Mole Calculations - Answers

1. Determine the molar mass of the following compounds:

a) nitrogen monoxide NO 30.0061 g/mol

b) ammonia NH_3 17.03052 g/mol

c) ammonium phosphate $(NH_4)_3PO_4$ 149.08674 g/mol

d) aluminum nitrate $Al(NO_3)_3$ 212.99624 g/mol

e) tin(II) oxalate SnC_2O_4 206.7296 g/mol

f) calcium hydroxide $Ca(OH)_2$ 74.09468 g/mol

g) ferric chloride $FeCl_3$ 162.206 g/mol

h) silver nitrate $AgNO_3$ 169.8731 g/mol

i) magnesium glutamate $Mg(C_5H_8NO_4)_2$ 316.55064 g/mol

2. Calculate the mass of:

a) 1.00 mol of ammonium chloride

NH_4Cl (1.00 mol)(53.49146 g/mol)

= 53.5 g

b) 3.50 mol of phosphorus trichloride

PCl_3 (3.50 mol)(137.33276 g/mol)

= 481 g

c) 1.70×10^{-24} mol of iron

Fe $(1.70 \times 10^{-24}\ mol)(55.847\ g/mol)$

$= 9.49 \times 10^{-23}$ g

d) 3.25×10^{2} mol of sodium hydrogen phosphate

Na_2HPO_4 $(3.25 \times 10^{2}\ mol)($ [illegible] g/mol)

= [illegible] g 4.61×10^{4} g

e) 0.0035 mol of ammonia

NH_3 (0.0035 mol)(17.03052 g/mol)

= 0.0[illegible] g

or 6.0×10^{-2} g

f) 4.50 mol of carbon dioxide

CO_2 (4.50 mol)(44.0098 g/mol)

= 198 g

g) 1.00×10^{-3} mol of sodium hydroxide

NaOH $(1.00 \times 10^{-3}\ mol)(39.9971\ g/mol)$

= 0.0400 g

h) 2.65 mol of plumbic nitrate

$Pb(NO_3)_4$

(2.65 mol)(455.2196 g/mol)

= 1210 g

i) 7.91×10^{-4} mol of sulfurous acid

H_2SO_3

$(7.91 \times 10^{-4}\ mol)(82.08008\ g/mol)$

= 0.0649 g

j) 0.0125 mol of sodium tartrate

$Na_2C_4H_4O_6$

(0.0125 mol)(194.0517 g/mol)

= 2.43 g

3. How many moles of the following substances are contained in:

a) 17.0 g of sulfuric acid

H_2SO_4 $\frac{17.0 g}{98.079\,48 g/mol}$

$= 0.173$ mol

f) 10.6 L of sulfur dioxide gas at STP

SO_2 $\frac{10.6 L}{22.4 L/mol}$

$= 0.473$ mol

b) 4.00×10^{12} molecules of ferric oxide

Fe_2O_3 $\frac{4.00 \times 10^{12} \text{ molecules}}{6.022 \times 10^{23} \text{ molecules/mol}}$

$= 6.64 \times 10^{-12}$ mol

g) 0.120 L of nitrogen dioxide gas at STP

NO_2 $\frac{0.120 L}{22.4 L/mol}$

$= 0.005\,36$ mol

c) 91.0 g of water

H_2O

$\frac{91.0 g}{18.015\,28 g/mol}$

$= 5.05$ mol

h) 53.0 g of carbon

C

$\frac{53.0 g}{12.011 g/mol} = 4.41$ mol

d) 175 mL of chlorine gas at STP

Cl_2 $\frac{0.175 L}{22.4 L/mol}$

$= 0.007\,81$ mol

i) 7.50×10^{21} molecules of nitric acid

HNO_3 $\frac{7.50 \times 10^{21} \text{ molecules}}{6.022 \times 10^{23} \text{ molecules/mol}}$

$= 0.012\,5$ mol

e) 5.50×10^{25} molecules of carbon tetrachloride

CCl_4 $\frac{5.50 \times 10^{25} \text{ molecules}}{6.022 \times 10^{23} \text{ molecules/mol}}$

$= 91.3$ mol

j) 25.0 mL of nitrogen gas at STP

N_2 $\frac{0.0250 L}{22.4 L/mol}$

$= 0.001\,12$ mol

4. Calculate the mass, in grams, of:

a) 2.00×10^6 molecules of carbon monoxide

CO $\left(\frac{2.00 \times 10^6 \text{ molecules}}{6.022 \times 10^{23}}\right)(28.0104 \text{ g/mol})$

