Percent Composition Notes

Answer Key

Percent composition is the percent of each element that makes up a compound based on the mass.

$$\%\text{element} = \frac{\text{mass of element}}{\text{mass of compound}} \times 100$$

Example 1. Determine the percent composition of carbon dioxide.

Using the periodic table, find the mass of each element then multiply by the number of atoms of each element in the compound.

Find the mass of carbon: 1 carbon x 12.01g = 12.01 g C

Find the mass of oxygen: 2 oxygen x 16.00g = 32.00g O

Find the mass of carbon dioxide: 32.00g + 12.01g = 44.01g

%C = mass C/ mass CO_2 x 100= 12.01g/44.01g x 100 = 27.29% C

%O= mass O/ mass CO_2 x 100 = 32.00/44.01 x 100 = 72.71% O

Example 2. Determine the percent of nitrogen in dinitrogen pentoxide.

Find the mass of nitrogen: 2 nitrogen x 14.01g = 28.02g N

Find the mass of oxygen: 5 oxygen x 16.00g = 80.00g O

Find the mass of N_2O_5: 28.02g + 80.00g = 108.02 g

%N = mass of nitrogen/ mass of N_2O_5 x 100 = 28.02g/108.02g x 100 = 25.94% N

Practice Problems:

K=117.3g

39.10x3
P=30.92

K_3PO_4

212.27g

1. Determine the percent of phosphorus if a compound is made up of 10.0g of phosphorus and 25.0g of oxygen. 10.0g P / 35.0g P+O x100 = 28.6% P
2. Determine the percent composition of nitrogen in aluminum nitrate. $Al(NO_3)_3$ N-42.03 42.03g / 213.01 x100 = 19.73% N
3. Determine the percent of potassium in potassium phosphate. K_3PO_4 K=117.03 117.03 / 212.27 x100 = 55.20% K
4. Determine the percent of iron in iron (III) sulfate. $Fe_2(SO_4)_3$ Fe=55.85x2=111.7g 111.7 / 399.91 x100 = 27.93%
5. What percent of tetraphosphorus decoxide is oxygen? P_4O_{10} O=16x10=160g 160 / 283.88 x100 = 56.36% O

55.26%

1.28.6%P 2. 19.64 %N 3. 55.42%K 4. 27.93% Fe 5. 56.36% O

Honors Chemistry: Moles Classwork

CW: Percent Composition

Calculate the percentage compositions for each of the following compounds.

1. potassium chlorate $KClO_3 = 122.55\ g$

K: $\frac{39.10}{122.55} \times 100 = 31.91\%$

Cl: $\frac{35.45}{122.55} \times 100 = 28.93\%$

O: $\frac{48}{122.55} \times 100 = 39.17\%$

2. $CoSO_4 = 155g$

Co: $\frac{58.93}{155g} \times 100 = 38.02\%$

S: $\frac{32.07}{155} \times 100 = 20.69\%$

O: $\frac{64}{155} \times 100 = 41.29\%$

3. A compound that contains 2.16g Al, 3.85g S, and 7.68g O.

$\rightarrow 13.69g$

Al: $\frac{2.16}{13.69} \times 100 = 15.78\%$

S: $\frac{3.85}{13.69} \times 100 = 28.12\%$

O: $\frac{7.68}{13.69} = 56.10\%$

Calculate the percentage compositions for the bolded element in each of the following compounds.

1. **potassium** chlorate

$KClO_3 = 122.55g$

$\frac{39.10}{122.55g} \times 100 = 31.91\%$

2. $C_2H_5OH = 46.068g$

$\frac{24.02}{46.068} \times 100 = 52.14\%$

3. **tetraphosphorus** decoxide

$P_4O_{10} = 283.88$

$\frac{123.88}{283.88} \times 100 = 43.64\%$

4. $Fe_3O_4 = 231.55$

$\frac{167.55}{231.55} \times 100 = 72.36\%$

5. $CoSO_4$

$\frac{64}{155} \times 100 = 41.29\%$

6. **lithium** carbide.

