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Structure 1.4

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The mole concept

The mole concept

How many carbon atoms are there in 1.00 mol of ethanol, C_2H_5OH?

How many hydrogen atoms are there in 2.00 mol of methane, CH_4?

How many Na^+ ions are there in 1.00 mol of NaCl?

What is the total number of ions in 0.50 mol of $(NH_4)_2CO_3$?

The mole concept

The mole, symbol mol, is the SI unit for amount of substance (*n*).

One mole contains exactly $6.02214076 \times 10^{23}$ elementary entities.

$$6.02 \times 10^{23}$$

The Avogadro constant, L or N_A is:

$$6.02 \times 10^{23}\ \text{mol}^{-1}$$

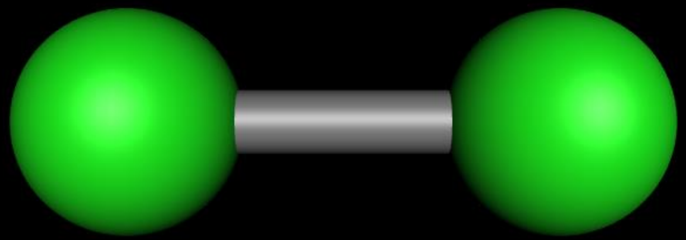
The mole concept

Elementary entity	Number of elementary entities in one mole
Atoms	6.02×10^{23}
Molecules	6.02×10^{23}
Ions	6.02×10^{23}
Formula units	6.02×10^{23}

The mole concept

Determine the number of chlorine molecules and chlorine atoms in 1.00 mol of chlorine gas, Cl_2.

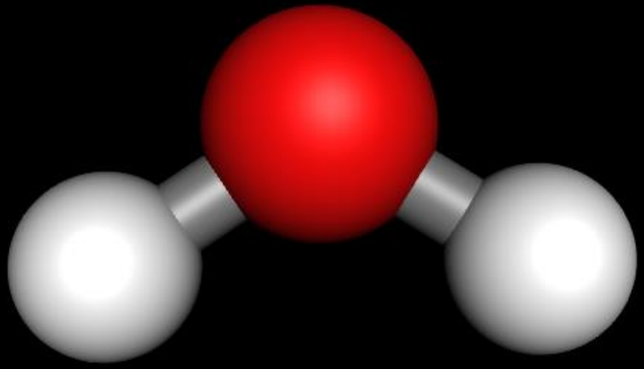
6.02×10^{23} ×



Cl_2 molecules	6.02×10^{23}
Cl atoms	$2 \times 6.02 \times 10^{23} = 1.20 \times 10^{24}$

The mole concept

Determine the number of hydrogen atoms and oxygen atoms in 0.500 mol of water, H_2O.

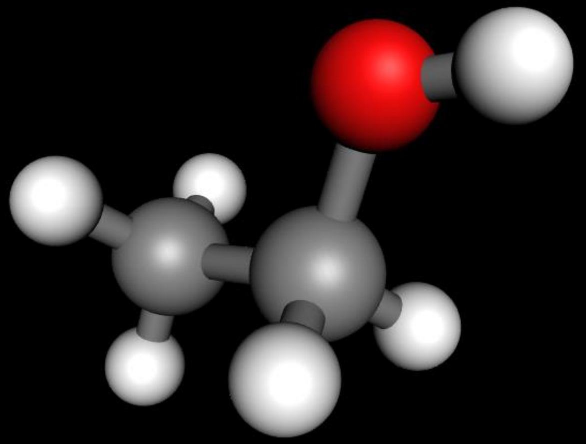
$0.500 \times 6.02 \times 10^{23} \times$ 

H atoms	$2 \times 0.500 \times 6.02 \times 10^{23} = 6.02 \times 10^{23}$
O atoms	$0.500 \times 6.02 \times 10^{23} = 3.01 \times 10^{23}$

The mole concept

Determine the number of carbon atoms, hydrogen atoms and oxygen atoms in 0.250 mol of ethanol, C_2H_5OH.

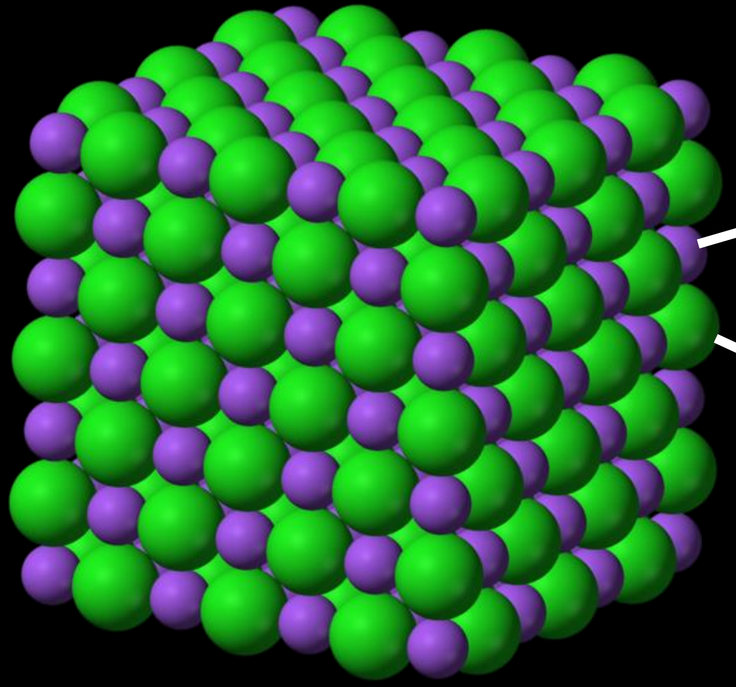
$$0.250 \times 6.02 \times 10^{23} \times$$



