INSTRUCTIONS

MOLECULAR MODELS

MV-800, 805 and 870

Gallenkamp

Issue 7

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CONTENTS

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1. INTRODUCTION

These sets of models are designed for use in the educational and research fields to represent the spatial structures of organic and inorganic molecules. They comprise numbers of plastic balls representing atoms and coloured in accordance with the recommendations of the X-ray group of the Institute of Physics, together with close-wound steel springs representing interatomic bonds. The balls are drilled to push-fit the ends of the springs and the angles of the drillings are carefully chosen to represent as accurately as possible natural bond angles. Model atoms with the 'Gallenkamp' universal drilling are included in sets MV-800 and MV-805 because they permit the construction of models with atoms in uncommon valency states, co-ordination compounds and crystal lattices. Several model atoms are purpose drilled for specific crystal structures but the 14-hole universal atom is suitable for all common symmetries.

2. DESCRIPTION

The full range of individual comppnents is as follows:-

List No.	Element	Colour	Dia. mm	Holes	Hole configuration
MV-810	Hydrogen	White	16	1	-
MV-811*	Hydrogen	White	16	1	-
MV-812	Halogen	Green	22	1	-
MV-814	Oxygen	Red	22	2	Dihedral as O_2 in H_2O
MV-816	Carbon	Black	22	4	Tetrahedral as C in CCl_4
MV-817	Zinc	Brown	22	4	"
MV-818	Nitrogen	Blue	22	4	"
MV-819	Oxygen	Red	22	4	"
MV-820	Sulphur	Yellow	22	4	"
MV-821	Sulphur	Yellow	22	14	Universal
MV-822	Carbon	Black	22	14	"
MV-824	Metals	Brown	22	14	"
MV-826	Universal	Orange	22	14	"
MV-828	Universal	Purple	22	14	"
MV-830	Carbon	Black	22	5	Trigonal bipyramid as $FE(CO)_5$
MV-832	Sodium	Yellow	22	6	Octahedral as $(Pt\ CL_6)^{2-}$
MV-833	Halogen	Green	22	6	"
MV-836	(Calcium) (Caesium)	Yellow	22	8	Body centred cubic
MV-837	Halogen	Green	22	8	"

* Ball drilled completely through to represent hydrogen in hydrogen bonding.

SPRINGS

MV-840 Spring bonds. Close wound spiral springs, electroplated finish.

Overall length	25	38	60	75 mm

2.1 CHEMISTRY SET, MV-800

The set comprises hydrogen, carbon, nitrogen, sulphur, oxygen, halogen, metal and universal carbon atoms, with 25 mm and 38 mm spring bonds. The set has very wide fields of application in chemistry as follows:

2.1.1 Organic Chemistry

* to exhibit stereochemical properties
* better benzene ring models
* inter-nuclear distance correctly scaled
* true valence angles
* approximate indication of electron density
* for construction of highly strained molecule models.

3-dimensional models can be made up which will exhibit all the stereochemical properties of organic molecules (geometrical and optical isomerism, conformational interconversion, etc.)

The plastics balls represent atomic centres, not atomic volumes, but the long and short bonding springs supplied give internuclear distances practically correct on a scale of 35 mm = 1Å

The 38 mm spring represents the bonds:

C	-	C	)
C	-	N	)
C	-	O	) Which are all about 1.5Å
C	-	S	)
C	-	Cl	)
S	-	H	)

The 25 mm spring represents the bonds:

C	-	H	)
N	-	H	) Which are all about 1.0Å
O	-	H	)

If it is desired to work on models of larger scales, this may be done by the use of longer spring bonds. Using 38 and 60 mm bonds results in a scale of 48 mm = 1Å. Using the 75 mm bond provides a scale of 60 mm = 1Å, which is consistent with the scale of Gallenkamp PEEL models which are for molecular orbital studies.

The valence-angle drillings are also practically correct, so that steric interactions may realistically be assessed by direct measurement on the models, it being approximately true that un-bonded atoms whose atomic centres are nearer than 2-3 Å (7-10 cm) will interact. Thus the possibility of hydrogen bonding or configurational strain may be shown on the models.

