

**SUBSTANCES, MOLECULES
AND SYMBOLS IN THE ICT
AGE**

THE CHEMIST'S TRIANGLE



THE MESS WE ARE IN

- Choose the correct statement completion:

Nitrogen

- A. is a colourless, unreactive gas;
- B. has a valency of three;
- C. has a triple bond;
- D. has zero dipole moment;
- E. is a diatomic molecule.

THE MESS WE ARE IN

The formula for -

- nitrogen is N_2 but for argon is Ar
- carbon is C but for sulfur is S_8

The name of -

- NaCl is sodium chloride whilst $CaCl_2$ is calcium chloride and $PbCl_4$ is lead tetrachloride

HOW DID WE GET INTO THIS MESS?

- Lavoisier's elements (1789)
- Binary nomenclature
- Dalton's atoms (1808)
- Atoms of two elements combine 1:1 unless otherwise indicated (multiple proportions)
- Like atoms may combine too (Avogadro, 1811)!

SOME CONCLUSIONS

In inorganic chemistry:

- Empirical and molecular formulae are not always distinguished, and hence the molecular nature of a substance is not disclosed in its formula.
- Names and formulae of substances are not always logically connected.

HOW CAN WE GET OUT OF THIS MESS?

FOLLOW THE ORGANIC EXAMPLE!

1. Adopt molecular formulae as the norm (eg $(\text{PbCl}_2)_n$ and PbCl_4).
2. Use names that better reflect the molecular formulae (eg lead dichloride and lead tetrachloride).

SOME BENEFITS - I

1. Facilitates the interconversion of names and formulae.
2. Links formulae with molecular models and diagrams.
3. Provides an essential basis for molecular visualisation.
4. Reduces mistakes in calculations (eg molar masses).

SOME BENEFITS - II

5. Makes sense of the state of substances at room temperature (eg compare $\text{CO}_2(\text{g})$ and $(\text{SiO}_2)_n(\text{s})$; or $\text{C}_n(\text{s})$ and $\text{N}_2(\text{g})$).
6. Provides a meaningful starting point for describing and interpreting the chemical bonding in the molecules.
7. Clarifies the triangular relation between substances, molecules and formulae.

CHANGES OF SUBSTANCES, MOLECULES AND SYMBOLS - I

1. Chemical and physical change

- $(\text{NaCl})_n(\text{s}) \rightarrow n\text{NaCl}(\text{g})$ versus $\text{CO}_2(\text{s}) \rightarrow \text{CO}_2(\text{g})$.
- The solid substance sublimes: this may be a physical or a chemical change. But what do the molecules do?

CHANGES OF SUBSTANCES, MOLECULES AND SYMBOLS - II

2. Substances react; what do molecules do?

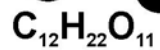
- Acids – change the colour of indicators;
 - neutralise bases;
 - liberate hydrogen with metals.
- Acids donate protons (Bronsted)? NO!
- Acid molecules – donate hydrons!

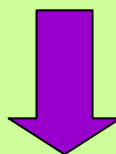
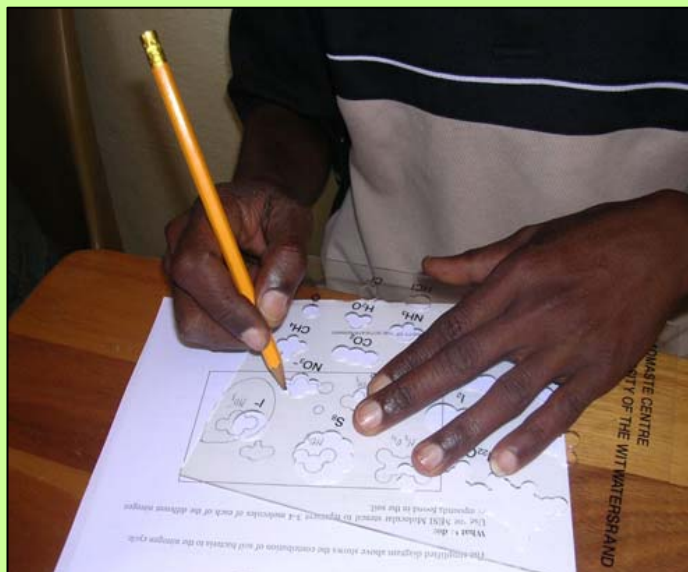
PLAYTIME WITH PARTICLES - I

