Key

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3 · The Mole & Stoichiometry

MOLE WS #1 - MOLAR MASSES

Calculate the molar masses of the following substances. Show ALL work and round your answer to 2 decimal places!

1) Cl_2 2(35.45) = 70.9 g/mole

2) potassium hydroxide
KOH = 39.10 + 16 + 1.01 = 56.11 g/mole

3) beryllium chloride
$BeCl_2$ = 9.01 + 2(35.45) = 79.91 g/mole

4) iron (III) chloride
$FeCl_3$ = 55.85 + 3(35.45) = 162.2 g/mole

5) boron trifluoride
BF_3 = 10.81 + 3(19) = 67.81 g/mole

6) magnesium hydroxide
$Mg(OH)_2$ = 24.31 + 2(16) + 2(1.01) = 58.32 g/mole

7) UF_6 = 238.03 + 6(19) = 352.03 g/mole

8) sulfur dioxide
SO_2 = 32.07 + 2(16) = 64.07 g/mole

9) phosphoric acid (H_3PO_4)
3(1.01) + 30.97 + 4(16) = 98.00 g/mole

10) ammonium sulfate
$(NH_4)_2SO_4$ = 2(14) + 8(1.01) + 32.07 + 4(16) = 132.15 g/mole

11) acetic acid ($HC_2H_3O_2$)
1.01 + 2(12.01) + 3.03 + 2(16) = 60.06 g/mole

12) lead (II) nitrate
$Pb(NO_3)_2$ = 207.2 + 2(14) + 6(16) = 331.2 g/mole

13) gallium sulfite
$Ga_2(SO_3)_3$ = 2(69.72) + 3(32.07) + 9(16) = 379.65 g/mole

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MOLE WS #2 – 1-STEP MOLE CONVERSIONS

1. Calculate the mass of 1.58 moles of CH_4.

$$\frac{1.58 \text{ moles } CH_4}{} \left| \frac{16.05 \text{ g } CH_4}{1 \text{ mole } CH_4} \right. = 25.4 \text{ g } CH_4$$

2. What volume will 7.29 moles of CO_2 gas occupy at STP?

$$\frac{7.29 \text{ moles } CO_2}{} \left| \frac{22.4 \text{ L } CO_2}{1 \text{ mole } CO_2} \right. = 163 \text{ L } CO_2$$

3. How many molecules are there in a 0.00583 mole sample of H_2O?

$$\frac{0.00583 \text{ moles } H_2O}{} \left| \frac{6.02\times10^{23} \text{ molecules } H_2O}{1 \text{ mole } H_2O} \right. = 3.51\times10^{21} \text{ mc } H_2O$$

4. What volume will 2.22 moles of N_2 gas occupy at STP?

$$\frac{2.22 \text{ moles } N_2}{} \left| \frac{22.4 \text{ L } N_2}{1 \text{ mole } N_2} \right. = 49.7 \text{ L } N_2$$

5. A bottle of lead (II) sulfate contains 158.1 g of the compound. How many moles of lead (II) sulfate are in the bottle? $PbSO_4$

$$\frac{158.1 \text{ g } PbSO_4}{} \left| \frac{1 \text{ mole } PbSO_4}{303.27 \text{ g } PbSO_4} \right. = 0.5213 \text{ moles } PbSO_4$$

6. How many moles of magnesium bromide contain 5.38×10^{24} formula units?

$$\frac{5.38\times10^{24} \text{ FU's } MgBr_2}{} \left| \frac{1 \text{ mole } MgBr_2}{6.02\times10^{23} \text{ FU's } MgBr_2} \right. = 8.94 \text{ moles } MgBr_2$$

7. How many molecules are there in a 0.0752 mole sample of H_2O?

$$\frac{0.0752 \text{ moles } H_2O}{} \left| \frac{6.02\times10^{23} \text{ mc } H_2O}{1 \text{ mole } H_2O} \right. = 4.53\times10^{22} \text{ mc } H_2O$$

8. How many moles of ammonia are in 1.20×10^{25} molecules of ammonia?

$$\frac{1.20\times10^{25} \text{ mc } NH_3}{} \left| \frac{1 \text{ mole } NH_3}{6.02\times10^{23} \text{ mc } NH_3} \right. = 19.9 \text{ moles } NH_3$$

9. You need 2.5 moles of aluminum for an experiment. How many atoms of aluminum is this?

$$\frac{2.5 \text{ moles Al}}{} \left| \frac{6.02\times10^{23} \text{ Atoms Al}}{1 \text{ mole Al}} \right. = 1.5\times10^{24} \text{ Atoms Al}$$

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MOLE WS #3 – 2-STEP MOLE CONVERSIONS

Show all work using dimensional analysis! Show the "given" and "find" and include correct significant figures and units.