(See Fig. 1. Chair and boat forms of cyclohexane).

A further feature of the use of flexible springs to represent valence-bonds is that to some extent the springs portray the actual distribution of electron-density in the bond.

Thus, in the representation of ethane, the single bond between the two carbon atoms is illustrated by the single spring. In ethylene, the double bond is represented by joining the carbon balls with two springs which protrude above and below the plane of the molecule. Thus the trigonal-planar valence distribution of the C atoms is shown, the reduced C-C bond distance is approximately to scale, and the pi-electron density distribution between the C atoms is represented by the two springs. A more accurate representation is provided with Gallenkamp PEEL models in which the distinction between pi and sigma bonding electrons is clearly portrayed.

Similarly in the model of acetylene, the greater reduction of the C-C distance is again correct, and the cylindrical nature of the pi-electron cloud surrounding the bond is apparent. Thus the increasing mechanical strength (and therefore increasing infra-red absorption frequency) but also increasing vulnerability to attack by electrophilic reagents along the bond series C-C, C=C C≡C is well brought out.

See (Fig. 2. Ethane, ethylene and acetylene).

The construction of highly strained molecules is also possible and the nature of the strain is graphically illustrated by the flexing of the springs for which, like chemical bonds, angular distortion is relatively easy, but linear extension relatively difficult. The springs enable strained structures (e.g. cyclopropane) to be constructed which could not be made with rigid-bond models.

The flexibility of the springs reflects the flexibility of organic molecules themselves, and the various modes of vibration of molecules and groups can be demonstrated, and correlated with their observed infra-red absorption frequencies - a valuable educational feature in view of the great importance of infra-red spectroscopy to the chemist.

(See Fig. 3 Cyclopropane).

The benzene ring cannot adequately be represented by tetrahedrally drilled models. For this reason, universally drilled carbon atoms are included in the set. These enable a benzene ring to be constructed showing the correct C=C distance, complete equivalence of all carbon atoms, and the pi-electron clouds above and below the plane of the ring. The clearest representation of benzene is provided by the PEEL model of benzene in which the pi-rings are mounted above and below the plane of the basic 6 carbon ring. This model shows the equivalence of all the carbon atoms and eliminates the need for a resonance concept.

These universally drilled balls are also valuable in the representation of compounds such as ferrocene and dibenzene chromium. Brown universally drilled balls are also included in the set to represent metals, or any atom in a non-tetrahedral valency (e.g. nitrogen in nitrobenzene).

(See Fig. 4. Nitrobenzene).

2.1.2 Inorganic Chemistry

* for construction of practically any inorganic model
* the modern approach to electron structure of compounds
* especially useful for metal co-ordination chemistry
* wide range of symmetries available.
* to exhibit stereochemical properties.

It is now widely recognised that a knowledge of the geometrical structure of many inorganic compounds is important in understanding their chemistry and electronic structure.

The Gallenkamp universally drilled model atom, see Section 3, enables models of practically all inorganic molecules to be built and their stereochemistry explained. This is of particular importance in the field of metal-coordination chemistry where stereochemical features are of considerable importance.

(See Fig. 5. The calcium complex of ethylene-diamine-tetra-acetate).

2.1.3 Polymer and macro-molecule chemistry

The compact nature of the models permits their use for constructing polymers and other macro-molecules. Quite high molecular weights may be simulated without the structures becoming unweildy. Important details of the configuration become apparent in a way that is impossible to reproduce by drawing.

(See Fig. 6. A silicone polymer chain of molecular weight about 500).

2.2 CRYSTALLOGRAPHIC SET, MV-805

* Vivid spatial representation of atoms in lattices
* invaluable for discussion of crystal properties.

This set comprises only universally drilled balls, orange, purple and brown in colour. The connecting springs are 38 mm and 60 mm. With large and complex models the use of the longer connectors is recommended. The two connector lengths give atomic centre spacings in the ratio of 1:2.

