Problems: Calculations with Formula Weights and Moles

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1. Calculate the formula weights of the following compounds.

In each case, set up a table showing listing the elements, number of atoms, and atomic weights. Calculate the total mass of each element in the compound and then add them together to get the formula weight. (Unless otherwise told, use atomic weights to one decimal place.) The units for formula weight will g/mole.

a) $K_2S_2O_4$

Element	No. atoms	At. Wt.	Total mass
K	2	39.1	78.2
S	2	32.1	64.2
O	4	16.0	64.0

Formula weight = 206.4 g/mol

b) Al_2S_3

Element	No. atoms	At. Wt.	Total mass
Al	2	27.0	54.0
S	3	32.1	64.2

Formula weight = 118.2 g/mol

c) Ag_2CO_3

Element	No. atoms	At. Wt.	Total mass
Ag	2	107.9	215.8
C	1	12.0	12.0
O	3	16.0	48.0

Formula weight = 275.8 g/mol

d) $Ca(C_2H_3O_2)_2$

Element	No. atoms	At. Wt.	Total mass
Ca	1	40.1	40.1
C	4	12.0	48.0
H	6	1.0	6.0
O	4	16.0	64.0

Formula weight = 158.1 g/mol

e) $Cr_2(SO_4)_3$

Element	No. atoms	At. Wt.	Total mass
Cr	2	52.0	104.0
S	3	32.1	96.3
O	12	16.0	192.0

Formula weigh = 392.3 g/mol

f) H_3PO_4

Element	No. atoms	At. Wt.	Total mass
H	3	1.0	3.0
P	1	31.0	31.0
O	4	16.0	64.0

Formula weight = 98.0 g/mol

g) $Sn(OH)_2$

Element	No. atoms	At. Wt.	Total mass
Sn	1	118.7	118.7
O	2	16.0	32.0
H	2	1.0	2.0

Formula weight = 152.7 g/mol

h) $Ni_2Fe(CN)_6$

Element	No. atoms	At. Wt.	Total mass
Ni	2	58.7	117.4
Fe	1	55.8	55.8
C	6	12.0	72.0
N	6	14.0	84.0

Formula weight = 329.2 g/mol

i) $Mg(IO_3)_2$

Element	No. atoms	At. Wt.	Total mass
Mg	1	24.3	24.3
I	2	126.9	253.8
O	6	16.0	96.0

Formula weight = 374.1 g/mol

j) $Co(ClO_4)_2$

Element	No. atoms	At. Wt.	Total mass
Co	1	58.9	58.9
Cl	2	35.5	71.0
O	8	16.0	128.0

Formula weight = 257.9 g/mol

2. Calculations involving the mole

These problems convert grams to moles and moles to grams. All the compounds used in these problems are those used for calculating formula weights in the previous section.

a) Convert 100.0 g of $K_2S_2O_4$ to moles.

$$?\,mol\,K_2S_2O_4 = 100\,g\,K_2S_2O_4 \times \frac{1\,mol\,K_2S_2O_4}{206.4\,g\,K_2S_2O_4}$$

This is the question

This is the conversion factor (the formula wt. of $K_2S_2O_4$)

= 0.484496 mol $K_2S_2O_4$ = **0.484 mol $K_2S_2O_4$** (3 sig. fig.)

b) How many g of $Sn(OH)_2$ are there in 2.50 moles?

$$?\,g\,Sn(OH)_2 = 2.50\,mol\,Sn(OH)_2 \times \frac{152.7\,g\,Sn(OH)_2}{1\,mol\,Sn(OH)_2}$$

This is the question

This is the conversion factor (the formula wt. of $Sn(OH)_2$)

= 381.75 g $Sn(OH)_2$ = **382 g $Sn(OH)_2$** (3 sig. fig.)

Summary: To convert from g to moles, divide by the formula weight of the compound.
To convert from moles to g, multiply by the formula weight of the compound.
Base the number of significant figures on the starting number given in the problem.

c) How many moles of H_3PO_4 are there in 325.0 g ?

$$?\,moles\,H_3PO_4 = 325.0\,g\,H_3PO_4 \times \frac{1\,mol\,H_3PO_4}{98.0\,g\,H_3PO_4}$$

= 3.316236 mol H_3PO_4 = **3.316 mol H_3PO_4** (4 sig. fig.)

d) How many g of $Ca(C_2H_3O_2)_2$ are the in 4.0 moles?

$$?\,g\,Ca(C_2H_3O_2)_2 = 4.0\,mol\,Ca(C_2H_3O_2)_2 \times \frac{158.1\,g\,Ca(C_2H_3O_2)_2}{1\,mol\,Ca(C_2H_3O_2)_2}$$

= 632.4 g $Ca(C_2H_3O_2)_2$ = **632 g $Ca(C_2H_3O_2)_2$**

Note: In this case, if you were weighing this amount in the lab, you would keep 3 sig. fig. to get mass to the nearest gram.

e) Calculate the number of moles in 500.0 g of Ag_2CO_3 ?

$$?\,mol\ Ag_2CO_3 = 500.0\,g\ Ag_2CO_3 \times \frac{1\,mol\ Ag_2CO_3}{275.8\,g\ Ag_2CO_3}$$

= 1.812908 mol Ag_2CO_3 = **1.1813 mol Ag_2CO_3** (4 sig. fig.)

f) Calculate the number of g in 0.25 mole of $Cr_2(SO_4)_3$?

$$?\,g\ Cr_2\left(SO_4\right)_3 = 0.25\,mol\ Cr_2\left(SO_4\right)_3 \times \frac{392.3\,g\ Cr_2\left(SO_4\right)_3}{1\,mol\ Cr_2\left(SO_4\right)_3}$$

= 98.075 g $Cr_2(SO_4)_3$ = **98 g $Cr_2(SO_4)_3$** (2 sig. fig.)

