

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

# Percentage Composition

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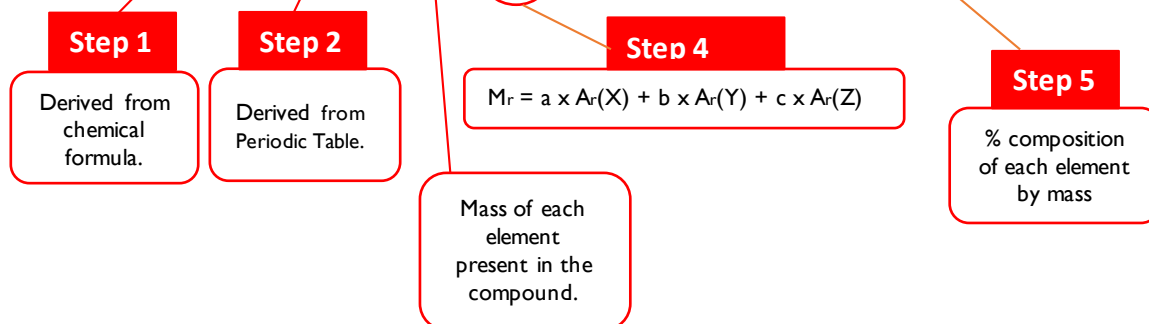
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## Determining Percentage Composition of Chemical Compounds

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

### Percentage Composition Calculating Frame for $X_a Y_b Z_c$

| 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%                               |



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 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 Sodium hydrogen carbonate  $Ca(NO_3)_2$

Glucose,  $C_6H_{12}O_6$

| Element | No. of atoms | $A_r$ | Mass               | % composition              |
|---------|--------------|-------|--------------------|----------------------------|
| C       | 6            | 12    | $6 \times 12 = 72$ | $72/180 \times 100 = 40$   |
| H       | 12           | 1     | $12 \times 1 = 12$ | $12/180 \times 100 = 6.7$  |
| O       | 6            | 16    | $6 \times 16 = 96$ | $96/180 \times 100 = 53.3$ |
| 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    | $1 \times 40 = 40$ | $40/164 \times 100 = 24.4$ |
| N       | 2            | 14    | $2 \times 14 = 28$ | $28/164 \times 100 = 17.1$ |
| O       | 6            | 16    | $6 \times 16 = 96$ | $96/164 \times 100 = 58.5$ |
| 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  $Ca_3(PO_4)_2$ .
- What is the percentage composition of ammonium sulfate,  $(NH_4)_2SO_4$ ?
- What is the mass of nitrogen present in 5g of aniline,  $C_6H_5NH_2$ ?
- 9.03g of Mg combine completely with 3.48g of N to form a compound. What is the percentage composition of this compound?
- 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    | $1 \times 28 = 28$    | $28/170 \times 100 = 16.5$  |
| Cl      | 4            | 35.5  | $4 \times 35.5 = 142$ | $142/170 \times 100 = 83.5$ |
| Total   |              |       | 170                   | 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    | $4 \times 16 = 64$     | $64/159.5 \times 100 = 40.1$   |
| 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   |              |       | 180                 | 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%                        |

Si accounts for 21.7%

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

- 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  $\text{H}_2\text{SO}_4 = 32.7 \text{ kg}$

- 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 =  $15.1/100 \times 5 = 0.76 \text{ g}$

- 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 =  $9.03 + 3.48 = 12.51$

% Mg =  $9.03/12.51 \times 100 = 72.2\%$

% N =  $3.38/12.51 \times 100 = 27.8\%$

- 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

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

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

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