Moles & Mass Practice Problems

1. Identify and calculate the number of representative particles in each of the following quantities

a. 2.15 moles of gold

$$2.15 \text{ mol Au} \times \frac{6.02 \times 10^{23} \text{ atoms Au}}{1 \text{ mol Au}} = 1.29 \times 10^{24} \text{ atoms Au}$$

b. 0.151 mole of nitrogen oxide

$$0.151 \text{ mol NO} \times \frac{6.02 \times 10^{23} \text{ molecules NO}}{1 \text{ mol NO}} = 9.09 \times 10^{22} \text{ molecules NO}$$

c. 11.5 moles of potassium bromide

$$11.5 \text{ mol KBr} \times \frac{6.02 \times 10^{23} \text{ units KBr}}{1 \text{ mol KBr}} = 6.92 \times 10^{24} \text{ molecules KBr}$$

2. Calculate the number of moles of the substance that contains the following number of representative particles.

a. 8.92×10^{23} atoms of barium

$$8.92 \times 10^{23} \text{ atoms Ba} \times \frac{1 \text{ mol Ba}}{6.02 \times 10^{23} \text{ atoms Ba}} = 1.48 \text{ mol Ba}$$

b. 5.50×10^{25} molecules of carbon monoxide

$$5.50 \times 10^{25} \text{ molecules CO} \times \frac{1 \text{ mol CO}}{6.02 \times 10^{23} \text{ molecules CO}} = 91.4 \text{ mol CO}$$

c. 2.66×10^{22} formula units of potassium iodide

$$2.66 \times 10^{22} \text{ units KI} \times \frac{1 \text{ mol KI}}{6.02 \times 10^{23} \text{ units KI}} = 0.0442 \text{ mol KI}$$

3. Determine the mass in grams of each of the following quantities.

a. 1.24 moles of beryllium

$$1.24 \text{ mol Be} \times \frac{9.01 \text{ g Be}}{1 \text{ mol Be}} = 11.2 \text{ g Be}$$

b. 3.35 moles of calcium

$$3.35 \text{ mol Ca} \times \frac{40.08 \text{ g Ca}}{1 \text{ mol Ca}} = 134. \text{ g Ca}$$

c. 0.155 mole of sulfur

$$0.155 \text{ mol S} \times \frac{32.07 \text{ g S}}{1 \text{ mol S}} = 4.97 \text{ g S}$$

4. Calculate the number of moles in each of the following quantities.

a. 6.35 g lithium

$$6.35 \text{ g Li} \times \frac{1 \text{ mol Li}}{6.94 \text{ g Li}} = 0.915 \text{ mol Li}$$

b. 346 g zinc

$$346 \text{ g Zn} \times \frac{1 \text{ mol Zn}}{65.39 \text{ g Zn}} = 5.29 \text{ mol Zn}$$

c. 115 g nickel

$$115 \text{ g Ni} \times \frac{1 \text{ mol Ni}}{58.69 \text{ g Ni}} = 1.96 \text{ mol Ni}$$

5. How many atoms are in the following samples?

a. 1.24 g cobalt

$$1.24\ g\ Co \times \frac{1\ mol\ Co}{58.93\ g\ Co} \times \frac{6.02 \times 10^{23}\ atoms\ Co}{1\ mol\ Co} = 1.27 \times 10^{22}\ atoms\ Co$$

b. 0.575 g cesium

$$0.575\ g\ Ce \times \frac{1\ mol\ Ce}{132.91\ g\ Ce} \times \frac{6.02 \times 10^{23}\ atoms\ Ce}{1\ mol\ Ce} = 2.60 \times 10^{21}\ atoms\ Ce$$

c. 65.6 g silicon

$$65.6\ g\ Si \times \frac{1\ mol\ Si}{28.09\ g\ Si} \times \frac{6.02 \times 10^{23}\ atoms\ Si}{1\ mol\ Si} = 1.41 \times 10^{24}\ atoms\ Si$$