$Li_4C = 39.774$

$\frac{27.764}{39.774} \times 100 = 69.80\%$

7. $H_2O_2 = 34.016$

$\frac{32.00}{34.016} \times 100 = 94.07\%$

8. **barium** chloride $BaCl_2 = 208.23$

$\frac{137.33}{208.23} \times 100 = 65.96\%$

CW: **One and Two Step Mole Problems**
One Step Mole Problems

1. Calculate the molar mass for each of the following compounds.
   a. sodium sulfate

Na_2SO_4

142.05 g/mol

   b. aluminum phosphate

$AlPO_4$

121.95 g/mol

   c. ammonium hydroxide

NH_4OH

35.05 g/mol

2. What is the mass of 1.75 moles of zinc atoms?

$$1.75 \text{ mol Zn} \left| \frac{65.39 \text{ g Zn}}{1 \text{ mol Zn}} \right. = 114 \text{ g Zn}$$

3. How many moles are there in 42.0g of aluminum?

$$42.0 \text{ g Al} \left| \frac{1 \text{ mol Al}}{26.98 \text{ g Al}} \right. = 1.56 \text{ mol Al}$$

4. How many atoms are there in 1.50 moles carbon?

$$1.50 \text{ mol C} \left| \frac{6.022 \times 10^{23} \text{ atom C}}{1 \text{ mol C}} \right. = 9.03 \times 10^{23} \text{ atom C}$$

5. How many moles are there in 7.50×10^{23} atoms of iron?

$$7.50 \times 10^{23} \text{ atom Fe} \left| \frac{1 \text{ mol Fe}}{6.022 \times 10^{23} \text{ atom Fe}} \right. = 1.25 \text{ mol Fe}$$

6. How many molecules are in 0.254 moles of carbon dioxide?

$$0.254 \text{ mol } CO_2 \left| \frac{6.022 \times 10^{23} \text{ molecules } CO_2}{1 \text{ mol } CO_2} \right. = 1.53 \times 10^{23} \text{ molecules } CO_2$$

7. How many moles are in 42.24 g of nickel(II) sulfite? $NiSO_3$

$$42.24 \text{ g } NiSO_3 \left| \frac{1 \text{ mol } NiSO_3}{138.76 \text{ g } NiSO_3} \right. = 0.3044 \text{ mol } NiSO_3$$

8. How many grams are in 0.049 moles of silver nitrate? $AgNO_3$

$$0.049 \text{ mol } AgNO_3 \left| \frac{169.88 \text{ g } AgNO_3}{1 \text{ mol } AgNO_3} \right. = 8.3 \text{ g } AgNO_3$$

9. How many liters are in 12.42 moles of chlorine gas?

$$12.42 \text{ mol } Cl_2 \left| \frac{22.4 \text{ L } Cl_2}{1 \text{ mol } Cl_2} \right. = 278.2 \text{ L } Cl_2$$

10. How many grams are in 0.0425 moles of potassium chloride? KCl

$$0.0425 \text{ mol } KCl \left| \frac{74.55 \text{ g } KCl}{1 \text{ mol } KCl} \right. = 3.17 \text{ g } KCl$$

11. How many grams are in 6.21 mole of carbon tetrachloride? CCl_4

$$6.21 \text{ mol } CCl_4 \left| \frac{153.81 \text{ g } CCl_4}{1 \text{ mol } CCl_4} \right. = 955 \text{ g } CCl_4$$

12. How many moles are in 4.16 L of dinitrogen pentoxide?

$$4.16 \text{ L } N_2O_5 \left| \frac{1 \text{ mol } N_2O_5}{22.4 \text{ L } N_2O_5} \right. = 0.186 \text{ mol } N_2O_5$$

Moles 2 Step Problems Perform the following conversions.

