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PROBLEMS OF STUDENTS IN LEARNING STEREOCHEMISTRY

By

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GIFT هدية

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PROBLEMS OF STUDENTS

IN LEARNING STEREOCHEMISTRY

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ABSTRACT

This research is in four parts:

1. To investigate the relationship between students' ages and their performance on spatial relationships programmes.

2. The design of remedial programmes using transparencies, slides and booklets, to alleviate problems encountered by students in visualizing rotations in molecular diagrams.

3. To investigate the effects of different degrees of colouring, on the effectiveness of the remedial programmes.

4. To investigate the effects of different numbers of diagrams on the effectiveness of the remedial programmes.

The findings showed:

1. In all cases the treatment groups were significantly better than the control group.

2. Performance on spatial relationship tasks is dependent upon age.

3. Remedial programmes which used coloured diagrams were more effective than black and white programmes.

4. The effectiveness of remedial programmes depended upon the degree of colouring.

5. The effect of the degree of colouring was age-dependent.

6. The number of diagrams used in the remediation programmes showed an age-dependent relationship to the effectiveness of their teaching.

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CHAPTER 1

INTRODUCTION

1.1 AN OVERVIEW

This chapter deals with the ideas and work that provide the main background to this research. It describes how the research problems were identified, reviews the related literature, and outlines the aims and tasks of the research.

1.2 INTRODUCTION TO THE PROBLEM

There is increasing recognition of the need to develop the critical and logical thinking ability of science students in order to facilitate their understanding of many important, but rather abstract concepts within the subject.

Students in chemistry have great trouble in understanding many areas in chemistry such as those in Table 1.1, and several others cited by Wells (1968), Clark (1977) and Nicholson (1976), where a considerable degree of abstract thinking is involved. In order to understand these areas, students should be able to visualise three-dimensional spatial relationships in diagrams. Such areas require the students to perform a variety of spatial tasks in relation to diagrams of three-dimensional structures such as those in Figure 1.1. At a lower level, students would be required merely to understand the spatial relationships portrayed in these diagrams. In particular, they must realise that the diagrams represent structures which have depth, as well as width and height. At a relatively advanced level, students must be able to

visualise how the diagrams should change to represent the effect of rotating a structure, or the equivalent task of visualising what the diagram would look like, if the structure is viewed from a different direction. Many students are known to be unable to understand such diagrams, as those in the lower part of Figure 1.2. This represents the structure portrayed in the upper diagram after rotating the structure about each of the three Cartesian axes, respectively.

TABLE 1.1

Areas in Chemistry in which the Understanding of Three-dimensional Relationships is Necessary.

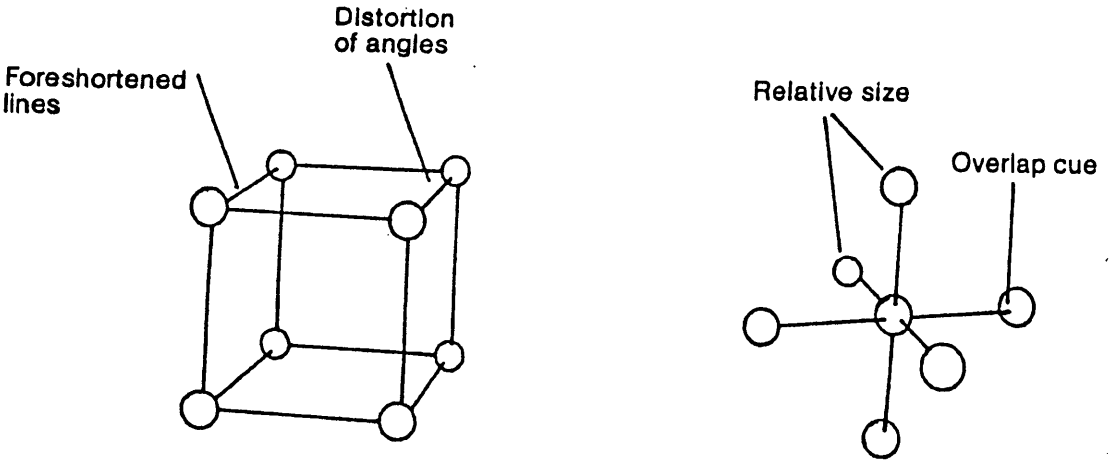
MAIN AREA	DETAILED CONTENTS
Atomic and Molecular structures	a) The classification of p and d orbitals from their angular probability functions. b) Application of the concept of electron-pair repulsions. c) The use of crystal field theory in correlating the properties of transition metals with their electronic structure. d) Using molecular orbital theory to explain the structures of compound with electron deficient, single and multiple bonds. e) The recognition of the normal vibrational modes of polyatomic molecules. f) The identification of asymmetric and dysymmetric molecules in studies of optical activity.
Chemical bonding	a) Electrovalent and covalent bonding illustrated with simple compounds. b) Structures of simple ionic solids, e.g. Na Cl Crystal
Carbon chemistry	a) Carbon and its compounds. b) Simple organic compounds.
Crystallography	a) Visualisation of structures of binary and tertiary ionic compounds and of polyions, e.g. diamond and silicates. b) The recognition of structural differences between the allotropes of an element. c) The use and interpretation of Miller Indices. d) The assignment of a unit cell to one of the crystal systems.