2.3 DEMONSTRATION SET, MV-870

The demonstration set is suitable for teaching 'A' level and more advanced chemistry courses. It contains atoms of each type and 25, 38 and 60 mm springs. With its components both chemistry and crystallography models may be assembled. Also included in this set is a stencil which facilitates the drawing of the models which are constructed.

3. THE UNIVERSAL MODEL ATOM

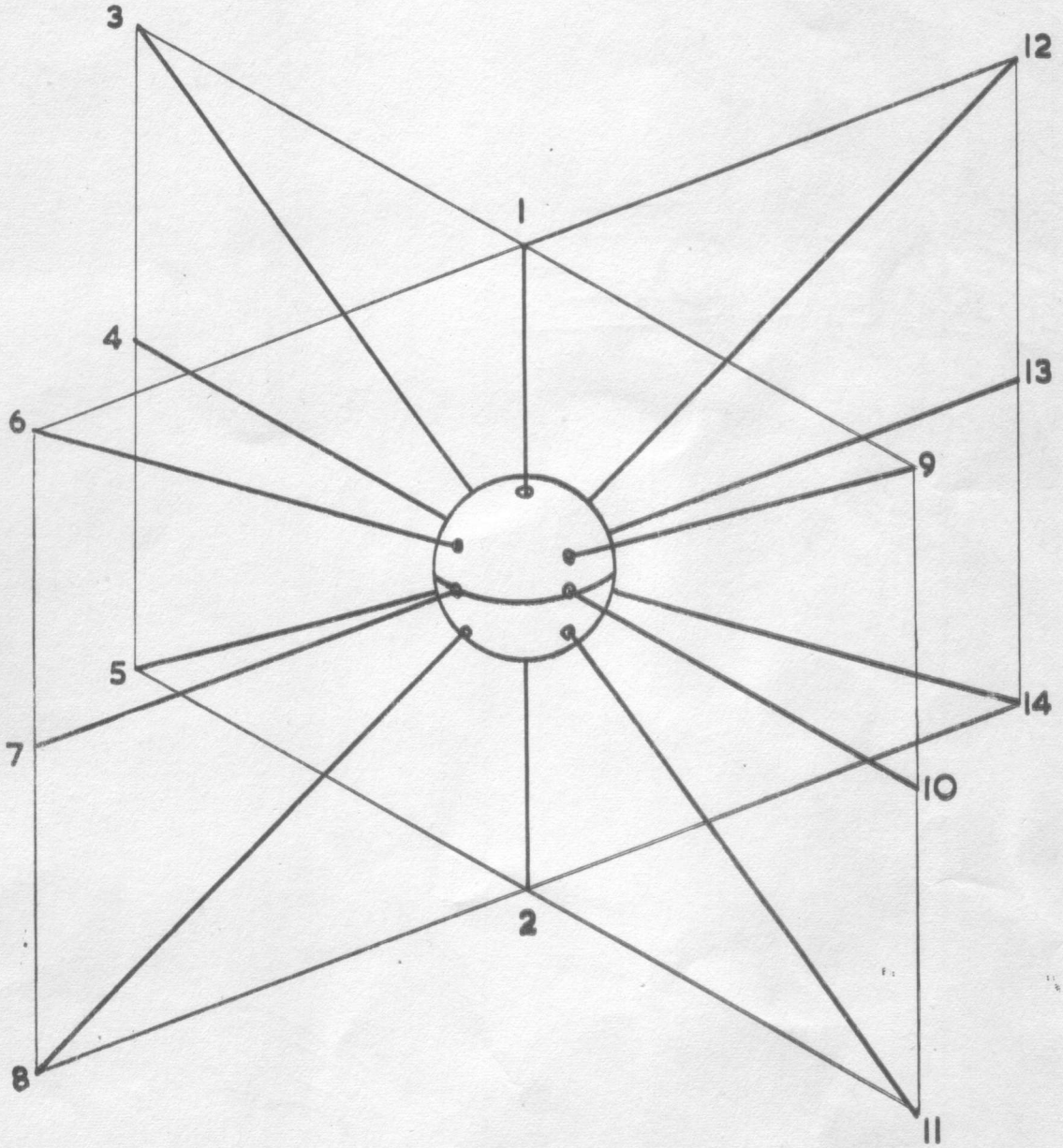
This is a ball drilled with 14 holes, directed as in the diagram along two intersecting planes at right angles. The holes directed along the line of intersection of the planes (holes 1 and 2) are termed the "poles" of the model; they serve to orientate the model for the user and are readily located as the corresponding 'equator' is moulded round the ball.