13. 6g of S to atoms

$$6 \text{ g S} \left| \frac{1 \text{ mol S}}{32.07 \text{ g S}} \right| \frac{6.022 \times 10^{23} \text{ atom S}}{1 \text{ mol S}} \quad 1 \times 10^{23} \text{ atom S}$$

14. 6.02×10^{14} atoms of Zn to grams

$$6.02 \times 10^{14} \text{ atom Zn} \left| \frac{1 \text{ mol Zn}}{6.022 \times 10^{23} \text{ atom Zn}} \right| \frac{65.39 \text{ g Zn}}{1 \text{ mol Zn}} = 6.54 \times 10^{-8} \text{ g Zn}$$

Cu_2SO_4 15. 5.5×10^{25} molecules copper (I) sulfate to grams

$$5.5 \times 10^{25} \text{ molecules } Cu_2SO_4 \left| \frac{1 \text{ mol } Cu_2SO_4}{6.022 \times 10^{23} \text{ molecules } Cu_2SO_4} \right| \frac{223.17 \text{ g } Cu_2SO_4}{1 \text{ mol } Cu_2SO_4} = 2.1 \times 10^{4} \text{ g } Cu_2SO_4$$

$CaCO_3$ 16. 5.5×10^{4} grams calcium carbonate to molecules

$$5.5 \times 10^{4} \text{ g } CaCO_3 \left| \frac{1 \text{ mol } CaCO_3}{100.9 \text{ g } CaCO_3} \right| \frac{6.022 \times 10^{23} \text{ molecules } CaCO_3}{1 \text{ mol } CaCO_3} = 3.3 \times 10^{26} \text{ molecules } CaCO_3$$

$Ca(OH)_2$ 17. 244.2 g calcium hydroxide to liters

$$244.2 \text{ g } Ca(OH)_2 \left| \frac{1 \text{ mol } Ca(OH)_2}{74.096 \text{ g } Ca(OH)_2} \right| \frac{22.4 \text{ L } Ca(OH)_2}{1 \text{ mol } Ca(OH)_2} = 73.82 \text{ L } Ca(OH)_2$$

18. 6.89 liters of bromine gas to grams

$$6.89 \text{ L } Br_2 \left| \frac{1 \text{ mol } Br_2}{22.4 \text{ L } Br_2} \right| \frac{159.8 \text{ g } Br_2}{1 \text{ mol } Br_2} = 49.2 \text{ g } Br_2$$

CW: Empirical & Molecular Formulas

Empirical formulas

1. If 4.02g of N reacts with 11.48g of O, what is the empirical formula of this compound?

$\frac{4.02\text{g N}}{} \left| \frac{1\text{ mol N}}{14.01\text{ g N}} \right. = 0.2869 / 0.2869 = 1 \times 2 = 2$

$\frac{11.48\text{g O}}{} \left| \frac{1\text{ mol O}}{16.00\text{ g O}} \right. = 0.7175 / 0.2869 = 2.5 \times 2 = 5$

N_2O_5

2. Calculate the empirical formulas of the compounds with the following percentage compositions:
   a) 40.2% K, 26.9% Cr, 32.9% O

$\frac{40.2\text{g K}}{} \left| \frac{1\text{ mol}}{39.10\text{ g K}} \right. = 1.028 / .5174 = 2$

$\frac{26.9\text{g Cr}}{} \left| \frac{1\text{ mol}}{51.99\text{ g K}} \right. = 0.5174 / .5174 = 1$

$\frac{32.9\text{g}}{} \left| \frac{1\text{ mol}}{16\text{ g K}} \right. = 2.056 / .5174 = 4$

K_2CrO_4

   b) 21.8% Mg, 27.9% P, 50.3% O

$\frac{21.8\text{ g Mg}}{} \left| \frac{1\text{ mol}}{24.31\text{ g Mg}} \right. = 0.8968 / 0.8968 = 1 \times 2 = 2$