6. Which quantity has the greatest mass?

a. 4.16×10^{23} atoms of radium

$$4.16 \times 10^{23}\ atoms\ Ra \times \frac{1\ mol\ Ra}{6.02 \times 10^{23}\ atoms\ Ra} \times \frac{226\ g\ Ra}{1\ mol\ Ra} = 156\ g\ Ra$$

b. 1.50×10^{20} atoms of cadmium

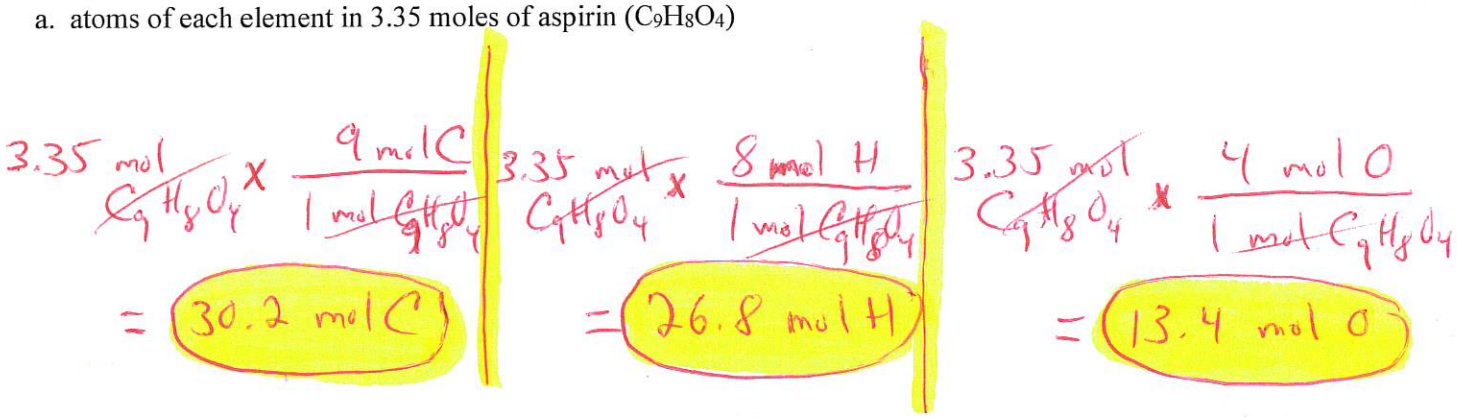
$$1.50 \times 10^{20}\ atoms\ Cd \times \frac{1\ mol\ Cd}{6.02 \times 10^{23}\ atoms\ Cd} \times \frac{112.41\ g\ Cd}{1\ mol\ Cd} = 0.0280\ g\ Cd$$

c. 1.33×10^{24} atoms of argon

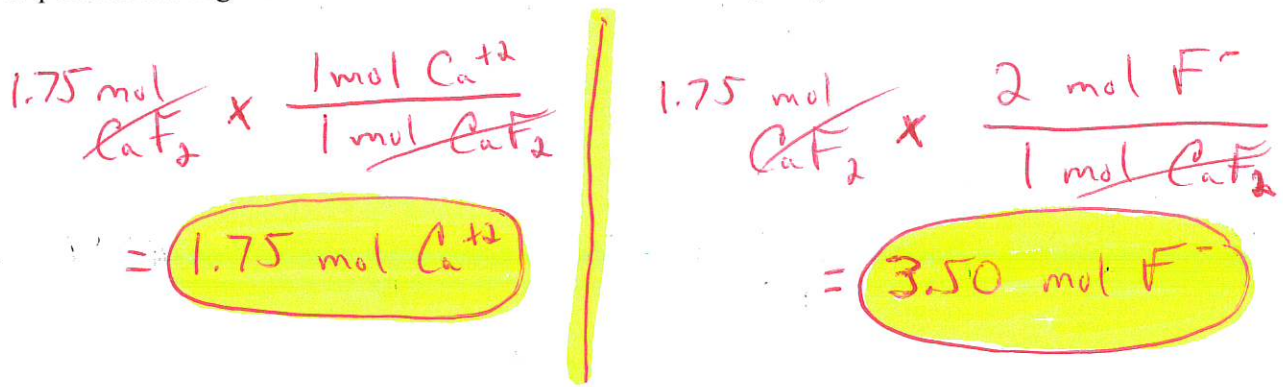
$$1.33 \times 10^{24}\ atoms\ Ar \times \frac{1\ mol\ Ar}{6.02 \times 10^{23}\ atoms\ Ar} \times \frac{39.95\ g\ Ar}{1\ mol\ Ar} = 88.3\ g\ Ar$$