3. Calculations involving the mole when Avogadro's Number is needed.

These problems specifically ask to calculate number of atoms or molecules or masses of atoms or molecules. All the compounds used in these problems are those used for calculating formula weights in the first section. (Look for the keywords number of particles, atoms or molecules in the problem.)

Avogadro's number, 6.02 x 10^{23} particles/mol is the conversion factor to convert between numbers of atoms or molecules and moles. Otherwise, conversions between moles and grams is the same as in the preceding section.

NOTE: Review exponents and scientific notation before working on this section.

a) What is the mass of a single molecule of $Ca(C_2H_3O_2)_2$?
(NOTE: Always assume that mass is expressed in g.)

$$?\,g\,Ca\left(C_2H_3O_2\right)_2 = 1.00\,molecule\,Ca\left(C_2H_3O_2\right)_2 \times \frac{1\,mol\,Ca\left(C_2H_3O_2\right)_2}{6.02x10^{23}\,molecules\,Ca\left(C_2H_3O_2\right)_2} \times \frac{158.1\,g\,Ca\left(C_2H_3O_2\right)_2}{1\,mol\,Ca\left(C_2H_3O_2\right)_2}$$

This is the question.

This is the conversion factor from no. of molecules to moles

This is the conversion factor from moles to g using the formula wt

= 2.62625 x 10^{-22} g $Ca(C_2H_3O_2)_2$ = **2.63 x 10^{-22} g $Ca(C_2H_3O_2)_2$**

b) How many molecules are there in 1.00 µg of $Sn(OH)_2$?

$$?\,molecules\,Sn(OH)_2 = 1.00\,\mu g\,Sn(OH)_2 \times \frac{1\,g\,Sn(OH)_2}{1\times10^6\,\mu g\,Sn(OH)_2} \times \frac{1\,mol\,Sn(OH)_2}{152.7\,g\,Sn(OH)_2} \times \frac{6.02\times10^{23}\,molecules\,Sn(OH)_2}{1\,mol\,Sn(OH)_2}$$

This is the question

This is the conversion from µg to g

This is the conversion from g to moles

This is the conversion from moles to number of molecules

= 3.829517 x 10^{15} molecules $Sn(OH)_2$ = **3.83 x 10^{15} molecules $Sn(OH)_2$**

c) How many silver atoms are there in 5.00 mg of Ag_2CO_3 ?

$$?\,atoms\,Ag = 5.00\,mg\,Ag_2CO_3 \times \frac{1\,g\,Ag_2CO_3}{1000\,mg\,Ag_2CO_3} \times \frac{1\,mol\,Ag_2CO_3}{275.8\,g\,Ag_2CO_3} \times \frac{6.02x10^{23}\,molecules\,Ag_2CO_3}{1\,mol\,Ag_2CO_3} \times \frac{2\,atoms\,Ag}{1\,molecule\,Ag_2CO_3}$$

= 2.18274 x 10^{19} atoms Ag = **2.18 x 10^{19} atoms Ag**

In this problem, you had to convert from mg to g, then from g to moles, followed by moles to molecules, and, finally, from the formula for Ag_2CO_3, the number of Ag toms per formula units.

d) What is the mass of 1000 molecules of $Cr_2(SO_4)_3$?

$$?\,g\,Cr_2(SO_4)_3 = 1000\,molecules\,Cr_2(SO_4)_3 \times \frac{1\,mol\,Cr_2(SO_4)_3}{6.02x10^{23}\,molecules\,Cr_2(SO_4)_3} \times \frac{392.3\,g\,Cr_2(SO_4)_3}{1\,mol\,Cr_2(SO_4)_3}$$

= 6.516611 x 10^{-19} g $Cr_2(SO_4)_3$ = **6.517 x 10^{-19} g $Cr_2(SO_4)_3$**

In this problem, you had to convert from a number of molecules to moles. Once you had the number of moles, use the formula weight to calculate the mass.

e) How many moles of Ni atoms are there in 1.00 ng of $Ni_2Fe(CN)_6$?

$$?\,mol\,Ni\,atoms = 1.00\,ng\,Ni_2Fe(CN)_6 \times \frac{1\,g\,Ni_2Fe(CN)_6}{1\times10^9\,ng\,Ni_2Fe(CN)_6} \times \frac{1\,mol\,Ni_2Fe(CN)_6}{329.2\,g\,Ni_2Fe(CN)_6} \times \frac{2\,mol\,Ni\,atoms}{1\,mol\,Ni_2Fe(CN)_6}$$

= 6.07533 x 10^{-13} mol Ni atoms = **6.08 x 10^{-13} mol Ni atoms**

In this problem, you can solve it without using Avogadro's Number if you know there are 2 mole of Ni atoms in a mole of $Ni_2Fe(CN)_6$. If not, use Avogadro's Number to determine the number of molecules of $Ni_2Fe(CN)_6$, then multiply by 2 atoms of Ni per 1 molecule of $Ni_2Fe(CN)_6$