C atoms	$2 \times 0.250 \times 6.02 \times 10^{23} = 3.01 \times 10^{23}$
H atoms	$6 \times 0.250 \times 6.02 \times 10^{23} = 9.03 \times 10^{23}$
O atoms	$0.250 \times 6.02 \times 10^{23} = 1.51 \times 10^{23}$

The mole concept

In one mole of sodium chloride (NaCl) there are 6.02×10^{23} NaCl formula units.



NaCl is an ionic compound therefore it does not form molecules.

One mole of NaCl has 6.02×10^{23} sodium ions and 6.02×10^{23} chloride ions (total number of ions = 1.20×10^{24}).

The mole concept

Determine the number of magnesium ions and chloride ions in 1.00 mol of magnesium chloride, $MgCl_2$.

$$6.02 \times 10^{23} \times MgCl_2$$

Mg^{2+} ions	6.02×10^{23}
Cl^- ions	$2 \times 6.02 \times 10^{23} = 1.20 \times 10^{24}$

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The mole concept

Determine the number of protons, neutrons and electrons in 0.750 mol of carbon-12 atoms.

$$0.750 \times 6.02 \times 10^{23} \times {}^{12}_{6}C$$

Protons	$0.750 \times 6 \times 6.02 \times 10^{23} = 2.71 \times 10^{24}$
Electrons	$0.750 \times 6 \times 6.02 \times 10^{23} = 2.71 \times 10^{24}$
Neutrons	$0.750 \times 6 \times 6.02 \times 10^{23} = 2.71 \times 10^{24}$

The mole concept

How many carbon atoms are there in 1.00 mol of ethanol, C_2H_5OH? 1.20×10^{24} C atoms

How many hydrogen atoms are there in 2.00 mol of methane, CH_4? 4.82×10^{24} H atoms

How many Na^+ ions are there in 1.00 mol of NaCl? 6.02×10^{23} Na^+ ions

What is the total number of ions in 0.50 mol of $(NH_4)_2CO_3$? 9.03×10^{23} ions

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The mole concept part 2

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The mole concept

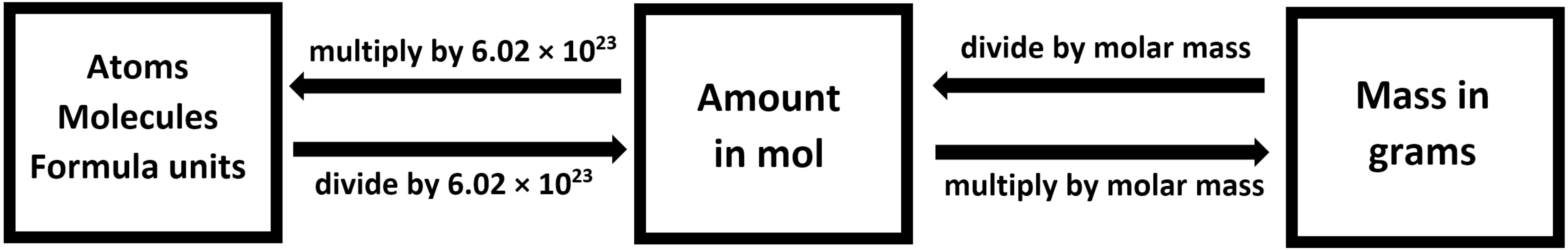
What is the mass of one molecule of ethane, C_2H_6?

How many H_2O molecules are there in 50.0 g of H_2O?

What is the mass of 1.81×10^{24} molecules of ethanol, C_2H_5OH?

How many formula units are there in 25.0 g of NaCl?

The mole concept



The mole concept

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Relative atomic mass and formula mass

Relative atomic mass (A_r)

Relative atomic mass, A_r, is the weighted average mass of the naturally occurring isotopes of an element relative to 1/12 the mass of an atom of carbon-12.

$^{12}_{6}C$

The relative atomic mass scale is based on the isotope carbon-12 which has a mass of exactly 12 amu.