$\frac{27.9\text{g P}}{} \left| \frac{1\text{ mol}}{30.97\text{ g P}} \right. = 0.9009 / 0.8968 = 1 \times 2 = 2$

$\frac{50.3\text{g O}}{} \left| \frac{1\text{ mol}}{16\text{ g O}} \right. = 3.144 / 0.8968 = 3.5 \times 2 = 7$

$Mg_2P_2O_7$

3. Determine the empirical formula for the following two compounds.
   a) 0.89g K, 1.18g Cr, 1.27g O

$\frac{0.89\text{g K}}{} \left| \frac{1\text{ mol K}}{39.10\text{g K}} \right. = 0.02276 / .02276 = 1 \times 2$

$\frac{1.18\text{g Cr}}{} \left| \frac{1\text{ mol Cr}}{51.99\text{ g Cr}} \right. = 0.0227 / .02276 = 1 \times 2$

$\frac{1.27\text{g O}}{} \left| \frac{1\text{ mol O}}{16.00\text{ g O}} \right. = 0.07938 / 0.02276 = 3.5 \times 2$

$K_2Cr_2O_7$

b) 1.03g K, 0.69g Cr, 0.84g O

$\frac{1.03\text{g K}}{} \left| \frac{1\text{ mol}}{39.10\text{ g}} \right. = 0.02634/0.01327 = 2$

$\frac{0.69\text{g Cr}}{} \left| \frac{1\text{ mol}}{51.99\text{ g Cr}} \right. = 0.01327/0.01327 = 1$

$\frac{0.84\text{g O}}{} \left| \frac{1\text{ mol}}{16\text{ g O}} \right. = 0.0525/0.01327 = 4$

K_2CrO_4

4. Calculate the empirical formulas of the compounds with the following percentage compositions:

a) 65.7% Sr, 10.4% Si, 23.9% O

$\frac{65.7\text{g Sr}}{} \left| \frac{1\text{ mol Sr}}{87.62\text{ g Sr}} \right. = .7498/.3702 = 2$

$\frac{10.4\text{g Si}}{} \left| \frac{1\text{ mol Si}}{28.09\text{ g Si}} \right. = 0.3702/.3702 = 1$

$\frac{23.9\text{g O}}{} \left| \frac{1\text{ mol O}}{16.00\text{ g O}} \right. = 1.494/.3702 = 4$

Sr_2SiO_4

b) 34.58% Na, 23.3%P, 42.12% O

$\frac{34.58\text{g Na}}{} \left| \frac{1\text{ mol}}{22.99\text{ g Na}} \right. = 1.504/.7523 = 2 \times 2 = 4$

$\frac{23.3\text{g P}}{} \left| \frac{1\text{ mol}}{30.97\text{ g P}} \right. = .7523/.7523 = 1 \times 2 = 2$

$\frac{42.12\text{g O}}{} \left| \frac{1\text{ mol}}{16.00\text{ g O}} \right. = 2.6325/.7523 = 3.5 \times 2 = 7$

$Na_4P_2O_7$

Molecular formulas

Determine the molecular formulas for the following:

1. empirical formula is CH; molecular mass is 26g

13.018

$26 / 13.018 = 2$

C_2H_2

2. empirical formula is C_2H_5; molecular mass is 58g

29.06

$\frac{58}{29.06} = 2$

C_4H_{10}

3. A compound of phosphorus and oxygen contains 56.36% phosphorus. If the molecular mass is 2204 g, what is the molecular formula?

