CHEMICAL FORMULA

VISUAL CHEM CARDS

Molecular Formula

A **molecular formula** consists of the chemical symbols for the constituent elements followed by numeric subscripts describing the number of atoms of each element present in the **molecule**.

Molecular Formula

$$X_aY_bZ_c$$

$$X_a(Y_bZ_c)_n = X_aY_{(b \times n)}Z_{(c \times n)}$$

X, Y and Z are chemical symbols and the subscripts (a, b, c) – gives the number of atoms of each element in a molecule. If no subscript, then assume "1".

	Number of types of atoms	Number of each atom type	Total number of atoms
$X_aY_bZ_c$	3 types: X, Y and Z	a atoms of X b atoms of Y c atoms of Z	a + b + c
NO_2	2 types: N and O	1 atom of N 2 atoms of O	1 + 2 = 3
$MgCO_3$	3 types: Mg, C and O	1 atom of Mg 1 atom of C 3 atoms of O	1 + 1 + 3 = 5
$X_a(Y_bZ_c)_n$	3 types: X, Y and Z	a atoms of X b x n atoms of Y c x n atoms of Z	a + nb + nc
$Al_2(SO_4)_3$	3 types: Al, S and O	2 atoms of Al 3 atoms of S 12 atoms of O	2 + 3 + 12 = 17
$K_4Pt(CN)_6$	4 types: K, Pt, C and N	4 atoms of K 1 atom of Pt 6 atoms of C 6 atoms of N	4 + 1 + 6 + 6 = 17

Empirical Formula

The empirical **formula** represents the simplest whole-integer ratio of atoms in a compound.
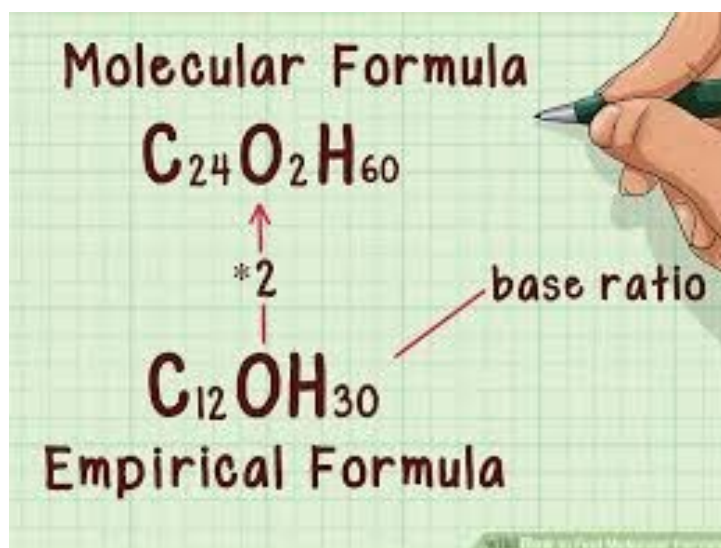
Name of compound	Empirical formula	Molecular formula
Hydrogen peroxide	HO	H_2O_2
Water	H_2O	H_2O
Glucose	CH_2O	$C_6H_{12}O_6$
Oxalic acid	HCO_2	$H_2C_2O_4$
Ethanol	C_2H_6O	C_2H_6O
Ethane	CH_3	C_2H_6
Ethylene	CH_2	C_2H_4
Caffeine	$C_4H_5N_2O$	$C_8H_{10}N_4O_2$

Empirical Formula

Empirical Formula from Molecular Formula, $X_aY_bZ_c$

   Step 1: Write down the subscripts, ie a, b, c;

   Step 2: Identify the largest number that divides into a, b and c;

   Step 3: Divide all subscripts by the number identified in step 2;

   Step 4: Write down the empirical formula.

Example: *What is the empirical formula of $C_6H_{12}O_6$?*

Step 1	Write down chemical formula subscripts	6, 12, 6
Step 2	Identify the largest common factor	6
Step 3	Divide subscripts by the largest common factor	$C_{6/6}$ H $_{12/6}$ $NO_{6/6}$
Step 4	Write down the empirical formula	Empirical Formula: **CH_2O**

Example: *What is the empirical formula of $C_8H_{10}N_4O_2$?*

Step 1	Write down chemical formula subscripts	8, 10, 4, 2
Step 2	Identify the largest common factor	2
Step 3	Divide subscripts by the largest common factor	$C_{8/2}$ $H_{10/2}$ $N_{4/2}$ $O_{2/2}$
Step 4	Write down the empirical formula	Empirical Formula: **C_4H_5 N_2O**

Empirical Formula

Empirical Formula from % Composition

To calculate empirical formula from percentage compositions of a compound use the calculating frame given below:

Empirical Formula from Percentage Composition Calculating Frame

Step 1: Write the names or symbols of the elements;

Step 2: For each element give its % composition;

Step 3: Using the Periodic Table find the A_r value for each element;

Step 4: Divide the % value for each element by its A_r;

Step 5: Divide throughout by the smallest value;

Step 6: Write down the empirical formula.

The action at Step 5 usually gives you the simplest whole number ratio straightaway. Sometimes it does not, so you might get 1 and 1.5. In this example, you would multiply both numbers by 2, giving 2 and 3 (instead of rounding 1.5 up to 2).