Such an arrangement has many possible forms of symmetry and the following geometrical forms, together with many subtractive forms included in them, may be constructed.

1.	Dihedral	The following angles are available: 180° (1,2), 145° (4,9), 125° (1,5), 110° (3,9), 90° (1,4), 70° (3,5), 55° (1,3), 35° (3,4).
2.	Trigonal	Three holes directed towards the corners of an equilateral triangle (1, 5, 11).
3.	Tetrahedral	Four holes directed towards the corners of a regular tetrahedron (3, 8, 9, 14).
4.	Square-planar	Four holes directed towards the corners of a square, thus making two axes at right angles (1,2,4,10).
5.	Square-puckered	Four holes directed alternately 15° above and below the corners of a square. (5, 6, 10, 13).

6.	Tetragonal-pyramid	Five holes directed to the corners of a tetragonal pyramid (1, 5, 8, 11, 14).
7.	Pentagonal *	Five holes directed towards the corners of a regular pentagon (1, 2, 3, 5, 10).
8.	Trigonal-bipyramid	Five holes, three directed to the corners of an equilateral triangle, and two forming an axis passing through the centre of the triangle at right angles. (1, 5, 7, 11, 13).
9.	Hexagonal	Six holes directed to the corners of a regular hexagon. (1, 2, 3, 5, 9, 11).
10.	Octagonal	Six holes directed towards the corners of a regular octahedron, making three axes mutually at right angles. (1, 2, 4, 7, 10, 13).
11.	Trigonal-biprism *	Six holes directed towards the corners of two similarly orientated equilateral triangles, above and below the plane of the atom (3, 5, 6, 8, 10, 13).
12.	Pentagonal-bipyramid	Seven holes, five directed to the corners of a rectangular pentagon, and two forming an axis passing through the centre of the pentagon at right angles. (1, 2, 3, 5, 7, 10, 13).
13.	Hexagonal-bipyramid	Eight holes directed towards the corners of a regular hexagon and two forming an axis passing through the centre of the hexagon at right angles. (1, 2, 3, 5, 7, 9, 11, 13).
14.	Cubic	Eight holes directed towards the corners of a cube. (3, 5, 6, 8, 9, 11, 12, 14).

* It will be appreciated that not all these symmetries can be mathematically exact with so few holes in the model. However, most of them are sufficiently close for most practical purposes, and those marked with an asterisk are adequate for demonstration. If they are made up into crystal lattices, the bending of the interlinking springs will, of course, take up any small departures from correct geometry in the balls themselves.