Atomic number **Element** Relative atomic mass	1 **H** 1.01	12 **Mg** 24.31	17 **Cl** 35.45	26 **Fe** 55.85

Relative atomic mass (A_r)

Element	Relative atomic mass	Mass compared to ^{12}C
Hydrogen	1.01	≈ 12 times lighter
Helium	4.00	≈ 3 times lighter
Magnesium	24.31	≈ 2 times heavier
Phosphorus	30.07	≈ 2.5 times heavier
Chlorine	35.45	≈ 3 times heavier

Relative atomic mass (A_r)

Isotope	Percent abundance (%)
^{24}Mg	78.99
^{25}Mg	10.00
^{26}Mg	11.01

$$A_r = \frac{(24 \times 78.99) + (25 \times 10.00) + (26 \times 11.01)}{100}$$

$$A_r = 24.32$$

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Relative formula mass (M_r)

Relative formula mass, M_r, is the weighted average mass of a substance relative to 1/12 the mass of an atom of ^{12}C.

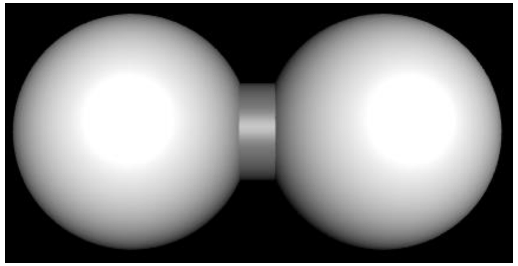
The M_r is the sum of the A_r of the atoms in the substance.

Substance	Atoms	Relative formula mass
H_2	2 × H (1.01)	2.02
H_2O	2 × H (1.01) 1 × O (16.00)	18.02
C_2H_6	2 × C (12.01) 6 × H (1.01)	30.08

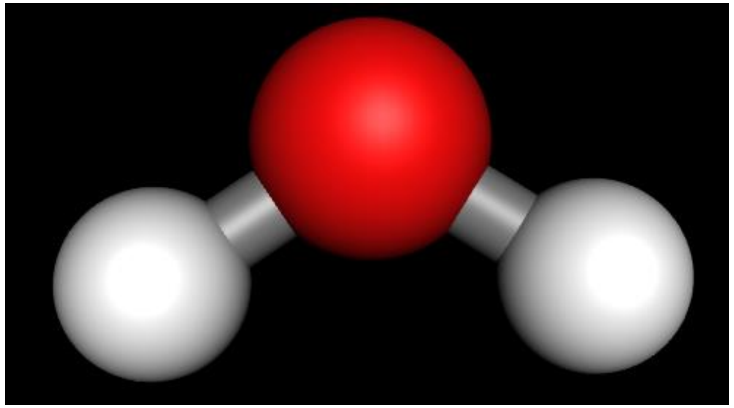
Relative formula mass (M_r)

Relative formula mass, M_r, is the weighted average mass of a substance relative to 1/12 the mass of an atom of carbon-12.

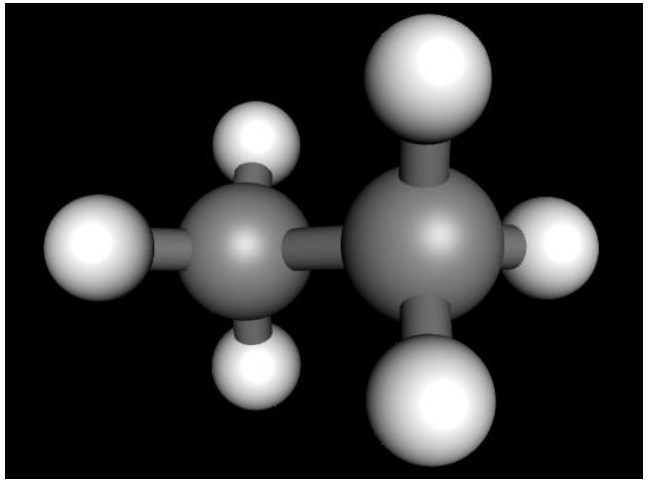
It is the sum of the A_r of the atoms in the substance.