7. Calculate the number of moles in each of the following quantities.

a. atoms of each element in 3.35 moles of aspirin ($C_9H_8O_4$)

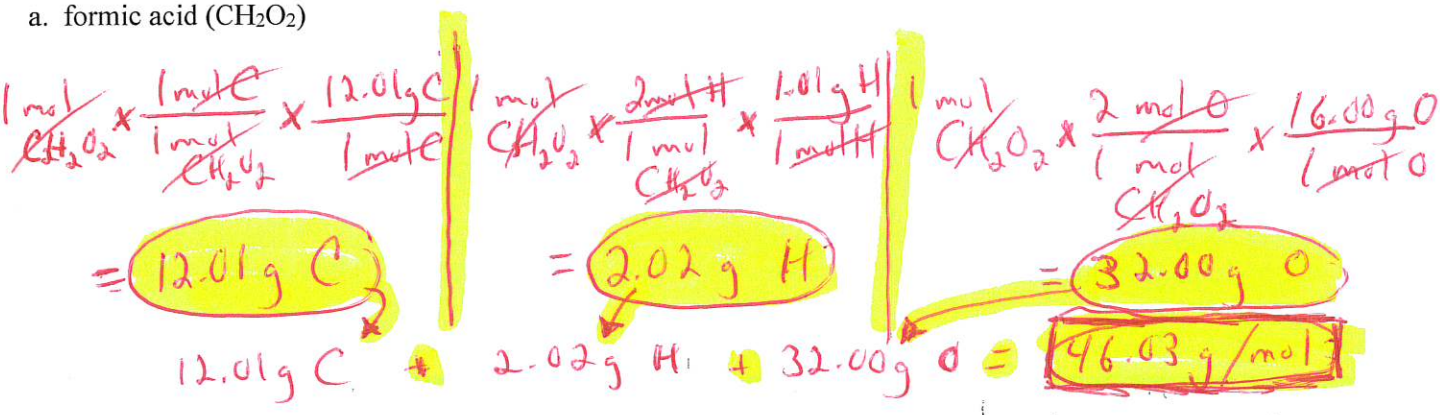


b. positive and negative ions in 1.75 moles of calcium fluoride (CaF_2)

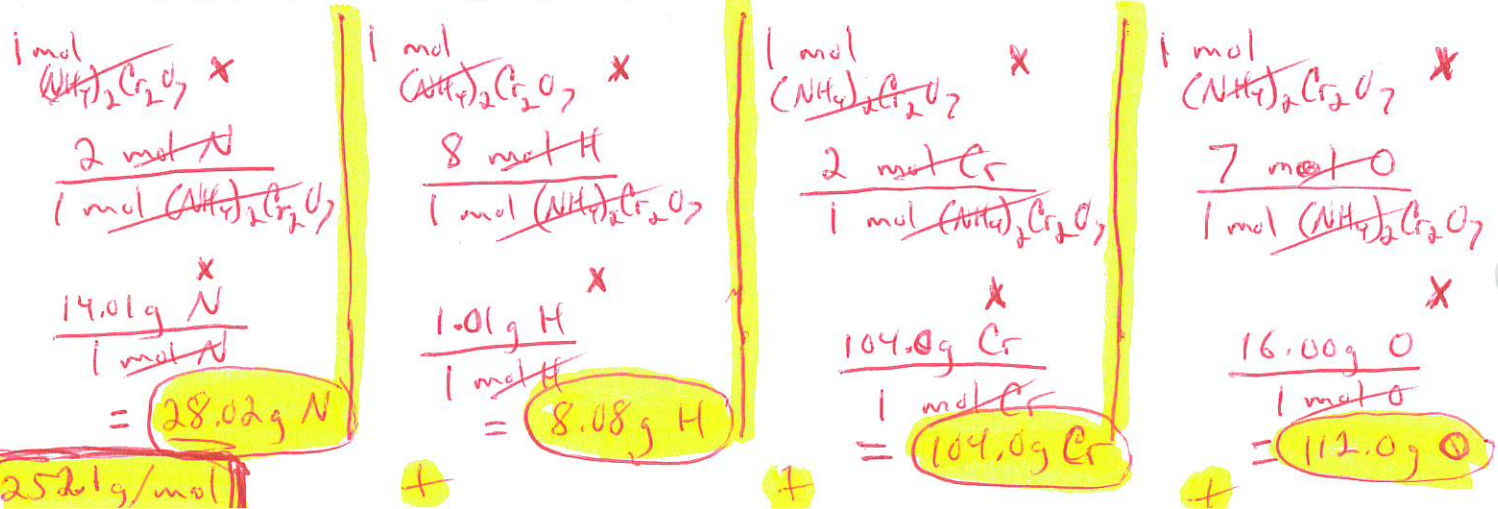


8. Determine the molar mass of each of the following compounds.

a. formic acid (CH_2O_2)