ATOMIC MODEL : UNIVERSAL DRILLING

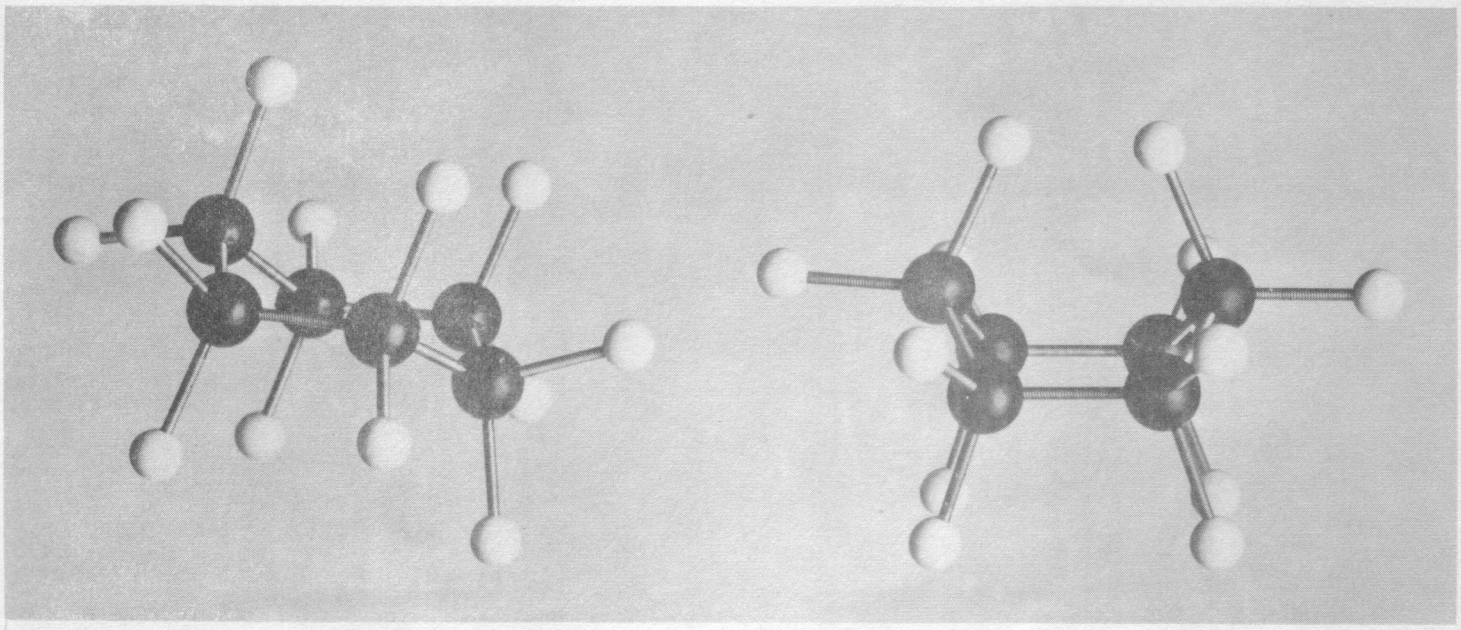


Fig.1