$= 9.30 \times 10^{-17}$ g

b) 1.25 L of ammonia gas at STP

NH_3 $\left(\frac{1.25 \text{ L}}{22.4 \text{ L/mol}}\right)(17.03052 \text{ g/mol})$

$= 0.950$ g

c) 5.00 molecules of nitrogen gas at STP

N_2 $\left(\frac{5.00 \text{ molecules}}{6.022 \times 10^{23}}\right)(28.0134 \text{ g/mol})$

$= 2.33 \times 10^{-22}$ g

d) ~~16 g~~ 3.41×10^{20} atoms silver

~~How many g~~ $\left(\frac{3.41 \times 10^{20}}{6.022 \times 10^{23}}\right)(107.8682 \text{ g/mol Ag})$

$= 0.0611$ g

e) 5.50×10^{-6} mol of water

H_2O $(5.50 \times 10^{-6} \text{ mol})(18.01528 \text{ g/mol})$

$= 9.91 \times 10^{-5}$ g

f) 4.15×10^{15} molecules of dinitrogen tetroxide

N_2O_4 $\left(\frac{4.15 \times 10^{15} \text{ molecules}}{6.022 \times 10^{23} \text{ molecules/mol}}\right)(92.011 \text{ g/mol})$

$= 6.34 \times 10^{-7}$ g

g) 1 atom of gold

Au $\left(\frac{1}{6.022 \times 10^{23}}\right)(196.96655 \text{ g/mol})$

$= 3.271 \times 10^{-22}$ g

h) 7 molecules of nitrogen

N_2 $\left(\frac{7}{6.022 \times 10^{23}}\right)(28.0134 \text{ g/mol})$

$= 3.256 \times 10^{-22}$ g

i) 3.45 mL of oxygen at STP

O_2 $\left(\frac{0.00345 \text{ L}}{22.4 \text{ L/mol}}\right)(31.9988 \text{ g/mol})$

$= 0.00493$ g

j) 20 atoms of helium

$\left(\frac{20}{6.022 \times 10^{23}}\right)(4.00260 \text{ g/mol})$

$= 1.329 \times 10^{-22}$ g

k) 1.00×10^8 L of hydrogen at STP

H_2 $\left(\frac{1.00 \times 10^8 \text{ L}}{22.4 \text{ L/mol}}\right)(2.01588 \text{ g/mol})$

$= 9.00 \times 10^6$ g

l) 5.91 mol of potassium oxalate $K_2C_2O_3$

$(5.91 \text{ mol})(150.2168 \text{ g/mol})$

$= 888$ g

5. Determine the number of atoms contained in:

a) 1.00 mol of ammonium chloride NH_4Cl

$(1.00\ mol)(6.022 \times 10^{23})(6)$

$= 3.61 \times 10^{24}$ atoms

b) 8.00 g of iron Fe

$\left(\frac{8.00\ g}{55.847\ g/mol}\right)(6.022 \times 10^{23})$

$= 8.63 \times 10^{22}$ atoms

c) 12.0 g of hydrogen peroxide H_2O_2

$\left(\frac{12.0\ g}{34.014\ 68\ g/mol}\right)(6.022 \times 10^{23})(4)$

$= 8.50 \times 10^{23}$ atoms

d) 55.0 mL of dinitrogen monoxide gas at STP N_2O

$\left(\frac{0.0550\ L}{22.4\ L/mol}\right)(6.022 \times 10^{23})(3)$

$= 4.44 \times 10^{21}$ atoms

e) 5.00 g of sodium chloride NaCl

$\left(\frac{5.00\ g}{58.442\ 77\ g/mol}\right)(6.022 \times 10^{23})(2)$

$= 1.03 \times 10^{23}$ atoms

f) 8.30×10^{-4} mL of boron trifluoride gas at STP BF_3

$\left(\frac{8.30 \times 10^{-7}\ L}{22.4\ L/mol}\right)(6.022 \times 10^{23})(4)$

