

# Simple Step-by-Step Guides to Solving Chemistry Problems

## Percentage Composition of Chemical Compounds



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## Determining Percentage Composition of Chemical Compounds

The percentage composition of a chemical compound is the percentage by mass of each constituent element.

### Percentage Composition Chemistry Calculating Frame for $X_aY_bZ_c$

Element	No. of atoms	$A_r$	Mass	% composition
X	a	$A_r(X)$	$a \times A_r(X)$	$a \times A_r(X)/M_r \times 100$
Y	b	$A_r(Y)$	$b \times A_r(Y)$	$b \times A_r(Y)/M_r \times 100$
Z	c	$A_r(Z)$	$c \times A_r(Z)$	$c \times A_r(Z)/M_r \times 100$
Total			$M_r$	100%

**Step 1**

Derived from chemical formula.

**Step 2**

Derived from Periodic Table.

**Step 3**

Mass of each element present in the compound.

**Step 4**

$M_r = a \times A_r(X) + b \times A_r(Y) + c \times A_r(Z)$

**Step 5**

% composition of each element by mass

To calculate the percentage composition of a chemical compound:

**Step 1:** Determine the number of atoms of each element present from its chemical formula;

**Step 2:** Using the Periodic Table find relative atomic mass ( $A_r$ ) for each element present;

**Step 3:** Calculate the total mass of each element present in the chemical formula of the compound, i.e.

$$\text{Mass of an element in compound} = A_r \times \text{number of atoms}$$

**Step 4:** Add together all the masses to obtain the Relative Molecular (Formula) Mass ( $M_r$ );

**Step 5:** For each element, calculate its percentage composition by mass by:

$$\text{Mass of element in the compound}/M_r \times 100$$

and check that the % composition of each element add up to 100.

If the values do not add up to 100 then you have made an error and will need to repeat the calculation.

**Example:** Determine the percentage composition of glucose ( $C_6H_{12}O_6$ ) and Calcium nitrate.

Glucose,  $C_6H_{12}O_6$

Element	No. of atoms	$A_r$	Mass	% composition
C	6	12	$6 \times 12 = 72$	$72/180 \times 100 = \mathbf{40}$
H	12	1	$12 \times 1 = 12$	$12/180 \times 100 = \mathbf{6.7}$
O	6	16	$6 \times 16 = 96$	$96/180 \times 100 = \mathbf{53.3}$
Total			180	100%

Percentage composition of glucose: **C 40%, H 6.7%, O 53.3%**

Calcium nitrate,  $Ca(NO_3)_2$

Element	No. of atoms	$A_r$	Mass	% composition
Ca	1	40	$1 \times 40 = 40$	$40/164 \times 100 = \mathbf{24.4}$
N	2	14	$2 \times 14 = 28$	$28/164 \times 100 = \mathbf{17.1}$
O	6	16	$6 \times 16 = 96$	$96/164 \times 100 = \mathbf{58.5}$
Total			164	100%

Percentage composition: **Ca 24.4%, N 17.1%, O 58.5%**



### Practice Problems

- What is the percentage composition by mass of silicon and chlorine in  $SiCl_4$ ?
- Calculate percentage composition of  $CuSO_4$
- Calculate the mass percentage of hydrogen in aspirin,  $C_9H_8O_4$ .
- What is the mass of silicon in 10g of clay,  $Al_2Si_2O_5(OH)_4$ ?
- What is the mass of sulphur in 1 tonne of  $H_2SO_4$ ?
- Determine the percentage composition of  $Ca_3(PO_4)_2$ .

- g) What is the percentage composition of ammonium sulfate,  $(\text{NH}_4)_2\text{SO}_4$ ?
- h) What is the mass of nitrogen present in 5g of aniline,  $\text{C}_6\text{H}_5\text{NH}_2$ ?
- i) 9.03g of Mg combine completely with 3.48g of N to form a compound. What is the percentage composition of this compound?
- j) A 27.0 g sample of a compound contains 7.20 g of C, 2.20 g of hydrogen and 17.6 g of oxygen. Calculate the percentage composition of the compound.

**Answers are given on the next page.**

## Practice Problem Answers

a) What is the percentage composition by mass of silicon and chlorine in  $\text{SiCl}_4$ ?

Element	No. of atoms	$A_r$	Mass	% composition
Si	1	28	$1 \times 28 = 28$	$28/170 \times 100 = \mathbf{16.5}$
Cl	4	35.5	$4 \times 35.5 = 142$	$142/170 \times 100 = \mathbf{83.5}$
Total			1	100

% composition of  $\text{SiCl}_4$ : **Si 16.5% and Cl 83.5%**

b) Calculate percentage composition of  $\text{CuSO}_4$

Element	No. of atoms	$A_r$	Mass	% composition
Cu	1	63.5	$1 \times 63.5 = 63.5$	$63.5/159.5 \times 100 = 39.8$
S	1	32	$1 \times 32 = 32$	$32/159.5 \times 100 = 20.1$
O	4	16	$4 \times 16 = 64$	$64/159.6 \times 100 = 40.1$
Total			159.5	100%

% composition of  $\text{CuSO}_4$ : **Cu 39.8%, S 20.1%, O 40.1%**

c) Calculate the mass percentage of hydrogen in aspirin,  $\text{C}_9\text{H}_8\text{O}_4$ .

