## Molecules of Elements and Compounds

L Molecules are combinations of atoms tightly bound together to form discreet, chemically identifiable units.

- Many elements are composed of molecules, but not all.
$\mathrm{Cl}_{2}, \mathrm{~S}_{8}$ - molecules
C(graphite) - no molecules (network solid)
Cu - no molecules (metallic structure)
L Molecules of elements are homonuclear, because they are composed of only one kind of atom.
- Many compounds are composed of molecules, but not all.
$\mathrm{H}_{2} \mathrm{O}, \mathrm{CH}_{4}$ - molecules
NaCl - no molecules (ionic solid)
$\mathrm{SiO}_{2}(\mathrm{~s})$ - no molecules (network solid)
L Molecules of compounds are heteronuclear, because they are composed of two or more different kinds of atoms.


## Molecular Formulas

L For a molecular substance (elements or compounds), the composition of the molecules is indicated by a molecular formula, which shows the kinds and numbers of each atom in the molecule.
$P_{4} \quad$ phosphorus molecule made up of 4 P atoms

$\mathrm{CH}_{4} \quad$ methane molecule made up of 1 C atom and 4 H atoms


## Common Elements Composed of Molecules

| Formula | Room Temperature Form |
| :---: | :--- |
| $\mathrm{H}_{2}$ | colorless gas |
| $\mathrm{O}_{2}$ | colorless gas |
| $\mathrm{N}_{2}$ | colorless gas |
| $\mathrm{P}_{4}$ | white solid |
| $\mathrm{S}_{8}$ | yellow solid |
| $\mathrm{F}_{2}$ | pale yellow gas |
| $\mathrm{Cl}_{2}$ | pale green gas |
| $\mathrm{Br}_{2}$ | dark red liquid |
| $\mathrm{I}_{2}$ | violet solid |

Network Solids
Graphite and Diamond (carbon allotropes)


Graphite


Diamond

## Molecular Formulas vs. Empirical Formulas

L An empirical formula indicates the lowest, wholenumber ratio of the atoms in a compound, regardless of whether or not it contains molecules.

| Molecular <br> Formula | Empirical <br> Formula |
| :---: | :---: |
| $\mathrm{H}_{2} \mathrm{O}$ | $\mathrm{H}_{2} \mathrm{O}$ |
| $\mathrm{H}_{2} \mathrm{O}_{2}$ | HO |
| $\mathrm{CH}_{4}$ | $\mathrm{CH}_{4}$ |
| $\mathrm{C}_{2} \mathrm{H}_{4}$ | $\mathrm{CH}_{2}$ |
| $\mathrm{C}_{4} \mathrm{H}_{8}$ | $\mathrm{CH}_{2}$ |
| $\mathrm{C}_{6} \mathrm{H}_{12}$ | $\mathrm{CH}_{2}$ |
| $\mathrm{NO}_{2}$ | $\mathrm{NO}_{2}$ |
| $\mathrm{~N}_{2} \mathrm{O}_{4}$ | $\mathrm{NO}_{2}$ |

L For molecular compounds, all the subscripts in the molecular formula are a whole-number multiple (1, 2,3 , etc.) of those in the empirical formula.

# Structural Formulas of Some Molecular Compounds With the Empirical Formula $\mathrm{CH}_{2}$ 


$\mathrm{C}_{2} \mathrm{H}_{4}$

$\mathrm{C}_{4} \mathrm{H}_{8}$

$\mathrm{C}_{6} \mathrm{H}_{12}$

## Ways of Depicting Molecules

Methanol, $\mathrm{CH}_{4} \mathrm{O}=\mathrm{CH}_{3} \mathrm{OH}$

## Structural Formula



Perspective Drawing


Ball-and-stick Model


Space Filling Model