The RADMASTE Molecular Stencil allows:

- * representation of solid, liquid and gaseous substances – both pure substances and mixtures;
- * all entities in the correct relative sizes;
- * an entity always looks the same;
- * physical and chemical changes can be represented as multimolecular systems;
- * static but only requires pencil/paper and USD 1.

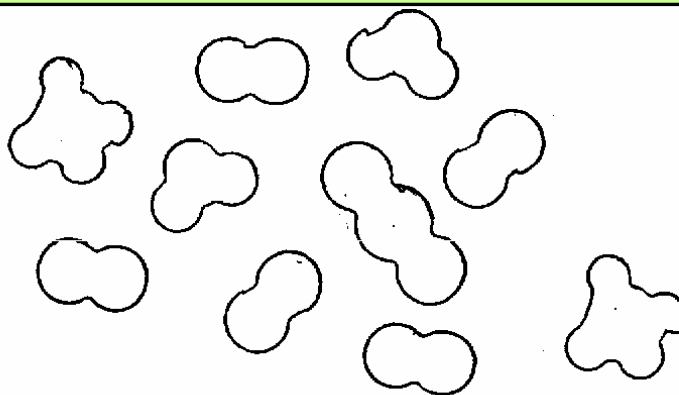
RADMASTE™ MOLECULAR STENCIL





(ii) $\bar{E}_{\text{extent}} = 0,33$

| | <u>Reacted</u> | <u>Left</u> |
|-------------------|----------------|-------------|
| CH ₄ : | 1 | 2 |
| O ₂ : | 2 | 5 |



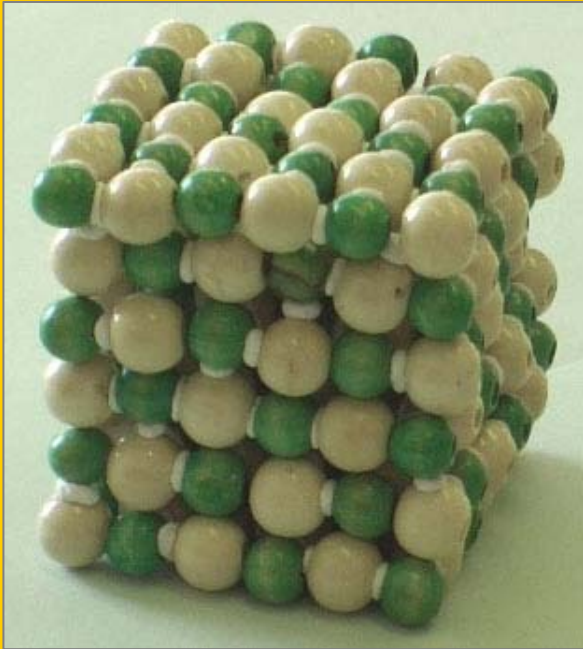
1 CO₂
2 H₂O

PLAYTIME WITH PARTICLES

- II

RADMASTE Molecular Modeling Kit allows:

- * constructing molecules based closely on their Lewis diagrams;
- * freedom to predict spatial geometry;
- * use of inexpensive beads, adhesive putty, supplemented by wires for macromolecules.



CONCLUSIONS

- ❖ For nearly a century IUPAC has helped the chemical community to communicate.
- ❖ But there is some unfinished business from the past, which probably bothers chemistry educators more than it bothers other chemists.
- ❖ We need to devote some expert time to relating substances, molecules and symbols, and I call upon IUPAC CCE to take up this challenge.