$= 8.93 \times 10^{16}$ atoms

g) 2.50 mol of oxygen O_2

$(2.50\ mol)(6.022 \times 10^{23})(2)$

$= 3.01 \times 10^{24}$ atoms

h) 15.0 L of argon at STP Ar

$\left(\frac{15.0\ L}{22.4\ L/mol}\right)(6.022 \times 10^{23})(1)$

$= 4.03 \times 10^{23}$ atoms

i) 2.50×10^{-4} mol of phosphoric acid H_3PO_4

$(2.50 \times 10^{-4})(6.022 \times 10^{23})(8)$

$= 1.20 \times 10^{21}$ atoms

I j) 40.0 g of potassium K

$\left(\frac{40.0\ g}{39.0983\ g/mol}\right)(6.022 \times 10^{23})$

$= 6.16 \times 10^{23}$ atoms

J k) 100.0 g of ammonium citrate $(NH_4)_3C_6H_5O_7$

$\left(\frac{100.0\ g}{243.216\ 88\ g/mol}\right)(6.022 \times 10^{23})(33)$

$= 8.17 \times 10^{24}$ atoms

K l) 15.0 g of potassium dichromate $K_2Cr_2O_7$

$\left(\frac{15.0\ g}{294.1844\ g/mol}\right)(6.022 \times 10^{23})(11)$

$= 3.38 \times 10^{23}$ atoms

6. What volume at STP is occupied by the following gases:

O_3 a) 0.235 mol of ozone

$(0.235\ mol)(22.4\ L/mol)$

$= 5.26\ L$

e) 9.36 mol of helium He

$(9.36\ mol)(22.4\ L/mol)$

$= 209\ L$ ~~209 L~~ $210.\ L$

SO_2 b) 16.5 g of sulfur dioxide

$\left(\frac{16.5\ g}{64.0648\ g/mol}\right)(22.4\ L/mol)$

$= 5.77\ L$

f) 6.98×10^{15} atoms of xenon Xe

$\left(\frac{6.98 \times 10^{15}}{6.022 \times 10^{23}}\right)(22.4\ L/mol)$

$= 2.60 \times 10^{-7}\ L$

H_2Te c) 28.4 mg of hydrogen telluride

$\left(\frac{0.0284\ g}{129.61588\ g/mol}\right)(22.4\ L/mol)$

$= 0.00491\ L = 4.91\ mL$

g) 5.65×10^{22} molecules of ammonia NH_3

$\left(\frac{5.65 \times 10^{22}}{6.022 \times 10^{23}}\right)(22.4\ L/mol)$

$2.10\ L$

HCl d) 8.65×10^{21} molecules of hydrogen chloride

$\left(\frac{8.65 \times 10^{21}}{6.022 \times 10^{23}}\right)(22.4\ L/mol)$

$= 0.322\ L$

h) 15.7 g of chlorine Cl_2

$\left(\frac{15.7\ g}{70.906\ g/mol}\right)(22.4\ L/mol)$

$= 4.96\ L$

7. Calculate the percentage composition of each compound listed below.

a) potassium nitrite KNO_2

% K $= \frac{39.0983}{85.1038}$ ~~101.1031~~

$=$ ~~38.[illegible] %~~ K

45.94 % K

% N $= \frac{14.0067}{85.1038}$ ~~101.1031~~

$=$ ~~13.[illegible] % N~~

16.46 % N

% O $= \frac{2(15.9994)}{85.1038}$ ~~101.1031~~

$=$ ~~47.47 % O~~

37.60 % O

7. Calculate the percentage composition of each compound listed below.

b) ammonium sulfate $(NH_4)_2SO_4$

$\%N = \frac{2(14.0067)}{132.14052} = 21.20\%N$ $\%H = \frac{8(1.00794)}{132.14052} = 6.10\%H$ $\%S = \frac{32.066}{132.14052} = 24.27\%S$ $\%O = \frac{4(15.9994)}{132.14052} = 48.43\%O$

c) calcium phosphate $Ca_3(PO_4)_2$

$\%Ca = \frac{3(40.08)}{310.18272} = 38.76\%Ca$ $\%P = \frac{2(30.97376)}{310.18272} = 19.92\%P$ $\%O = \frac{8(15.9994)}{310.18272} = 41.26\%O$

d) ammonium carbonate $(NH_4)_2CO_3$

$\%N = \frac{2(14.0067)}{96.08612} = 29.15\%N$ $\%H = \frac{8(1.00794)}{96.08612} = 8.39\%H$ $\%C = \frac{(12.011)}{96.08612} = 12.50\%C$ $\%O = \frac{3(15.9994)}{96.08612} = 49.95\%O$