H_2 $M_r = 2.02$



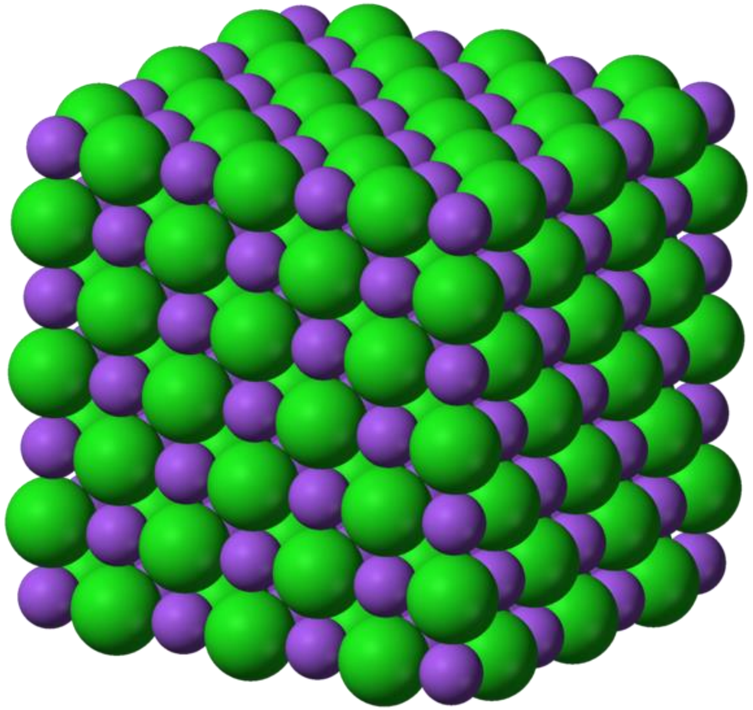
H_2O $M_r = 18.02$



C_2H_6 $M_r = 30.08$

Relative formula mass (M_r)

Relative formula mass is also used for substances that do not form molecules, such as ionic compounds.



11	17
Na	**Cl**
22.99	35.45

The relative formula mass of sodium chloride, NaCl, is 58.44

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Molar mass

Molar mass

Molar mass (*M*) is the mass in grams of one mole of a substance (g mol^{-1}).

One mole of substance contains 6.02×10^{23} particles.

The molar mass of a substance is numerically equal to its relative atomic mass.

Atomic number	6	12	16	26
Element	**C**	**Mg**	**S**	**Fe**
Relative atomic mass	12.01	24.31	32.07	55.85

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Molar mass

To convert A_r to M, multiply by the molar mass constant, M_u, which is approximately equal to 1 g mol^{-1}

Element	Relative atomic mass	Molar mass (g mol^{-1})
C	12.01	12.01
Mg	24.31	24.31
S	32.07	32.07
Fe	55.85	55.85

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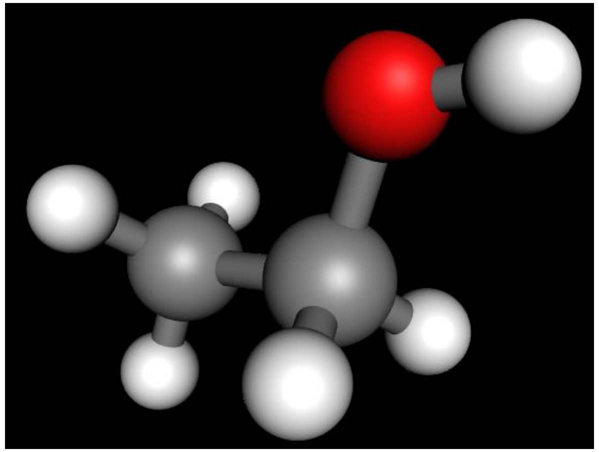
Molar mass

Determine the molar mass of ethanol, C_2H_5OH.



2 carbon atoms $A_r = 12.01$

1 oxygen atom $A_r = 16.00$

6 hydrogen atoms $A_r = 1.01$

$M_r = (2 \times 12.01) + 16.00 + (6 \times 1.01) = 46.08$

$M = 46.08 \times M_u$ ($\approx$ 1 g mol^{-1})

$M = 46.08$ g mol^{-1}

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Molar mass

Substance	Relative molecular mass/formula mass	Molar mass *M* (g mol^{-1})
O_2	32.00	32.00
H_2O	18.02	18.02
CH_4	16.05	16.05
NaCl	58.44	58.44
$(NH_4)_2CO_3$	96.11	96.11
Al_2O_3	101.96	101.96

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Calculating amount of substance

Calculating amount of substance

How to calculate the amount (in mol) of a substance from its mass (*m*) and molar mass (*M*).

$$\text{amount of substance (mol)} = \frac{\text{mass (g)}}{\text{molar mass (g mol}^{-1}\text{)}}$$

$$n(\text{mol}) = \frac{m\ (\text{g})}{M\ (\text{g mol}^{-1})} \qquad n = \frac{m}{M}$$

Calculating amount of substance

$$\text{mass (g)} = \text{amount (mol)} \times \text{molar mass} \left(\text{g mol}^{-1}\right)$$

$$m = nM$$

$$\text{molar mass} \left(\text{g mol}^{-1}\right) = \frac{\text{mass (g)}}{\text{amount (mol)}}$$

$$M = \frac{m}{n}$$

Calculating amount of substance

Calculate the amount (in mol) of O_2 in a 16.00 g sample of O_2.

$$M(\mathrm{O_2}) = 16.00 \times 2 = 32.00\ \mathrm{g\ mol^{-1}}$$

$$n(\mathrm{O_2}) = \frac{16.00\ \mathrm{g}}{32.00\ \mathrm{g\ mol^{-1}}}$$

$$n(\mathrm{O_2}) = 0.5000\ \mathrm{mol}$$

Calculating amount of substance

Calculate the amount (in mol) of H_2O in a 100.0 g sample of H_2O.