b. ammonium dichromate ($(NH_4)_2Cr_2O_7$)



$2.53 \text{ mol } Pb(NO_3)_2 \times \frac{331.2 \text{ g } Pb(NO_3)_2}{1 \text{ mol } Pb(NO_3)_2} = 838 \text{ g}$

9. What is the mass in grams of each of the following quantities?

a. 2.53 moles of lead (II) nitrate ($Pb(NO_3)_2$)

331.2 g/mol =

$1 \text{ mol } Pb(NO_3)_2 \times \frac{1 \text{ mol Pb}}{1 \text{ mol } Pb(NO_3)_2} \times \frac{207.2 \text{ g Pb}}{1 \text{ mol Pb}} = 207.2 \text{ g Pb}$

$1 \text{ mol } Pb(NO_3)_2 \times \frac{2 \text{ mol N}}{1 \text{ mol } Pb(NO_3)_2} \times \frac{14.01 \text{ g N}}{1 \text{ mol N}} = 28.02 \text{ g N}$

$1 \text{ mol } Pb(NO_3)_2 \times \frac{6 \text{ mol O}}{1 \text{ mol } Pb(NO_3)_2} \times \frac{16.00 \text{ g O}}{1 \text{ mol O}} = 96.00 \text{ g O}$

b. 4.62 moles of magnesium bromide ($MgBr_2$)

$1 \text{ mol } MgBr_2 \times \frac{1 \text{ mol Mg}}{1 \text{ mol } MgBr_2} \times \frac{24.31 \text{ g Mg}}{1 \text{ mol Mg}} = 24.31 \text{ g Mg}$

$1 \text{ mol } MgBr_2 \times \frac{2 \text{ mol Br}}{1 \text{ mol } MgBr_2} \times \frac{79.90 \text{ g Br}}{1 \text{ mol Br}} = 159.80 \text{ g Br}$

24.31 g Mg + 159.80 g Br

184.11 g/mol

$4.62 \text{ mol } MgBr_2 \times \frac{184.11 \text{ g } MgBr_2}{1 \text{ mol } MgBr_2} = 851 \text{ g}$

10. Calculate the number of moles in each of the following samples.

a. 3.75 g calcium carbide (CaC_2)

$1 \text{ mol } CaC_2 \times \frac{2 \text{ mol C}}{1 \text{ mol } CaC_2} \times \frac{12.01 \text{ g C}}{1 \text{ mol C}} = 24.02 \text{ g C}$

$1 \text{ mol } CaC_2 \times \frac{1 \text{ mol Ca}}{1 \text{ mol } CaC_2} \times \frac{40.08 \text{ g Ca}}{1 \text{ mol Ca}} = 40.08 \text{ g Ca}$

24.02 g C + 40.08 g Ca

64.10 g/mol

$3.75 \text{ g } CaC_2 \times \frac{1 \text{ mol } CaC_2}{64.10 \text{ g } CaC_2} = 0.0585 \text{ mol } CaC_2$

b. 245 g aluminum nitrite ($Al(NO_2)_3$)

$1 \text{ mol } Al(NO_2)_3 \times \frac{1 \text{ mol Al}}{1 \text{ mol } Al(NO_2)_3} \times \frac{26.98 \text{ g Al}}{1 \text{ mol Al}} = 26.98 \text{ g Al}$

$1 \text{ mol } Al(NO_2)_3 \times \frac{3 \text{ mol N}}{1 \text{ mol } Al(NO_2)_3} \times \frac{14.01 \text{ g N}}{1 \text{ mol N}} = 42.03 \text{ g N}$

$1 \text{ mol } Al(NO_2)_3 \times \frac{6 \text{ mol O}}{1 \text{ mol } Al(NO_2)_3} \times \frac{16.00 \text{ g O}}{1 \text{ mol O}} = 96.00 \text{ g O}$