$P_2O_3 \rightarrow 109.94$

$56.36\text{g P} \left| \frac{1\text{ mol}}{30.97\text{g P}} \right. = 1.8198 / 1.8198 = 1 \times 2 = 2$

$43.64\text{g O} \left| \frac{1\text{ mol}}{16.00\text{g O}} \right. = 2.7275 / 1.8198 = 1.5 \times 2 = 3$

$\frac{2204}{109.94} = 20$

$P_{40}O_{60}$

Determine the molecular formulas for the following:

4. empirical formula is C_3H_2O; molecular mass is 216g

54.046

$\frac{216\text{g}}{54.046\text{g}} = 4$

$C_{12}H_8O_4$

5. compound contains 0.240 g C and 0.020 g H; molecular mass is 78g

$0.240\text{g C} \left| \frac{1\text{ mol C}}{12.01\text{g C}} \right. = 0.01998 / .01.98 = 1$

$0.020\text{g H} \left| \frac{1\text{ mol H}}{1.008\text{g H}} \right. = 0.0198 / 0.0198 = 1$

CH

13.018

$\frac{78}{13.018} = 6$

C_6H_6

CW: Hydrates

1. What is the formula and name of a hydrate that is 85.3% barium chloride and 14.7% water?

* assume it's out of 100g

$BaCl_2$

$85.3\text{ g} \left| \frac{1\text{ mol } BaCl_2}{208.28\text{ g } BaCl_2} \right. = 0.4095\text{ mol} / 0.4095 = 1$

$14.7\text{ g } H_2O \left| \frac{1\text{ mol } H_2O}{18.016\text{ g } H_2O} \right. = 0.8159\text{ mol} / 0.4095 = 2$

$BaCl_2 \cdot 2H_2O$
Barium chloride dihydrate

2. A 4.89 grams sample of a hydrate was heated, and after the water was driven off, 3.87 g of anhydrous calcium sulfate remained. Determine the formula of this hydrate and name the compound. $CaSO_4$

hydrate - 4.89g
salt - 3.87g
water - 1.02g

$CaSO_4 \cdot 2H_2O$
calcium sulfate dihydrate

$3.87\text{g } CaSO_4 \left| \frac{1\text{ mol } CaSO_4}{136.15\text{ g } CaSO_4} \right. = 0.0284 / 0.0284 = 1$

$1.02\text{g } H_2O \left| \frac{1\text{ mol } H_2O}{18.016\text{ g } H_2O} \right. = 0.0566 / 0.0284 = 2$

3. A 1.628 grams sample of a hydrate of magnesium iodide is heated until its mass is reduced to 1.072 g and all water has been removed. What is the formula of the hydrate?

MgI_2

hydrate - 1.628g
salt - 1.072g
water - 0.556g

$MgI_2 \cdot 8H_2O$
magnesium octahydrate

$1.072\text{g } MgI_2 \left| \frac{1\text{ mol } MgI_2}{278.11\text{ g } MgI_2} \right. = 0.00385 / 0.00385 = 1$

$0.556\text{g } H_2O \left| \frac{1\text{ mol } H_2O}{18.016\text{ g } H_2O} \right. = 0.0309 / 0.00385 = 8$

4. A hydrate of Na_2CO_3 has a mass of 4.31 g before heating. After heating, the mass of the anhydrous compound is found to be 3.22 g. Determine the formula of the hydrate and then write out the name of the hydrate.

hydrate = 4.31g
salt = 3.22g
water = 1.09g

$Na_2CO_3 \cdot 2H_2O$
Sodium carbonate dihydrate

$$3.22g\ Na_2CO_3 \left| \frac{1\ mol\ Na_2CO_3}{105.99\ g\ Na_2CO_3} \right. = 0.0304 / 0.0304 = 1$$

$$1.09g\ H_2O \left| \frac{1\ mol\ H_2O}{18.016\ g\ H_2O} \right. = 0.0605 / 0.0304 = 2$$

5. Given that the molar mass of $Na_2SO_4 \cdot nH_2O$ is 322.1 g/mol, calculate the value of n.

① find percent of anhydrous salt and water

$$\frac{142.05g}{322.1g} \times 100 = 44.1\%\ Na_2SO_4$$

$100 - 44.1 = 55.9\%\ H_2O$

$Na_2SO_4 \cdot 10H_2O$

$$44.1g\ Na_2SO_4 \left| \frac{1\ mol\ Na_2SO_4}{142.05\ g\ Na_2SO_4} \right. = 0.3105 / 0.3105 = 1$$

$$55.9g\ H_2O \left| \frac{1\ mol\ H_2O}{18.016\ g\ H_2O} \right. = 3.1028 / 0.3105 = 10$$