Step 1		Element X	Element Y	Element Z
Step 2	% composition	x	y	z
Step 3	Relative atomic mass, A_r	$A_r[X]$	$A_r[Y]$	$A_r[Z]$
Step 4	% composition/A_r x 100	$x/A_r[X]$ x 100	$y/A_r[Y]$ x 100	$z/A_r[Z]$ x 100
Step 5	Divide by smallest number from Step 4	Step 4 answer/ Smallest no. Step 4 = a	Step 4 answer/ Smallest no. Step 4 = b	Step 4 answer/ Smallest no. Step 4 = c
Step 6	Empirical Formula	X_aYbZ_c		

Empirical Formula

Empirical Formula from Elemental Masses (XYZ)

If you are given the elemental composition of an unknown substance in grams, you will need to proceed according to the following instructions.

Example: *Find the empirical formula of an unknown substance made from p grams of element X, q grams of element Y and r grams of element Z.*

Step 1: Write the names or symbols of the elements;

Step 2: Determine total mass of unknown substance, i.e. p + q + r grams

Step 3: For each element calculate its % composition, i.e. p/(p + q + r) x 100

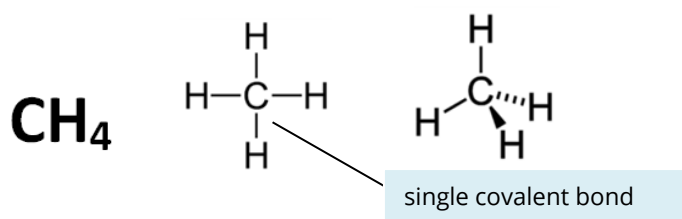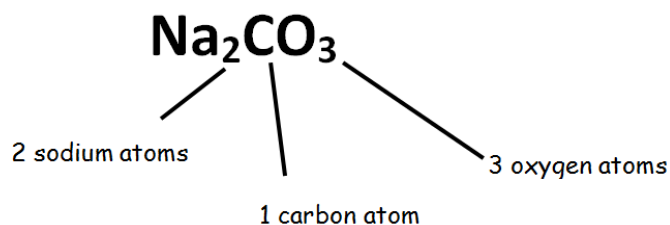Step 4: Using the Periodic Table find the A_r value for each element;

Step 5: Divide the % value for each element calculated in Step 3 by its A_r;

Step 6: Divide throughout by the smallest value calculated in Step 5;
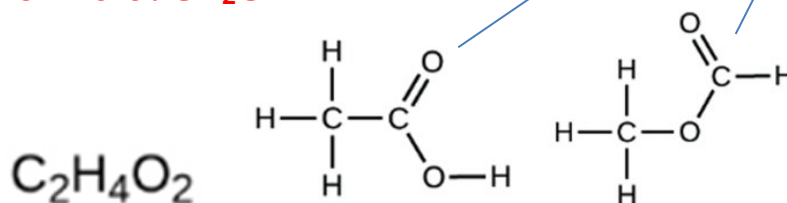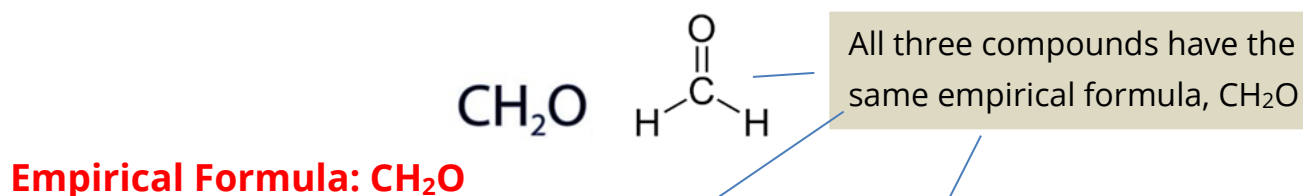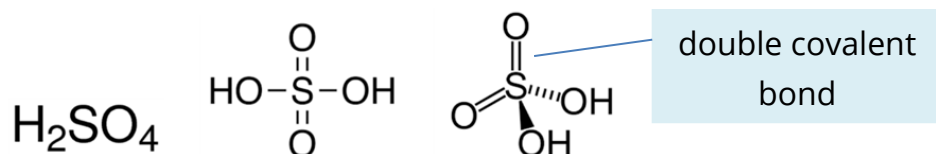
Step 7: Write down the empirical formula.

Step 1		X	Y	Z	Total
Step 2	Mass	n	p	q	x + y + z
Step 3	% Composition	p/(p + q + r)	q/(p + q + r)	r/(p + q + r)	
Step 4	Ar	$A_r[X]$	$A_r[Y]$	$A_r[Z]$	
Step 5	Divide step 2 value for each element by its A_r	Step 2 value/ $A_r[X]$	Step 2 value/ $A_r[Y]$	Step 2 value/ $A_r[Z]$	
Step 6	Divide Step 4 answer by the lowest step 4 value	Step 4 value/Lowest Step 4 value = a	Step 4 value/Lowest Step 4 value = b	Step 4 value/Lowest Step 4 value = c	
Step 7	Empirical Formula	$X_aY_bZ_c$			

Molecular & Structural Formula

Na_2CO_3

2 sodium atoms

3 oxygen atoms

1 carbon atom

CH_4

single covalent bond

Molecular Formula   **Structural Formula**

H_2SO_4 HO–S–OH

O=S⁗OH

double covalent bond

Empirical Formula: **CH_2O**

CH_2O

All three compounds have the same empirical formula, CH_2O

$C_2H_4O_2$

Molecular Formula   **Structural Formula**

Compounds that have the same chemical formula, but different structural formula are known as **isomers.**