$$M(\mathrm{H_2O}) = 16.00 + (2 \times 1.01) = 18.02\ \mathrm{g\ mol^{-1}}$$

$$n(\mathrm{H_2O}) = \frac{100.0\ \mathrm{g}}{18.02\ \mathrm{g\ mol^{-1}}}$$

$$n(\mathrm{H_2O}) = 5.549\ \mathrm{mol}$$

Calculating amount of substance

Calculate the amount (in mol) of NaCl in a 50.00 g sample of NaCl.

$$M(\mathrm{NaCl}) = 22.99 + 35.45 = 58.44\ \mathrm{g\ mol^{-1}}$$

$$n(\mathrm{NaCl}) = \frac{50.00\ \mathrm{g}}{58.44\ \mathrm{g\ mol^{-1}}}$$

$$n(\mathrm{NaCl}) = 0.8556\ \mathrm{mol}$$

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Calculating amount of substance

Calculate the amount (in mol) of $Ni(NO_3)_2$ in a 75.23 g sample of $Ni(NO_3)_2$.

$$M(\mathrm{Ni(NO_3)_2}) = 58.69 + (2 \times 14.01) + (6 \times 16.00) = 182.71\ \mathrm{g\ mol^{-1}}$$

$$n(\mathrm{Ni(NO_3)_2}) = \frac{75.23\ \mathrm{g}}{182.71\ \mathrm{g\ mol^{-1}}}$$

$$n(\mathrm{Ni(NO_3)_2}) = 0.4117\ \mathrm{mol}$$

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Calculating mass (g) from amount (in mol)

Calculating mass from amount

$$n(\text{mol}) = \frac{m\ (\text{g})}{M\ (\text{g mol}^{-1})} \qquad n = \frac{m}{M}$$

$$\text{mass (g)} = \text{amount (mol)} \times \text{molar mass}\left(\text{g mol}^{-1}\right)$$

$$m = nM$$

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Calculating mass from amount

Calculate the mass (in g) of 0.6437 mol of $CaCO_3$.

$$M(\mathrm{CaCO_3}) = 40.08 + 12.01 + (3 \times 16.00)$$

$$M(\mathrm{CaCO_3}) = 100.09\ \mathrm{g\ mol^{-1}}$$

$$m = nM$$

$$m = 0.6437\ \mathrm{mol} \times 100.09\ \mathrm{g\ mol^{-1}}$$

$$m = 64.43\ \mathrm{g}$$

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Calculating mass from amount

Calculate the mass (in g) of 0.8539 mol of $AlCl_3$

$$M(\mathrm{AlCl_3}) = 26.98 + (3 \times 35.45)$$

$$M(\mathrm{AlCl_3}) = 133.33\ \mathrm{g\ mol^{-1}}$$

$$m = nM$$

$$m = 0.8539\ \mathrm{mol} \times 133.33\ \mathrm{g\ mol^{-1}}$$

$$m = 113.9\ \mathrm{g}$$

Calculating mass from amount

Calculate the mass (in g) of 1.379 mol of $C_6H_{12}O_6$

$$M(\mathrm{C_6H_{12}O_6}) = (6 \times 12.01) + (12 \times 1.01) + (6 \times 16.00)$$

$$M(\mathrm{C_6H_{12}O_6}) = 180.18\ \mathrm{g\ mol^{-1}}$$

$$m = nM$$

$$m = 1.379\ \mathrm{mol} \times 180.18\ \mathrm{g\ mol^{-1}}$$

$$m = 248.5\ \mathrm{g}$$

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Calculating mass from amount

Calculate the mass (in g) of 1.264 mol of $Ni(NO_3)_2$

$$M(\mathrm{Ni(NO_3)_2}) = 58.69 + (2 \times 14.01) + (6 \times 16.00)$$

$$M(\mathrm{Ni(NO_3)_2}) = 182.71\ \mathrm{g\ mol^{-1}}$$

$$m = nM$$

$$m = 1.264\ \mathrm{mol} \times 182.71\ \mathrm{g\ mol^{-1}}$$

$$m = 230.9\ \mathrm{g}$$

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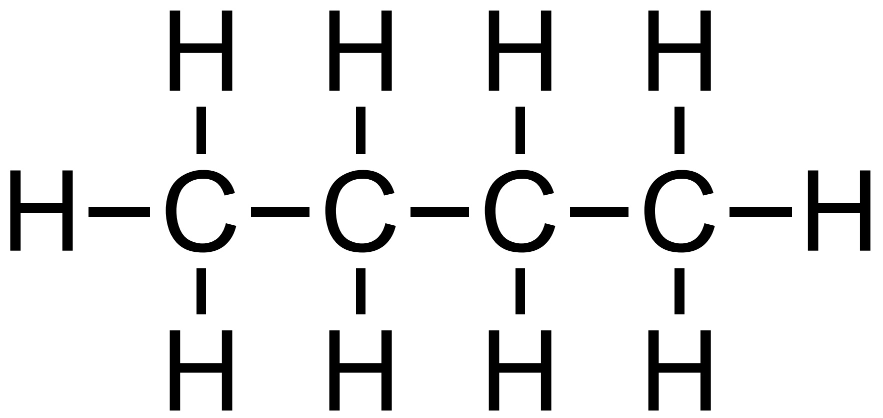
Empirical and molecular formulas

Empirical and molecular formulas

The molecular formula is the actual number of atoms in a compound.