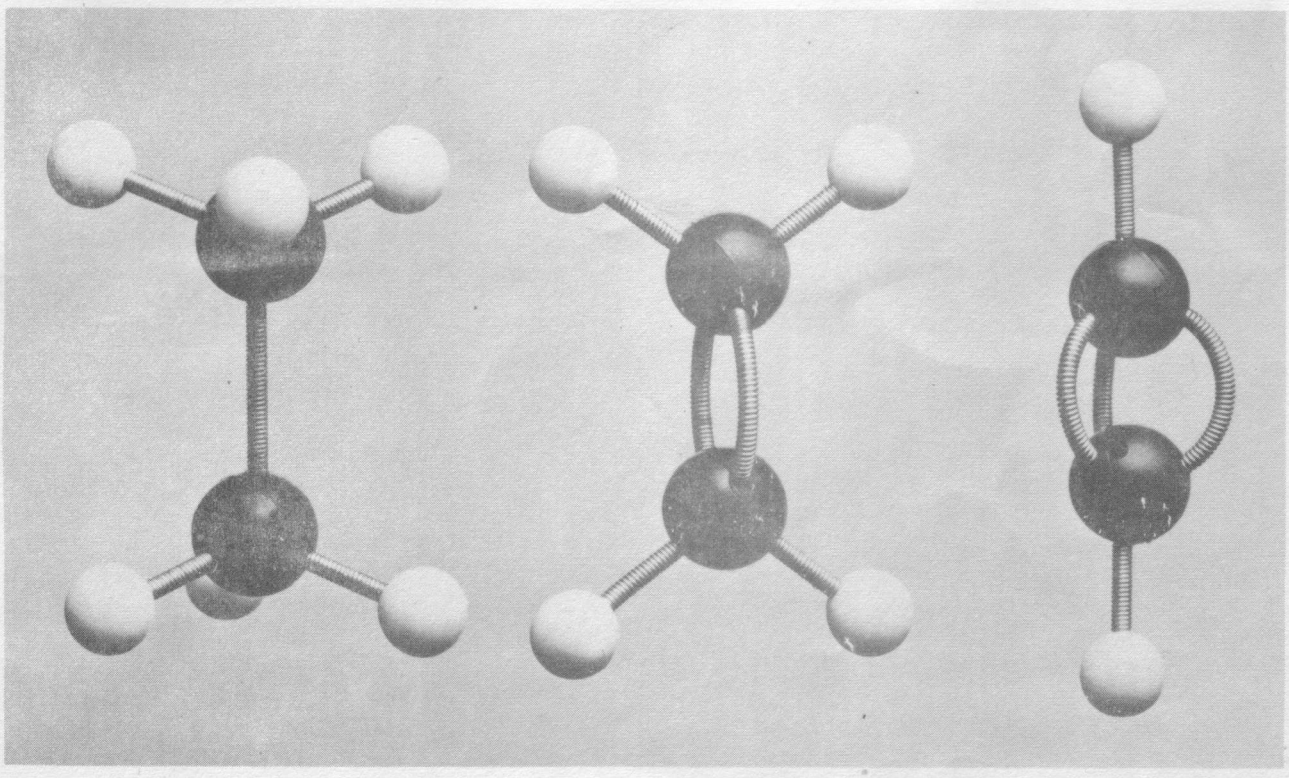


Fig. 2

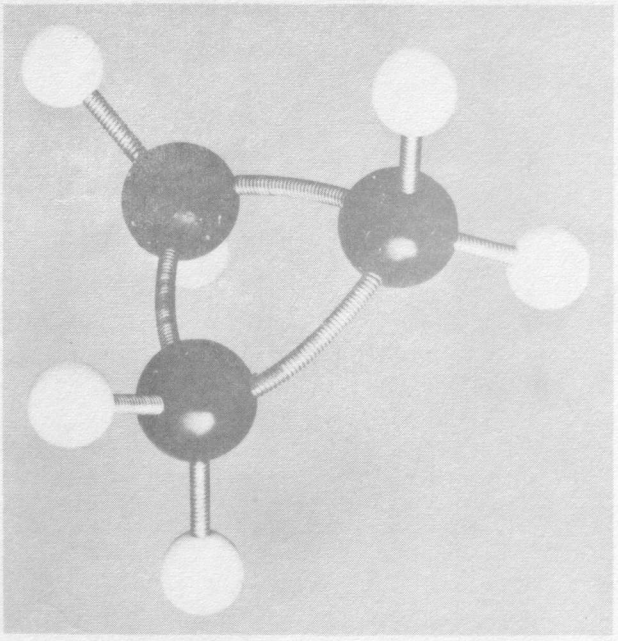


Fig. 3