7. Calculate the percentage composition of each compound listed below.

e) aluminum nitrate $Al(NO_3)_3$

$\%\ Al = \frac{26.98154}{212.99624}$ $\%\ N = \frac{3(14.0067)}{212.99624}$ $\%\ O = \frac{9(15.9994)}{212.99624}$

$= 12.67\ \%\ Al$ $= 19.73\ \%\ N$ $= 67.60\ \%\ O$

f) calcium acetate $Ca(C_2H_3O_2)_2$

$\%\ Ca = \frac{40.08}{158.16924}$ $\%\ C = \frac{4(12.011)}{158.16924}$ $\%\ H = \frac{6(1.00794)}{158.16924}$ $\%\ O = \frac{4(15.9994)}{158.16924}$

$= 25.34\ \%\ Ca$ $= 30.38\ \%\ C$ $= 3.82\ \%\ H$ $= 40.46\ \%\ O$

8. Determine the empirical formula for each compound listed below.

a) 80.0% carbon; 20.0% hydrogen

$\frac{80.0\ g\ C}{12.011}$ $\frac{20.0\ g\ H}{1.00794}$

$\frac{6.66056}{6.66056}$ $\frac{19.84245}{6.66056}$

$1 : 2.979 \Rightarrow 1:3 \Rightarrow CH_3$

8. Determine the empirical formula for each compound listed below.

b) 35.0% nitrogen; 5.0% hydrogen; 60.0% oxygen

$\frac{35.0\ g\ N}{14.0067\ g/mol}$ $\frac{5.0\ g\ H}{1.00794\ g/mol}$ $\frac{60.0\ g\ O}{15.9994\ g/mol}$

$\frac{2.498\ 804\ mol}{2.498\ 804}$ $\frac{4.960\ 613\ mol}{2.498\ 804}$ $\frac{3.750\ 141\ mol}{2.498\ 804}$

1.00 (×2) 1.985 (×2) 1.50 (×2)

⇒ 2 : 4 : 3 $N_2H_4O_3$

c) 83.7% carbon; 16.3% hydrogen

$\frac{83.7\ g\ C}{12.011\ g/mol}$ $\frac{16.3\ g\ H}{1.00794\ g/mol}$

$\frac{6.968\ 612\ mol}{6.968\ 612}$ $\frac{16.171\ 598\ mol}{6.968\ 612}$

1 (×3) : 2.320 634 (×3) C_3H_7

3 : 6.962

3 : 7

d) 26.6% potassium; 35.4% chromium; 38.0% oxygen

$\frac{26.6\ g\ K}{39.0983\ g/mol}$ $\frac{35.4\ g\ Cr}{51.996\ g/mol}$ $\frac{38.0\ g\ O}{15.9994\ g/mol}$

$\frac{0.680\ 336\ mol}{0.680\ 336}$ $\frac{0.680\ 822\ mol}{0.680\ 336}$ $\frac{2.375\ 089\ mol}{0680\ 336}$

1 (×2) : 1.000 7 (×2) : 3.491 (×2) $K_2Cr_2O_7$

2 : 2 : 7

8. Determine the empirical formula for each compound listed below.

e) 21.2% nitrogen; 6.1% hydrogen; 24.3% sulfur; 48.4% oxygen

21.2 g N	6.1 g H	24.3 S	48.4 g O
14.0067	1.00794	32.066	15.9994
1.513561	6.051948	0.757812	3.025113
0.757812	0.757812	0.757812	0.757812
1.997	7.99 :	1 :	3.99

$\Rightarrow$ 2 : 8 : 1 : 4

$N_2H_8SO_4$

$(NH_4)_2SO_4$

f) An oxide of arsenic which contains 3.26 g of arsenic and 1.04 g of oxygen.

3.26 g As	1.04 g O
74.9216 g/mol	15.9994 g/mol
0.043 512 mol	0.065 002 mol
0.043 512	0.043 512
1 (×2) :	1.49 (×2)

2 : 3

As_2O_3

g) Chemical analysis of a 10.000 g of oil of wintergreen shows that it consists of 6.320 g of carbon, 0.530 g of hydrogen, and 3.16 g of oxygen. What is the simplest formula for oil of wintergreen?

6.320 g C	0.530 g H	3.16 g O
12.011	1.00794	15.9994
0.526 184	0.525 825	0.197 507
0.197 507	0.197 507	0.197 507
2.664 123 (×3) :	2.662 305 (×3) :	1 (×3)
7.992	7.987 :	3

8 : 8 : 3

$C_8H_8O_3$

8. Determine the empirical formula for each compound listed below.

a) A rock sample weighing 5.88×10^{-4} g is known to contain calcium, phosphorus, and oxygen. The amount of the first two elements in this rock is found to be 2.28×10^{-4} g and 1.18×10^{-4} g respectively. What is the empirical formula for the compound in this rock sample?