Continued...

TABLE 1.1 (continued)

MAIN AREA	DETAILED CONTENTS
Reaction mechanisms	a) Explanation of reaction in terms of first and second order substitution nucleophilic reactions. b) Effects of conformational differences upon the rate of substitution of reactive species in organic compounds. c) The use of potential energy surfaces to express reaction paths.

FIGURE 1.1 Examples of the Depth Cues used in Diagrams of Three-Dimensional Structures.



(In the actual models being represented all the spheres are the same size, all the rods are the same length, and all the angles between adjacent rods are 90°)

FIGURE 1.1 Examples of the Depth Cues used in Diagrams of Three-Dimensional Structures.

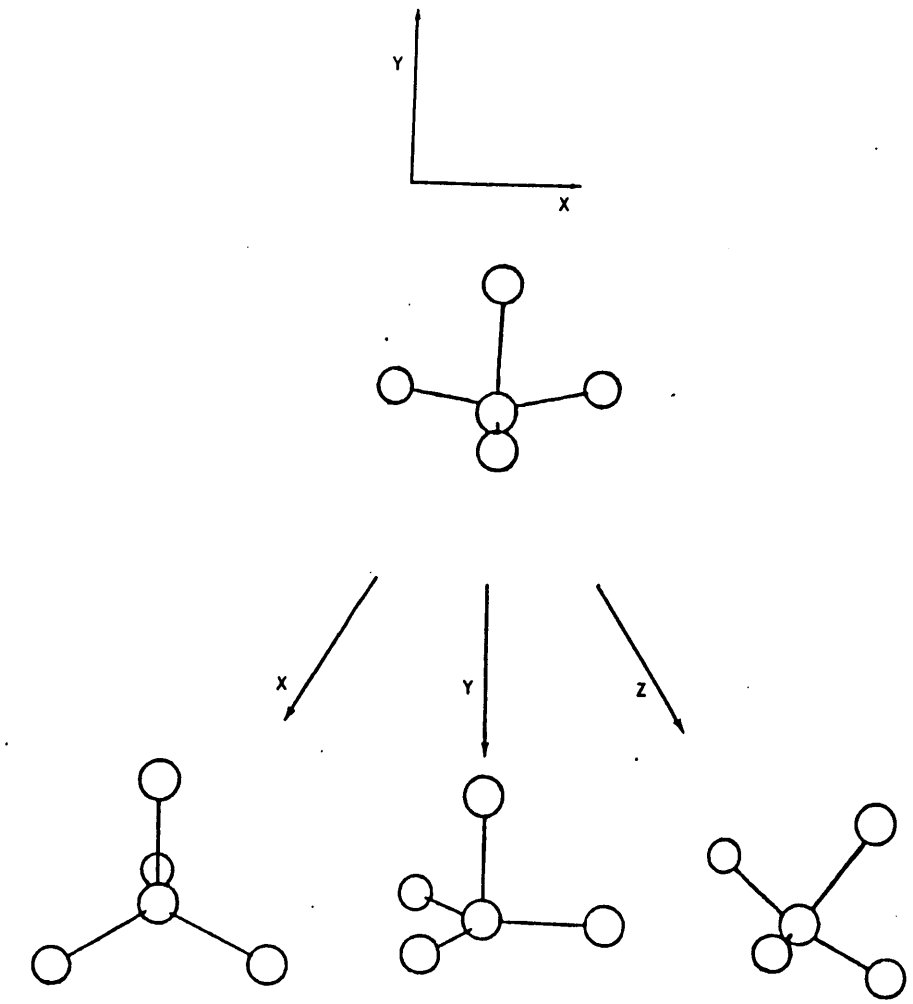


FIGURE 1.2 An Illustration of How the Depth Cues Change When the Structure is Rotated About the Cartesian axes.

1.3 MOTIVATING FACTORS FOR THE STUDY

There were three explicit factors which prompted this study; these are as follows :

(1) A high proportion of Bahrainian students find it very difficult to interpret the diagrammatic representation of rotation in molecular diagrams. This is a finding from Shubber (1982) as shown in Table 1.2. In addition the problem cuts across international boundaries as shown in Table 1.3

(2) There are a series of topics within most chemistry courses which demand the understanding of spatial relationships in diagrams of three-dimensional molecular structures. This has already been outlined in Table 1.1.

(3) There has been relatively little research carried out into problems that students encounter when interpreting three-dimensional diagrams.

TABLE 1.2

Means, Standard Deviations, and the Percentage of Students Who Fail the Molecular Rotation Test.

SAMPLE	AGE RANGE	STATISTICS		
		Mean	S.D.	% Not Achieving Criterion
School A (N = 101)	16-17	9.00	3.20	87.13
School B (N = 56)	16-17	8.69	3.21	92.86