165.01 g/mol

$245 \text{ g } Al(NO_2)_3 \times \frac{1 \text{ mol } Al(NO_2)_3}{165.01 \text{ g } Al(NO_2)_3} = 1.48 \text{ mol } Al(NO_2)_3$

11. Determine the percent composition of each of the following compounds.

a. manganese oxide (MnO)

$1\ \text{mol MnO} \times \frac{1\ \text{mol Mn}}{1\ \text{mol MnO}} \times \frac{54.94\ \text{g Mn}}{1\ \text{mol Mn}} = 54.94\ \text{g Mn}$

+

$1\ \text{mol MnO} \times \frac{1\ \text{mol O}}{1\ \text{mol MnO}} \times \frac{16.00\ \text{g O}}{1\ \text{mol O}} = 16.00\ \text{g O}$

$= 70.94\ \text{g}$

$\%\ \text{Mn} = \frac{54.94\ \text{g Mn}}{70.94\ \text{g MnO}} \times 100 = 77.45\%$ | $\%\ \text{O} = \frac{16.00\ \text{g O}}{70.94\ \text{g MnO}} \times 100 = 22.55\%$

b. propanol (C_3H_8O)

$1\ \text{mol } C_3H_8O \times \frac{3\ \text{mol C}}{1\ \text{mol } C_3H_8O} \times \frac{12.01\ \text{g C}}{1\ \text{mol C}} = 36.03\ \text{g C}$

+

$1\ \text{mol } C_3H_8O \times \frac{8\ \text{mol H}}{1\ \text{mol } C_3H_8O} \times \frac{1.01\ \text{g H}}{1\ \text{mol H}} = 8.08\ \text{g H}$

$= 60.11\ \text{g}$

+

$1\ \text{mol } C_3H_8O \times \frac{1\ \text{mol O}}{1\ \text{mol } C_3H_8O} \times \frac{16.00\ \text{g O}}{1\ \text{mol O}} = 16.00\ \text{g O}$

$\%\ \text{C} = \frac{36.03}{60.11} \times 100 = 59.94\%$ | $\%\ \text{H} = \frac{8.08}{60.11} \times 100 = 13.44\%$ | $\%\ \text{O} = \frac{16.00}{60.11} \times 100 = 26.6\%$

12. Determine the empirical formula for a 100.00-g sample of a compound having the following percent composition.

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a. 94.07% sulfur and 5.93% hydrogen (mass of S = 94.07 g / mass of H = 5.93 g)

$94.07\ \text{g S} \times \frac{1\ \text{mol S}}{32.07\ \text{g S}} = 2.93\ \text{mol S}$

$5.93\ \text{g H} \times \frac{1\ \text{mol H}}{1.01\ \text{g H}} = 5.87\ \text{mol H}$

$\frac{5.87\ \text{mol H}}{2.93\ \text{mol S}} = \frac{2\ \text{mol H}}{1\ \text{mol S}}$

H_2S

b. 80.68% mercury, 12.87% oxygen, and 6.45% sulfur (80.68 g Hg; 12.87 g O; 6.45 g S)

$80.68\ \text{g Hg} \times \frac{1\ \text{mol Hg}}{200.59\ \text{g Hg}} = 0.4022\ \text{mol Hg}$

$12.87\ \text{g O} \times \frac{1\ \text{mol O}}{16.00\ \text{g O}} = 0.8044\ \text{mol O}$

$6.45\ \text{g S} \times \frac{1\ \text{mol S}}{32.07\ \text{g S}} = 0.2011\ \text{mol S}$

$\frac{0.4022\ \text{mol Hg}}{0.2011\ \text{mol S}} = \frac{2\ \text{mol Hg}}{1\ \text{mol S}}$

$\frac{0.8044\ \text{mol O}}{0.2011\ \text{mol S}} = \frac{4\ \text{mol O}}{1\ \text{mol S}}$

$\frac{0.2011\ \text{mol S}}{0.2011\ \text{mol S}} = \frac{1\ \text{mol S}}{1\ \text{mol S}}$

Hg_2SO_4

13. A 48.30-g sample of an aluminum-iodine compound contains 3.20 g of aluminum. What is the empirical formula for the compound?