1) How many formula units are there in 24 grams of iron (III) fluoride? FeF_3

$\frac{24 \text{ g } FeF_3}{} \times \frac{1 \text{ mole } FeF_3}{112.85 \text{ g } FeF_3} \times \frac{6.02\times10^{23} \text{ FU's } FeF_3}{1 \text{ mole } FeF_3} = 1.3\times10^{23} \text{ FU's } FeF_3$

2) How many grams are there in 2.3×10^{24} atoms of silver?

$\frac{2.3\times10^{24} \text{ atoms Ag}}{} \times \frac{1 \text{ mole Ag}}{6.02\times10^{23} \text{ atoms Ag}} \times \frac{107.87 \text{ g Ag}}{1 \text{ mole Ag}} = 410 \text{ g Ag}$

3) How many grams are there in 7.4×10^{23} formula units of silver nitrate?

$\frac{7.4\times10^{23} \text{ FU's } AgNO_3}{} \times \frac{1 \text{ mole } AgNO_3}{6.02\times10^{23} \text{ FU's } AgNO_3} \times \frac{169.88 \text{ g } AgNO_3}{1 \text{ mole } AgNO_3} = 210 \text{ g } AgNO_3$

4) How carbon atoms are in 2.5g of C_2H_6?

$\frac{2.5 \text{ g } C_2H_6}{} \times \frac{1 \text{ mole } C_2H_6}{30.08 \text{ g } C_2H_6} \times \frac{2 \text{ mole C}}{1 \text{ mole } C_2H_6} \times \frac{6.02\times10^{23} \text{ atoms C}}{1 \text{ mole C}} = 1.0\times10^{23} \text{ atoms C}$

5) How many formula units are there in 122 grams of copper (II) nitrate?

$\frac{122 \text{ g } Cu(NO_3)_2}{} \times \frac{1 \text{ mole } Cu(NO_3)_2}{187.57 \text{ g } Cu(NO_3)_2} \times \frac{6.02\times10^{23} \text{ FU's } Cu(NO_3)_2}{1 \text{ mole } Cu(NO_3)_2} = 3.92\times10^{23} \text{ FU's } Cu(NO_3)_2$

6) How many grams are there in 9.4×10^{25} molecules of hydrogen gas?

$\frac{9.4\times10^{25} \text{ mc } H_2}{} \times \frac{1 \text{ mole } H_2}{6.02\times10^{23} \text{ mc } H_2} \times \frac{2.02 \text{ g } H_2}{1 \text{ mole } H_2} = 320 \text{ g } H_2$

7) How many formula units are there in 230 grams of cobalt (II) chloride?

$\frac{230 \text{ g } CoCl_2}{} \times \frac{1 \text{ mole } CoCl_2}{129.83 \text{ g } CoCl_2} \times \frac{6.02\times10^{23} \text{ FU's } CoCl_2}{1 \text{ mole } CoCl_2} = 1.1\times10^{24} \text{ FU's } CoCl_2$

8) How many liters are occupied by 28.5 grams of nitrogen trihydride gas at STP?

$\frac{28.5 \text{ g } NH_3}{} \times \frac{1 \text{ mole } NH_3}{17.04 \text{ g } NH_3} \times \frac{22.4 \text{ L } NH_3}{1 \text{ mole } NH_3} = 37.5 \text{ L } NH_3$

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MOLE WS – % COMPOSITION

Percent Composition Using Molar Masses

It is useful to determine how much of a compound's mass is made up of each element. Water, H_2O, for example has a mass of 18.02 g/mol. The H's mass is 2(1.01) = 2.02 g/mol. The O's mass is 16.00 g/mol. We can set up ratios for each element: H = $\frac{2.02}{18.02}$ x 100 = 11.2%, O = $\frac{16.00}{18.02}$ x 100 = 88.8%

Determine the percent composition of each element in each compound below:

$Ca(OH)_2$ 1. calcium hydroxide 74.1	Ca = $\frac{40.08}{74.1}$ x 100 = 54.1%	O = $\frac{32}{74.1}$ x 100 = 43.2%	H = $\frac{2.02}{74.1}$ x 100 = 2.7%
CO_2 2. carbon dioxide 44.01	C = $\frac{12.01}{44.01}$ x 100 = 27.3%	O = $\frac{32}{44.01}$ x 100 = 72.7%	
$Ca(NO_3)_2$ 3. calcium nitrate	Ca = $\frac{40.08}{164.1}$ x 100 = 24.4%	N = $\frac{28.02}{164.1}$ x 100 = 17.1%	O = $\frac{96}{164.1}$ x 100 = 58.5%
4. CH_3OH	C = $\frac{12.01}{32.05}$ x 100 = 37.5%	O = $\frac{16}{32.05}$ x 100 = 49.9%	H = $\frac{4.04}{32.05}$ x 100 = 12.6%

Percent Composition Using Laboratory Data

Find the percent composition of each compound below.

