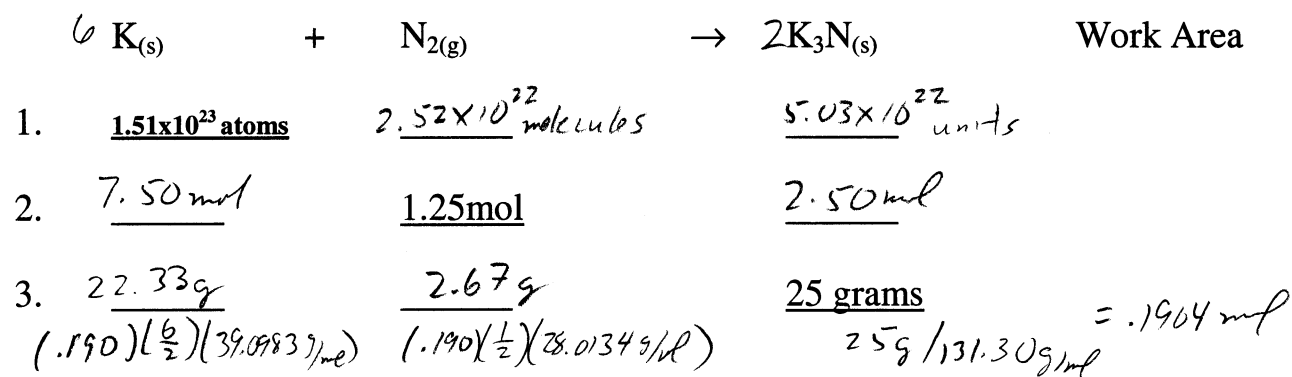
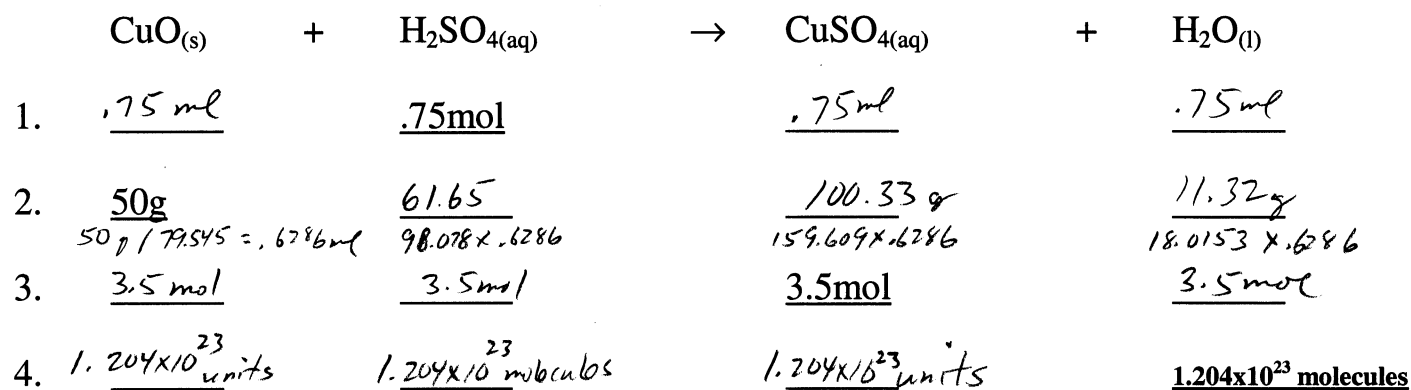
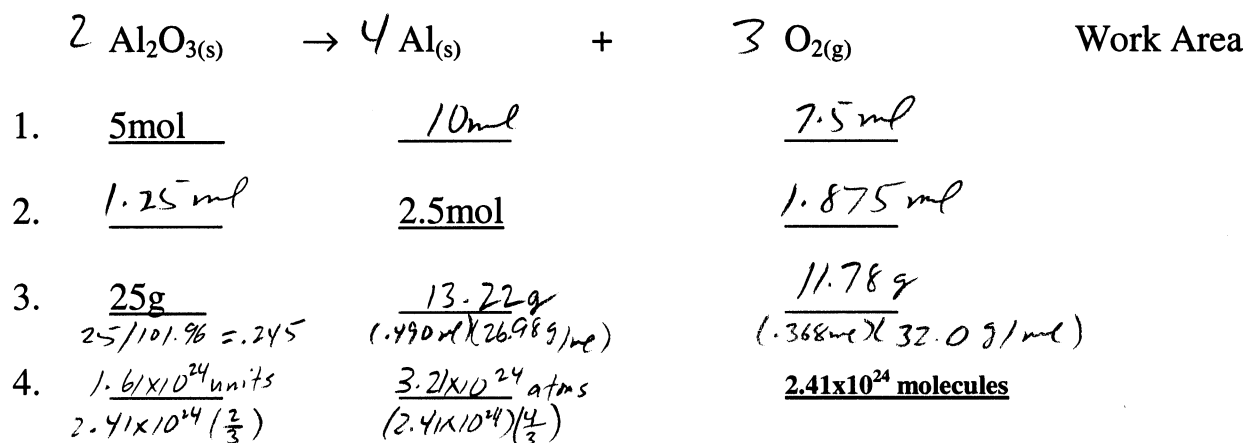
Honors Chemistry