The empirical formula is the lowest whole number ratio of atoms in a compound.

butane



Molecular formula C_4H_{10}

Empirical formula C_2H_5

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Empirical and molecular formulas

Compound	Molecular formula	Empirical formula
Ethane	C_2H_6	CH_3
Propene	C_3H_6	CH_2
Glucose	$C_6H_{12}O_6$	CH_2O
Phosphorus pentoxide	P_4O_{10}	P_2O_5
Hydrogen peroxide	H_2O_2	HO
Ethanol	C_2H_6O	C_2H_6O

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Empirical and molecular formulas

The molecular formula of a compound can be determined from its empirical formular and M_r (or molar mass, M).

A compound has the empirical formula CH_2O and a M_r of 180.18. Determine its molecular formula.

$$\text{mass of empirical formula: } 12.01 + (2 \times 1.01) + 16.00 = 30.03$$

$$\frac{180.18}{30.03} = 6$$

$$CH_2O \times 6 = C_6H_{12}O_6$$

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Percentage composition by mass

Percentage composition by mass

The percentage composition by mass is the percent by mass of an element in a compound.

$$\% \text{ composition of X} = \frac{\text{mol of X in compound} \times \text{molar mass of X}}{\text{molar mass of compound}} \times 100$$

1. Calculate the molar mass of the compound.
2. Multiply the mol of the element in the compound by its molar mass.
3. Use the above equation to calculate the percent composition.

Percentage composition by mass

Determine the percentage composition by mass of carbon in ethanol (CH_3CH_2OH).

M CH_3CH_2OH = 46.08 g mol^{-1}

2 mol of C in CH_3CH_2OH: 2 × 12.01 g mol^{-1} = 24.02 g mol^{-1}

$$\%\ \text{composition of C} = \frac{24.02\ \text{g mol}^{-1}}{46.08\ \text{g mol}^{-1}} \times 100$$

$$\%\ \text{composition of C} = 52.13\ \%$$

Percentage composition by mass

Determine the percentage composition by mass of oxygen in propanoic acid (CH_3CH_2COOH).

M CH_3CH_2COOH = 74.09 g mol^{-1}

2 mol of O in CH_3CH_2COOH: 2 × 16.00 g mol^{-1} = 32.00 g mol^{-1}

$$\% \text{ composition of O} = \frac{32.00 \text{ g mol}^{-1}}{74.09 \text{ g mol}^{-1}} \times 100$$

$$\% \text{ composition of O} = 48.63\ \%$$

Percentage composition by mass

Determine the percentage composition by mass of sodium in sodium chloride (NaCl).

M NaCl = 58.44 g mol^{-1}

1 mol of Na in NaCl: 1 × 22.99 g mol^{-1} = 22.99 g mol^{-1}

$$\%\ \text{composition of Na} = \frac{22.99\ \text{g mol}^{-1}}{58.44\ \text{g mol}^{-1}} \times 100$$

$$\%\ \text{composition of Na} = 39.34\ \%$$

Percentage composition by mass

Determine the percentage composition by mass of magnesium in magnesium carbonate ($MgCO_3$).

M $MgCO_3$ = 84.32 g mol^{-1}

1 mol of Mg in $MgCO_3$: 1 × 24.31 g mol^{-1} = 24.31 g mol^{-1}

$$\%\ \text{composition of Mg} = \frac{24.31\ \text{g mol}^{-1}}{84.32\ \text{g mol}^{-1}} \times 100$$

$$\%\ \text{composition of Mg} = 28.83\ \%$$

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Calculate empirical formula from percent composition

Calculating empirical formula

An organic compound contains 62.0% carbon, 13.9% hydrogen and 24.1% nitrogen by mass. Determine its empirical formula.

C	H	N
$\frac{62.0}{12.01}$	$\frac{13.9}{1.01}$	$\frac{24.1}{14.01}$
5.16	13.8	1.72

Calculating empirical formula

C	H	N
$\frac{5.16}{1.72}$	$\frac{13.8}{1.72}$	$\frac{1.72}{1.72}$
3	8	1

$$C_3H_8N$$

Calculating empirical formula

The molar mass of the compound is 116.24 g mol^{-1}. Determine its molecular formula.

mass of empirical formula: $(3 \times 12.01) + (8 \times 1.01) + 14.01 = 58.12$

$$\frac{116.24}{58.12} = 2$$

$$C_3H_8N \times 2 = C_6H_{16}N_2$$

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Calculating empirical formula

An organic compound contains 49.20% carbon, 6.95% hydrogen and 43.85% oxygen by mass. Determine its empirical formula.