$48.30\ g\ (compound) - 3.20\ g\ Al = 45.10\ g\ I$

$3.20\ g\ Al \times \frac{1\ mol\ Al}{26.98\ g\ Al} = 0.1186\ mol\ Al$

$45.10\ g\ I \times \frac{1\ mol\ Al}{126.90\ g\ I} = 0.3554\ mol\ I$

$\frac{0.3554\ mol\ I}{0.1186\ mol\ Al} = \frac{3\ mol\ I}{1\ mol\ Al}$

$\frac{0.1186\ mol\ Al}{0.1186\ mol\ Al} = \frac{1\ mol\ Al}{1\ mol\ Al}$

AlI_3

14. A 50.00-g sample of hydrated manganese(II) chloride yields 31.75 g of the anhydrous compound after heating. Determine the chemical formula and name of the hydrate.

$50.00\ g\ hydrate - 31.75\ g\ anhydrous = 18.25\ g\ water$

$1\ mol\ MnCl_2 \times \frac{1\ mol\ Mn}{1\ mol\ MnCl_2} \times \frac{54.94\ g\ Mn}{1\ mol\ Mn} = 54.94\ g\ Mn$

$+$

$1\ mol\ MnCl_2 \times \frac{2\ mol\ Cl}{1\ mol\ MnCl_2} \times \frac{35.45\ g\ Cl}{1\ mol\ Cl} = 70.90\ g\ Cl$

$= 125.84\ g/mol$

$31.75\ g\ MnCl_2 \times \frac{1\ mol\ MnCl_2}{125.84\ g\ MnCl_2} = 0.2523\ mol\ MnCl_2$

$18.25\ g\ H_2O \times \frac{1\ mol\ H_2O}{18.02\ g\ H_2O} = 1.013\ mol\ H_2O$

$\frac{1.013\ mol\ H_2O}{0.2523\ mol\ MnCl_2} = \frac{4\ mol\ H_2O}{1\ mol\ MnCl_2}$

$MnCl_2 \cdot 4H_2O$

15. Caffeine is a compound found in some natural coffees and teas and in some colas.

a. Determine the empirical formula for caffeine, using the following composition of a 100.00-g sample.

49.47 grams of carbon
28.85 grams of nitrogen
16.48 grams of oxygen
5.20 grams of hydrogen

$49.47\ g\ C \times \frac{1\ mol\ C}{12.01\ g\ C} = 4.119\ mol\ C$

$28.85\ g\ N \times \frac{1\ mol\ N}{14.01\ g\ N} = 2.059\ mol\ N$

$16.48\ g\ O \times \frac{1\ mol\ O}{16.00\ g\ O} = 1.030\ mol\ O$

$5.20\ g\ H \times \frac{1\ mol\ H}{1.01\ g\ H} = 5.15\ mol\ H$

$\frac{4.119\ mol\ C}{1.030\ mol\ O} = \frac{4\ mol\ C}{1\ mol\ O}$

$\frac{2.059\ mol\ N}{1.030\ mol\ O} = \frac{2\ mol\ N}{1\ mol\ O}$

$\frac{5.15\ mol\ H}{1.030\ mol\ O} = \frac{5\ mol\ H}{1\ mol\ O}$

$\frac{1.030\ mol\ O}{1.030\ mol\ O} = \frac{1\ mol\ O}{1\ mol\ O}$

4 mol C : 2 mol N : 5 mol H : 1 mol O

$C_4H_5N_2O$

b. If the molar mass of caffeine is 194.19 g/mol, calculate its molecular formula.

$4\ mol\ C \times \frac{12.01\ g\ C}{1\ mol\ C} = 48.04\ g\ C$ +

$2\ mol\ N \times \frac{14.01\ g\ N}{1\ mol\ N} = 28.02\ g\ N$ +

$5\ mol\ H \times \frac{1.01\ g\ H}{1\ mol\ H} = 5.05\ g\ H$ +

$1\ mol\ O \times \frac{16.00\ g\ O}{1\ mol\ O} = 16.00\ g\ O$

$= 97.11\ g/mol$

$n = \frac{\text{molar mass of compound}}{\text{molar mass of empirical formula}} = \frac{194.19\ g/mol}{97.11\ g/mol}$

2.00

$C_8H_{10}N_4O_2$