Stoichiometry Practice Problems

Name Key

Period _____ Date _____

Instructions: Balance the following chemical equations and then determine the missing information for each of the conditions given. The four questions related to each equation are independent of one another. Answers for a particular numbered problem should be in the same units as the information given (i.e. grams to grams, moles to moles, particles to particles).



Equation Balancing and Stoichiometry

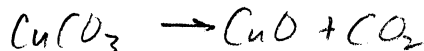
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Balance the following reactions:

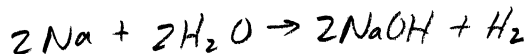
- $\text{CuO} + \text{H}_2 \rightarrow \text{Cu} + \text{H}_2\text{O}$ *balanced*
- $2\text{Sb} + 3\text{H}_2\text{O} \rightarrow \text{Sb}_2\text{O}_3 + 3\text{H}_2$
- $2\text{Ac}(\text{OH})_3 \rightarrow \text{Ac}_2\text{O}_3 + 3\text{H}_2\text{O}$
- $\text{Zn} + 2\text{CrCl}_3 \rightarrow 2\text{CrCl}_2 + \text{ZnCl}_2$
- $\text{BaCO}_3 + \text{C} + \text{H}_2\text{O} \rightarrow 2\text{CO} + \text{Ba}(\text{OH})_2$

Write and balance the following reactions:

- Copper(II) carbonate decomposes to copper(II) oxide and carbon dioxide gas.



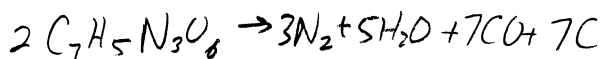
- Sodium reacts with water to produce sodium hydroxide and hydrogen gas.



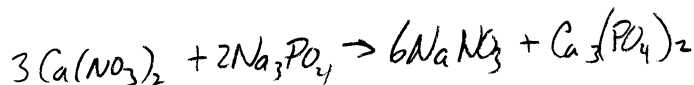
- Calcium carbonate reacts with hydrochloric acid to produce calcium chloride, water and carbon dioxide.



- Detonation of TNT ($\text{C}_7\text{H}_5\text{N}_3\text{O}_6$) to form nitrogen gas, water, carbon monoxide and carbon.



- Mixing solutions of calcium nitrate and sodium phosphate forms sodium nitrate and solid calcium phosphate.



Solve the following:

- Blood hemoglobin contains 0.33% iron. Assuming that there are two atoms of iron per molecule of hemoglobin, calculate the approximate molecular weight of hemoglobin.

$$\begin{aligned} 2 \times \text{mass Fe} &= 0.33\% \text{ of molecule} \\ 2 \times 55.845 &= 111.69 = 0.33\% \\ 111.69 &= .0033 \times \text{MW} \\ \text{MW} &= \frac{111.69}{0.0033} = 33,845 \text{ u/molecule} \end{aligned}$$

- Calculate the formula of a compound, given that 55.85g of iron combines with 32.06g of sulfur.

$$\begin{aligned} \frac{55.85 \text{ g Fe}}{55.85 \text{ g/mol}} &= 1.0 \text{ mol} \\ \frac{32.06 \text{ g S}}{32.07 \text{ g/mol}} &\approx 1.0 \text{ mol} \\ \text{[FeS]} & \end{aligned}$$

- Aluminum metal reacts with chlorine gas to form solid aluminum trichloride, AlCl_3 . What mass of chlorine gas is needed to react completely with 163g of aluminum?