Element	No. of atoms	$A_r$	Mass	% composition
C	9	12	$9 \times 12 = 108$	$108/180 \times 100 = 60$
H	8	1	$8 \times 1 = 8$	$8/180 \times 100 = 4.5$
O	4	16	$4 \times 16 = 64$	$64/180 \times 100 = 35.5$
Total				100%

% composition of  $\text{C}_9\text{H}_8\text{O}_4$ : **C 60%, H 4.5%, O 35.5%**

d) What is the mass of silicon in 10g of clay,  $\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$ ?

Element	No. of atoms	$A_r$	Mass	% composition
Al	2	27	$2 \times 27 = 54$	$54/258 \times 100 = 21$
Si	2	28	$2 \times 28 = 56$	$56/258 \times 100 = 21.7$
O	9	16	$9 \times 16 = 144$	$144/258 \times 100 = 55.8$
H	4	1	$4 \times 1 = 4$	$4/258 \times 100 = 1.5$

Total			258	100%
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Si accounts for 21.7%

Therefore, 10g will contain  $10 \times 21.7/100 = \mathbf{2.17g}$

e) What is the mass of sulphur in 1 tonne of  $\text{H}_2\text{SO}_4$ ?

Element	No. of atoms	$A_r$	Mass	% composition
H	2	1	$2 \times 1 = 2$	$2/98 \times 100 = 2$
S	1	32	$1 \times 32 = 32$	$32/98 \times 100 = 32.7$
O	4	16	$4 \times 16 = 64$	$64/98 \times 100 = 65.3$
Total				100%

Mass of Sulphur in 1 tonne of  $\text{H}_2\text{SO}_4 = \mathbf{32.7 \text{ kg}}$

f) Determine the percentage composition of  $\text{Ca}_3(\text{PO}_4)_2$ .

Element	No. of atoms	$A_r$	Mass	% composition
Ca	3	40	$3 \times 40 = 120$	$120/310 \times 100 = 38.7$
P	2	31	$2 \times 31 = 62$	$62/310 \times 100 = 20$
O	8	16	$8 \times 16 = 128$	$128/310 \times 100 = 41.3$
Total			310	100%

% composition of  $\text{Ca}_3(\text{PO}_4)_2$ : **Ca 38.7%, P 20%, O 41.3%**

g) What is the percentage composition of ammonium sulfate,  $(\text{NH}_4)_2\text{SO}_4$ ?

Element	No. of atoms	$A_r$	Mass	% composition
N	2	14	$2 \times 14 = 28$	$28/132 \times 100 = 21$
H	8	1	$8 \times 1 = 8$	$8/132 \times 100 = 6$
S	1	32	$1 \times 32 = 32$	$32/132 \times 100 = 24$
O	4	16	$4 \times 16 = 64$	$64/132 \times 100 = 48$
Total				100%

% composition,  $(\text{NH}_4)_2\text{SO}_4$ : **N 21.2%, H 6.1%, S 24.2%, O 48.5%**

h) What is the mass of nitrogen present in 5g of aniline,  $\text{C}_6\text{H}_5\text{NH}_2$ ?

Element	No. of atoms	$A_r$	Mass	% composition
C	6	12	$6 \times 12 = 72$	$72/93 \times 100 = 77.4$
H	7	1	$7 \times 1 = 7$	$7/93 \times 100 = 7.5$
N	1	14	$1 \times 14 = 14$	$14/93 \times 100 = 15.1$
Total			93	100%

Mass of N in 5 g =  $15.1/100 \times 5 = \mathbf{0.76g}$

- i) 9.03g of Mg combine completely with 3.48g of N to form a compound. What is the percentage composition of this compound?

Total mass of compound =  $9.03 + 3.48 = \mathbf{12.51}$

% Mg =  $9.03/12.51 \times 100 = \mathbf{72.2\%}$

% N =  $3.38/12.51 \times 100 = \mathbf{27.8\%}$

- j) A 27.0 g sample of a compound contains 7.20 g of C, 2.20 g of hydrogen and 17.6 g of oxygen. Calculate the percentage composition of the compound.

Total mass of compound = 27.0

% C =  $7.2/27 \times 100 = \mathbf{26.7}$

% H =  $2.20/27 \times 100 = \mathbf{8.1}$

% O =  $17.6/27 \times 100 = \mathbf{65.2}$