C	H	O
$\frac{49.20}{12.01}$	$\frac{6.95}{1.01}$	$\frac{43.85}{16.00}$
4.10	6.88	2.74

Calculating empirical formula

C	H	O
$\frac{4.10}{2.74}$	$\frac{6.88}{2.74}$	$\frac{2.74}{2.74}$
1.50	2.51	1

$$C_3H_5O_2$$

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Calculating empirical formula

The molar mass of the compound is 146.16 g mol^{-1}. Determine its molecular formula.

mass of empirical formula: $(3 \times 12.01) + (5 \times 1.01) + (2 \times 16.00) = 73.08$

$$\frac{146.16}{73.08} = 2$$

$$C_3H_5O_2 \times 2 = C_6H_{10}O_4$$

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Concentration of solutions

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Calculating amount of substance

How to calculate the amount (in mol) of a substance from its volume (*V*) and concentration (*c*).

$$\text{amount (mol)} = \text{concentration}\left(\text{mol dm}^{-3}\right) \times \text{volume}\left(\text{dm}^{3}\right)$$

$$n(\text{mol}) = c\left(\text{mol dm}^{-3}\right) \times V\left(\text{dm}^{3}\right)$$

$$n = cV$$

$$1\ \text{cm}^3 \times \frac{1\ \text{dm}^3}{1000\ \text{cm}^3} = 0.001\ \text{dm}^3$$

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Calculating amount of substance

$$\text{concentration}\ (\text{mol dm}^{-3}) = \frac{\text{amount (mol)}}{\text{volume}\ (\text{dm}^3)}$$

$$c = \frac{n}{V}$$

$$\text{volume}\ (\text{dm}^3) = \frac{\text{amount (mol)}}{\text{concentration}\ (\text{mol dm}^{-3})}$$

$$V = \frac{n}{c}$$

Calculating amount of substance

Calculate the amount (in mol) of HCl in 100.0 cm^3 of 0.500 mol dm^{-3} $HCl_{(aq)}$

$$100.0\ \mathrm{cm^3} \times \frac{1\ \mathrm{dm^3}}{1000\ \mathrm{cm^3}} = 0.100\ \mathrm{dm^3}$$

$$n(\mathrm{HCl}) = 0.500\ \mathrm{mol\ dm^{-3}} \times 0.100\ \mathrm{dm^3}$$

$$n(\mathrm{HCl}) = 0.0500\ \mathrm{mol}$$

Calculating amount of substance

Calculate the amount (in mol) of NaOH in 50.0 cm^3 of 2.00 mol dm^{-3} $NaOH_{(aq)}$

$$50.0\ \mathrm{cm^3} \times \frac{1\ \mathrm{dm^3}}{1000\ \mathrm{cm^3}} = 0.0500\ \mathrm{dm^3}$$

$$n(\mathrm{NaOH}) = 2.00\ \mathrm{mol\ dm^{-3}} \times 0.0500\ \mathrm{dm^3}$$

$$n(\mathrm{NaOH}) = 0.100\ \mathrm{mol}$$

Calculating amount of substance

Calculate the amount (in mol) of NaCl in 60.0 cm^3 of 0.850 mol dm^{-3} $NaCl_{(aq)}$.

$$60.0\ \mathrm{cm^3} \times \frac{1\ \mathrm{dm^3}}{1000\ \mathrm{cm^3}} = 0.0600\ \mathrm{dm^3}$$

$$n(\mathrm{NaCl}) = 0.850\ \mathrm{mol\ dm^{-3}} \times 0.0600\ \mathrm{dm^3}$$

$$n(\mathrm{NaCl}) = 0.0510\ \mathrm{mol}$$

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Concentration of solutions

Concentration can be measured in g dm^{-3}, mol dm^{-3}, or ppm.

$$c\ (\text{g dm}^{-3}) = \frac{\text{mass of solute (g)}}{\text{volume of solution (dm}^3\text{)}}$$

$$c\ (\text{mol dm}^{-3}) = \frac{\text{amount of solute (mol)}}{\text{volume of solution (dm}^3\text{)}}$$

$$\text{ppm} = \frac{\text{mass of solute (g)}}{\text{mass of solution (g)}} \times 10^6$$

Concentration of solutions

A solution with a volume of 500.0 cm^3 contains 12.50 g of NaCl. Calculate its concentration in g dm^{-3}.

$$c\ (\mathrm{g\ dm^{-3}}) = \frac{\text{mass of solute (g)}}{\text{volume of solution } (\mathrm{dm^3})}$$

$$c = \frac{12.50\ \mathrm{g}}{0.5000\ \mathrm{dm^3}} = 25.00\ \mathrm{g\ dm^{-3}}$$