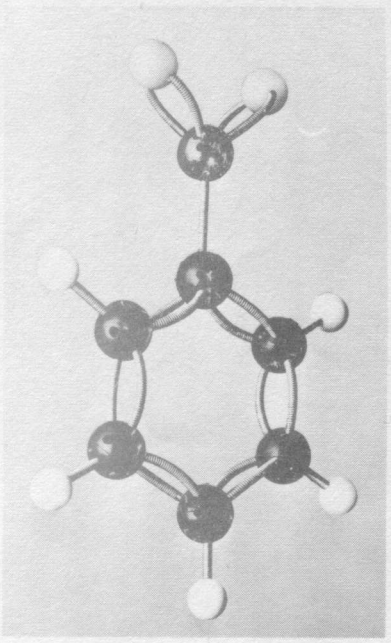


Fig. 4

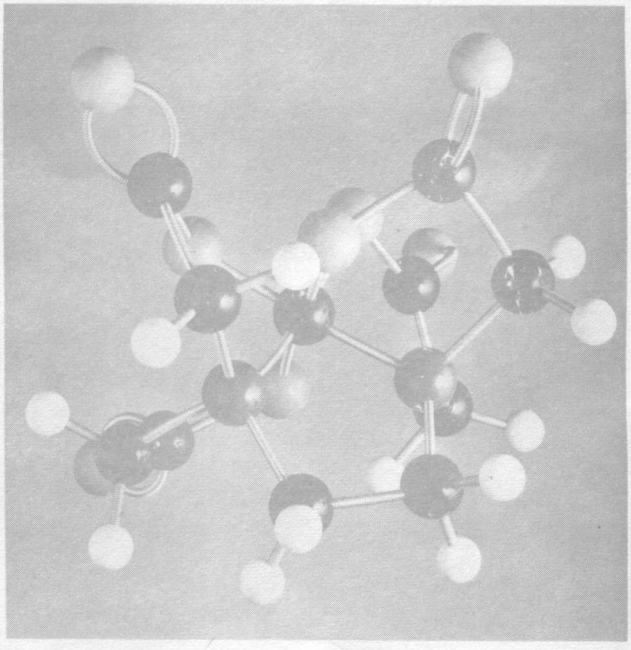


Fig. 5