6. Anhydrous lithium perchlorate (4.78 g) was dissolved in water and re-crystalized. Care was taken to isolate all the lithium perchlorate as its hydrate. The mass of the hydrated salt obtained was 7.21 g. What hydrate is it?

hydrate = 7.21g
salt = 4.78g
H_2O = 2.43g

$LiClO_4 \cdot 3H_2O$
Lithium perchlorate trihydrate

$$4.78g\ LiClO_4 \left| \frac{1\ mol\ LiClO_4}{106.39\ g\ LiClO_4} \right. = 0.0449 / 0.0449 = 1$$

$$2.43g\ H_2O \left| \frac{1\ mol\ H_2O}{18.016\ g\ H_2O} \right. = 0.1349 / 0.0449 = 3$$

7. A substance was found to have the following percentages by mass: 23% zinc; 11% sulfur; 22% oxygen; 44% water. What is the empirical formula?

$\frac{23\text{g Zn}}{1}\left|\frac{1\text{ mol Zn}}{65.34\text{ g Zn}}\right. = 0.3517/0.343 = 1$

$\frac{11\text{g S}}{1}\left|\frac{1\text{ mol S}}{32.07\text{ g S}}\right. = 0.343/0.343 = 1$

$\frac{22\text{g O}}{1}\left|\frac{1\text{ mol O}}{16.00\text{g O}}\right. = 1.375/0.343 = 4$

$ZnSO_4$

$\frac{56\text{g ZnSO}_4}{1}\left|\frac{1\text{ mol ZnSO}_4}{113.46\text{ g ZnSO}_4}\right. = .4936/.4936 = 1$

$\frac{44\text{g H}_2\text{O}}{1}\left|\frac{1\text{ mol H}_2\text{O}}{18.016\text{ g H}_2\text{O}}\right. = 2.44/.493 = 5$

$ZnSO_4 \cdot 5H_2O$ zinc sulfate pentahydrate

8. A 5.00 g sample of hydrated barium chloride, $BaCl_2 \cdot nH_2O$, is heated to drive off the water. After heating, 4.26 g of anhydrous barium chloride, $BaCl_2$, remains. What is the value of n in the hydrate's formula?

hydrate = 5.00g
salt = 4.26 g
water = 0.74g

$BaCl_2 \cdot 2H_2O$
Barium chloride dihydrate

$\frac{4.26\text{g BaCl}_2}{1}\left|\frac{1\text{ mol BaCl}_2}{208.23\text{ g BaCl}_2}\right. = 0.0205/0.0205 = 1$

$\frac{0.74\text{g H}_2\text{O}}{1}\left|\frac{1\text{ mol H}_2\text{O}}{18.016\text{ g H}_2\text{O}}\right. = 0.0411/0.0205 = 2$

9. A 1.98 g sample of a cobalt(II) chloride hydrate is heated over a burner. When cooled, the mass of the remaining dehydrated compound is found to be 1.55 g. What is the formula for the original hydrate? How can you make sure that all of the water of hydration has been removed?

hydrate = 1.98g
salt = 1.55g
water = 0.43g

$CoCl_2 \cdot 2H_2O$
Cobalt(II) chloride dihydrate

$\frac{1.55\text{g CoCl}_2}{1}\left|\frac{1\text{ mol CoCl}_2}{124.83\text{ g CoCl}_2}\right. = 0.0119/0.0119 = 1$

$\frac{0.43\text{g H}_2\text{O}}{1}\left|\frac{1\text{ mol H}_2\text{O}}{18.016\text{ g H}_2\text{O}}\right. = 0.0239/0.0119 = 2$