Concentration of solutions

Calculate the concentration of the solution in mol dm^{-3}

$$c\ (\text{mol dm}^{-3}) = \frac{\text{amount of solute (mol)}}{\text{volume of solution (dm}^3)}$$

$$n = \frac{m}{M} = \frac{12.50\ \text{g}}{58.44\ \text{g mol}^{-1}} = 0.2139\ \text{mol}$$

$$c = \frac{0.2139\ \text{mol}}{0.5000\ \text{dm}^3} = 0.4278\ \text{mol dm}^{-3}$$

Concentration of solutions

A 300.0 g water sample contains 1.514 × 10^{-3} g of dissolved oxygen. Calculate the concentration in ppm.

$$\text{ppm} = \frac{\text{mass of solute (g)}}{\text{mass of solution (g)}} \times 10^6$$

$$c = \frac{1.514 \times 10^{-3}\ \text{g}}{300.0\ \text{g}} \times 10^6$$

$$c = 5.047\ \text{ppm}\ (\text{or } 5.047\ \text{mg dm}^{-3})$$

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Avogadro's law

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Avogadro's law

Avogadro's law - the volume occupied by a gas is directly proportional to the amount (in mol) of gas (at constant *P* and *T*).

$$V \propto n \qquad \frac{V}{n} = k \qquad \frac{V_1}{n_1} = \frac{V_2}{n_2}$$

At the same temperature and pressure equal volumes of any gas contain the same number of particles.

Avogadro's law

Gas	Amount (mol)	Volume at STP (dm^3)	Number of particles
O_2	1.00	22.7	6.02×10^{23}
H_2	1.00	22.7	6.02×10^{23}
N_2	1.00	22.7	6.02×10^{23}
CO_2	1.00	22.7	6.02×10^{23}
CH_4	1.00	22.7	6.02×10^{23}

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Avogadro's law

$$2CO_{(g)} + O_{2(g)} \rightarrow 2CO_{2(g)}$$

$$2\text{ mol } CO_{(g)} + 1\text{ mol } O_{2(g)} \rightarrow 2\text{ mol } CO_{2(g)}$$

$$2\text{ volumes } CO_{(g)} + 1\text{ volume } O_{2(g)} \rightarrow 2\text{ volumes } CO_{2(g)}$$

$$2\text{ dm}^3\ CO_{(g)} + 1\text{ dm}^3\ O_{2(g)} \rightarrow 2\text{ dm}^3\ CO_{2(g)}$$

$$10\text{ dm}^3\ CO_{(g)} + 5\text{ dm}^3\ O_{2(g)} \rightarrow 10\text{ dm}^3\ CO_{2(g)}$$

Avogadro's law

50.0 dm^3 of CO is reacted with 25.0 dm^3 of O_2 at STP.
Determine the volume of CO_2 produced.

$$2CO_{(g)} + O_{2(g)} \rightarrow 2CO_{2(g)}$$

2 volumes $CO_{(g)}$ + 1 volume $O_{2(g)}$ $\rightarrow$ 2 volumes $CO_{2(g)}$

50.0 dm^3 $CO_{(g)}$ + 25.0 dm^3 $O_{2(g)}$ $\rightarrow$ 50.0 dm^3 $CO_{2(g)}$

Answer = 50.0 dm^3 of CO_2

Avogadro's law

40.0 dm^3 of CO is reacted with 40.0 dm^3 of O_2 at STP.

Determine the volume of CO_2 produced.

$$2CO_{(g)} + O_{2(g)} \rightarrow 2CO_{2(g)}$$

2 volumes $CO_{(g)}$ + 1 volume $O_{2(g)}$ → 2 volumes $CO_{2(g)}$

CO: 40/2 = 20 (limiting reactant)

O_2: 40/1 = 40 (excess reactant)

Avogadro's law

40.0 dm^3 of CO is reacted with 40.0 dm^3 of O_2 at STP.
Determine the volume of CO_2 produced.

$$2CO_{(g)} + O_{2(g)} \rightarrow 2CO_{2(g)}$$

CO: 40/2 = 20 (limiting reactant)

O_2: 40/1 = 40 (excess reactant)

40.0 dm^3 of CO will produce 40.0 dm^3 of CO_2

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Avogadro's law

20.0 dm^3 of N_2 is reacted with 50.0 dm^3 of H_2 at STP. Determine the volume of NH_3 produced and the volume of the excess reactant remaining .

$$N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$$

N_2: 20/1 = 20 (excess reactant)

H_2: 50/3 = 16.7 (limiting reactant)

Avogadro's law

20.0 dm^3 of N_2 is reacted with 50.0 dm^3 of H_2 at STP. Determine the volume of NH_3 produced and the volume of the excess reactant remaining .

$$N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$$

50.0 dm^3 of H_2 will produce 33.3 dm^3 NH_3

Volume of N_2 remaining:

20.0 dm^3 – 16.7 dm^3 = 3.3 dm^3