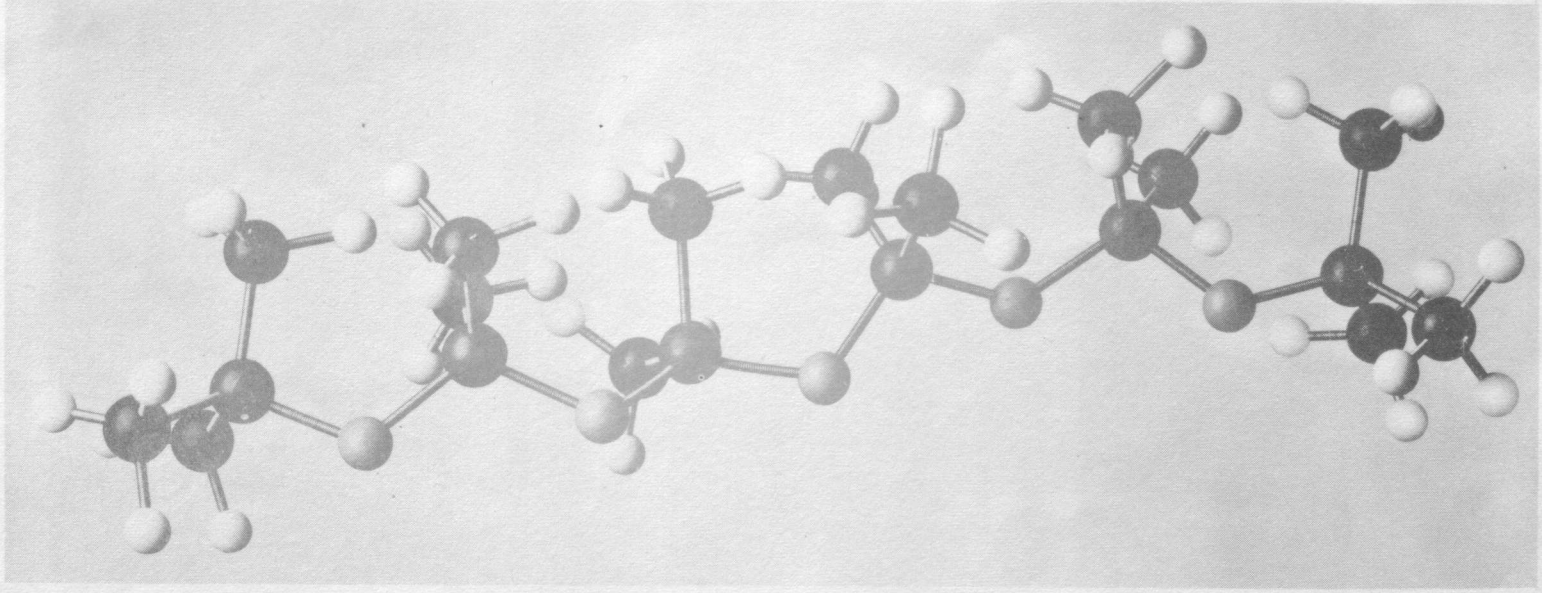


Fig. 6

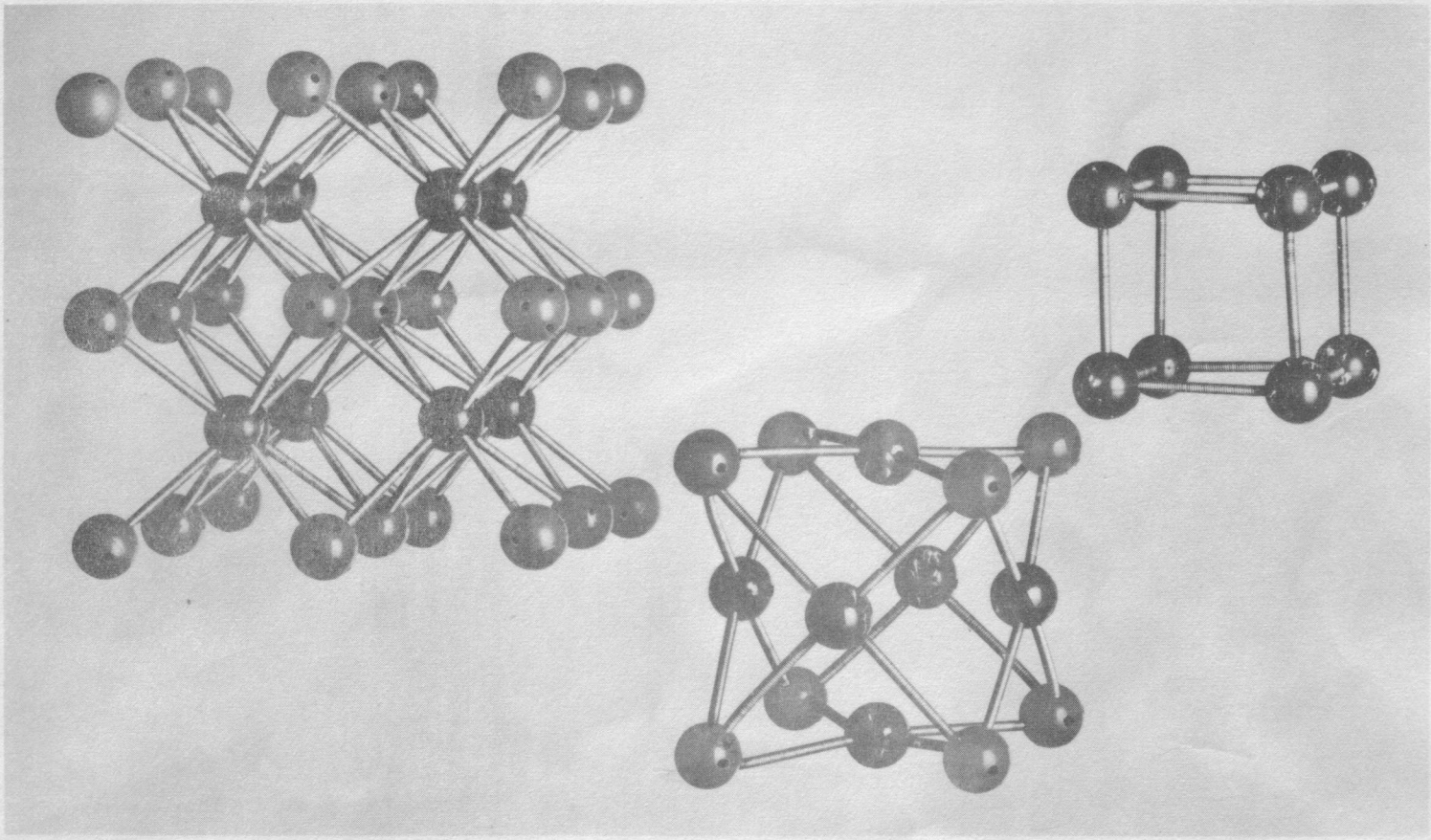


Fig. 7