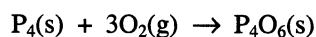
$$\begin{aligned} 2\text{Al} + 3\text{Cl}_2 &\rightarrow 2\text{AlCl}_3 \\ \frac{163 \text{ g}}{26.98 \text{ g/mol}} &= 6.047 \text{ mol Al} \\ 6.047 \text{ mol Al} \times \frac{3 \text{ mol Cl}_2}{2 \text{ mol Al}} &= 9.062 \text{ mol Cl}_2 \\ 9.062 \text{ mol Cl}_2 \times 70.9 \text{ g/mol} &= 642 \text{ g Cl}_2 \end{aligned}$$

- How many grams of oxygen gas can be produced from the decomposition of 50.0g of aluminum oxide to aluminum and oxygen? If 8.0 grams are produced, what is the percent yield of the reaction?

$$\begin{aligned} 2\text{Al}_2\text{O}_3 &\rightarrow 4\text{Al} + 3\text{O}_2 \\ \frac{50.0 \text{ g Al}_2\text{O}_3}{101.96 \text{ g/mol}} &= .490 \text{ mol Al}_2\text{O}_3 \\ .490 \text{ mol Al}_2\text{O}_3 \left(\frac{3 \text{ mol O}_2}{2 \text{ mol Al}_2\text{O}_3} \right) &= .735 \text{ mol O}_2 \\ .735 \text{ mol O}_2 (32.0 \text{ g/mol}) &= 23.52 \text{ g O}_2 \end{aligned}$$

$\frac{8.0 \text{ g}}{23.52 \text{ g}} = .3401$
34.01%

- Tetraphosphorus hexaoxide (219.9g/mol) is formed by the reaction of phosphorus (123.9g/mol) with oxygen gas (32.00g/mol).



- If a mixture of 75.3g of phosphorus and 38.7g of oxygen produce 43.3g of P_4O_6 , what is the percent yield for the reaction?

$$\begin{aligned} \text{mol P}_4 &= 75.3 \text{ g} / 123.9 \text{ g/mol} = .608 \text{ mol P}_4 \\ \text{mol O}_2 &= 38.7 \text{ g} / 32.0 \text{ g/mol} = 1.21 \text{ mol O}_2 \\ .608 \text{ mol P}_4 \left(\frac{3 \text{ mol O}_2}{1 \text{ mol P}_4} \right) &= 1.824 \text{ mol O}_2 \text{ (limiting)} \\ 1.21 \text{ mol O}_2 \left(\frac{1 \text{ mol P}_4\text{O}_6}{3 \text{ mol O}_2} \right) &= .403 \text{ mol P}_4\text{O}_6 \\ .403 \text{ mol P}_4\text{O}_6 (219.9 \text{ g/mol}) &= 88.62 \text{ g} \end{aligned}$$

$\frac{43.3 \text{ g}}{88.62 \text{ g}} = .4886$
48.86%

- How many moles of lithium oxide will remain unreacted if an available 25.00g of lithium oxide (29.88g/mol) produces 1.000mol of LiOH in the reaction = $\text{Li}_2\text{O}(\text{s}) + \text{H}_2\text{O}(\text{l}) \rightarrow 2\text{LiOH}(\text{aq})$?

$$\begin{aligned} \frac{25.00 \text{ g}}{29.88 \text{ g/mol}} &= .8367 \text{ mol} \\ 1.000 \text{ mol LiOH} \left(\frac{1 \text{ mol Li}_2\text{O}}{2 \text{ mol LiOH}} \right) &= .5000 \text{ mol} \\ \Delta \text{mol} &= .8367 - .5000 \text{ mol} = .3367 \text{ mol Li}_2\text{O} \end{aligned}$$