10. Analysis of a compound shows that it consists of 43.40 g of copper and 10.95 g of sulfur.

total = 43.40g + 10.95g = 54.35g

Cu: $\frac{43.40g}{54.35g}$ x100 = 79.9% S: $\frac{10.95g}{54.35g}$ x 100 = 20.1%

11. A sample of benzene is analyzed and found to consist of 13.74 g of carbon and 1.15 g of hydrogen.

C: $\frac{13.74g}{(13.74+1.15)g}$ x100 = 92.3% H: $\frac{1.15g}{(13.74+1.15)g}$ x 100 = 7.7%

12. Analysis of an unknown compound shows that it consists of 21.8 g of oxygen, 4.09 g of aluminum, and 6.36 g of nitrogen.

O: $\frac{21.8g}{32.25g}$ x 100 = 67.6% Al: $\frac{4.09g}{32.25g}$ x100 = 12.7%

N: $\frac{6.36g}{32.25g}$ = 19.7%

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MOLE WS #6 – EMPIRICAL & MOLECULAR FORMULAS

1. A compound used to test for the presence of ozone in the stratosphere contains 96.2% thallium and 3.77% oxygen. What is its empirical formula?

$$Tl: \frac{96.2g \mid 1 mole}{\mid 204.38g} = \frac{0.470691849 moles}{0.235625 moles} = 1.997 \approx 2$$

$$O: \frac{3.77g \mid 1 mole}{\mid 16g} = \frac{0.235625 moles}{0.235625 moles} = 1$$

$\boxed{Tl_2O}$

2. What is the empirical formula of a compound that contains 42.9% carbon and 57.1% O?

$$C: \frac{42.9g \mid 1 mole}{\mid 12.01g} = \frac{3.572023314 moles}{3.56875 moles} = 1$$

$$O: \frac{57.1g \mid 1 mole}{\mid 16g} = \frac{3.56875 moles}{3.56875 moles} = 1$$

$\boxed{CO}$

3. Calculate the molecular formula of a compound that contains 94.1% O and 5.9% H and has a molar mass of 34 grams.

$$O: \frac{94.1g \mid 1 mole}{\mid 16g} = \frac{5.88125 moles}{5.841584158 moles} = 1$$

OH

$$H: \frac{5.9g \mid 1 mole}{\mid 1.01g} = \frac{5.841584158 moles}{5.841584158 moles} = 1$$

$$EF_{mass} = 16 + 1.01 = 17.01 g/mole$$

$$\frac{34g}{17.01g} = 1.9988 \approx 2$$

$\boxed{O_2H_2}$

4. Calculate the molecular formula of a compound whose molar mass is 60.0 g/mol and the empirical formula is CH_4N.

$EF_{mass} = 12.01 + 4(1.01) + 14.01 = 30.06 g/mol$

$\frac{60.0 g/mol}{30.06 g/mol} = 1.996 \approx 2$

$C_2H_8N_2$

5. The molecular mass of benzene, an important industrial solvent and know carcinogen, is 78 g/mol and its empirical formula is CH. What is the molecular formula of benzene?

$EF_{mass} = 12.01 + 1.01 = 13.02 g/mol$

$\frac{78 g/mol}{13.02 g/mol} = 5.99 \approx 6$

C_6H_6

6. Ascorbic acid, or vitamin C, has a percent composition of 40.9% C, 4.58% H, and 54.5% O. Its molecular mass is 176.1 *g/mol*. Find its <u>empirical</u> and <u>molecular</u> formulas. (HINT: Multiply by 2, 3, or 4 to get whole number subscripts.)

C: $\frac{40.9 g | 1 mole}{| 12.01 g} = \frac{3.40549542 moles}{3.40549542 moles} = 1 \times 3 = 3$

H: $\frac{4.58 g | 1 mole}{| 1.01 g} = \frac{4.534653465 moles}{3.40549542 moles} = 1.33 \times 3 = 4$

O: $\frac{54.5 g | 1 mole}{| 16 g} = \frac{3.40625 moles}{3.40549542 moles} = 1.000 \approx 1 \times 3 = 3$

EF: $C_3H_4O_3$

$EF_{mass} = 3(12.01) + 4(1.01) + 3(16) = 88.07 g/mole$

$\frac{176.1 g/mol}{88.07 g/mol} = 1.999 \approx 2$

MF: $C_6H_8O_6$