$\frac{2.28 \times 10^{-4}\ g\ Ca}{40.08\ g/mol}$ $\frac{1.18 \times 10^{-4}\ g\ P}{30.973\ 76\ g/mol}$ $\frac{2.42 \times 10^{-4}\ g\ O}{15.9994}$

$\frac{5.688\ 623 \times 10^{-6}}{3.809\ 676 \times 10^{-6}}$ $\frac{3.809\ 676 \times 10^{-6}}{3.809\ 676 \times 10^{-6}}$ $\frac{1.512\ 557 \times 10^{-5}\ mol}{3.809\ 676 \times 10^{-6}}$

$1.49_{(\times 2)} : 1_{(\times 2)} : 3.97_{(\times 2}$

3 : 2 : 8

$Ca_3P_2O_8$

$Ca_3(PO_4)_2$

9. Calculate the molecular formula for the following compounds.

a) 26.7% carbon; 2.2% hydrogen; 71.1% oxygen; molar mass = 90.0 g/mol

$\frac{24.03\ g\ C}{12.011}$ $\frac{1.98\ g\ H}{1.00794}$ $\frac{63.99\ g\ O}{15.9994}$

2.00 mol C 1.96 mol H 4.00 mol O

$C_2H_2O_4$

b) 54.6% carbon; 9.0% hydrogen; 36.4% oxygen; molar mass = 176 g/mol

$\frac{96.096\ g\ C}{12.011}$ $\frac{15.84\ g\ H}{1.00794}$ $\frac{64.064\ g\ O}{15.9994}$

8.00 mol C 15.72 mol H 4.004 mol O

$C_8H_{16}O_4$

9. Calculate the molecular formula for the following compounds.

c) Analysis of a compound shows that it consists of 24.3% carbon, 4.1% hydrogen, and 71.6 chlorine. The molecular mass of the compound is determined to be ~~99.8~~ 98.8 g/mol. What molecular formula corresponds to these data?

$\frac{24.251\text{ g C}}{12.011}$ $\frac{4.0918\text{ g H}}{1.00794}$ $\frac{71.4568\text{ g Cl}}{35.453\text{ g/mol}}$

2.019 mol C 4.055 mol H 2.016 mol Cl

$C_2H_4Cl_2$

d) Chemical analysis of a gaseous compound show its composition to be 36.4% carbon, 57.5% fluorine, and 6.1% hydrogen. A sample of 1.00 L of this gas has a mass of 2.96 g. What molecular formula do these data suggest for this compound?

$\frac{2.96\text{ g}}{1.00\text{ L}} = \frac{x}{22.4\text{ L}} = 66.304\text{ g/mol}$

$\frac{24.135\text{ g C}}{12.011}$ $\frac{38.1248\text{ g F}}{18.998403}$ $\frac{4.044544\text{ g H}}{1.00794}$

2.009 mol C 2.007 mol F 4.013 mol H

$C_2F_2H_4$

9. Calculate the molecular formula for the following compounds.

e) Analysis of an organic compound indicates that it has a percentage composition as follows: 40.7% carbon; 5.0% hydrogen; 54.3% oxygen. When this compound is vapourized, 35.0 mL of the vapour has a mass of 0.184 g. What molecular formula do you predict for this compound?

$\frac{0.0350\ L}{0.184\ g} = \frac{22.4\ L}{x}$ $\quad x = 117.76\ g/mol$

$\frac{47.99832\ g\ C}{12.011}$ $\quad$ $\frac{5.888\ g\ H}{1.00794}$ $\quad$ $\frac{63.94368\ g\ O}{15.9994}$

3.99 mol C $\quad$ 5.84 mol H $\quad$ 4.00 mol O

$C_4H_6O_4$

f) A gaseous compound is found to have the following composition: 30.5% nitrogen and 69.5% oxygen. The molar mass of the gas is found to be 91.8 g/mol. What is the molecular formula of this gas?

$\frac{27.999\ g\ N}{14.0067}$ $\quad$ $\frac{63.801\ g\ O}{15.9994}$

1.999 mol N $\quad$ 3.99 mol O

N_2O_4