School C (N = 72)	16-17	10.64	6.62	72.22
School D (N = 55)	16-17	7.98	3.89	96.36
University (N = 46)	17-18	7.70	2.70	95.65
University (N = 33)	18-19	12.73	6.16	57.58

Perfect score = 30
Criterion = 14

TABLE 1.3

Percentage of Students Who Fail the Molecular Rotation Test Samples From Different Populations

COUNTRY	AGE RANGE	SUBTEST X	SUBTEST Y	SUBTEST Z
England (Cleary, 1975) (N = 148)	1. 13 - 14	65.1	67.2	46.0
	2. 14 - 15	56.5	58.7	40.6
	3. 16 - 17	15.7	17.1	20.0
England (Jusoh, 1979) (N = 149)	13 - 15	40.3	44.3	38.3
Bahrain (Shubber, 1982)	1. 16 - 17 (N = 72)	77.8	77.8	72.2
	2. 18 - 19 (N = 33)	72.7	69.7	72.7
Nigeria (Eniaiyeju, 1981)	1. 17 - 19			
	School A (N = 176)	84.1	92.6	74.4
	School B (N = 165)	94.5	95.8	72.1
	School C (N = 160)	91.3	73.1	73.1
	2. 17 - 23			
	School D (N = 245)	88.2	91.9	75.2
Pakistan (Tariq, 1982) (N = 223)	17 - 19	82.4	17.2	56.8
Portugal (Tariq, 1982) (N = 188)	18 - 21	59.0	24.5	43.6
Cape Verde (Tariq, 1982) (N = 95)	17 - 19	79.2	51.0	43.8

Perfect Score = 10
Criterion = 6

1.4 BACKGROUND TO THE STUDY

This research is about helping students who experience difficulty in the perception of depth in diagrams or drawing of three-dimensional objects or in visualising spatial rotation in molecular diagrams.

School chemistry text books often use two-dimensional diagrams to represent three-dimensional structures. Students are then required to recognise the structure by interpreting the depth implied in these diagrams, and also to visualise their movements into various other positions. This is further complicated by the lack of consistency in the representation of molecular structures that is evident in many text books. Students may be required to interpret implied depth with or without the aid of variety of visual cues, such as foreshortening, overlap, relative size or distortions in the angles and as a result their understanding of chemistry will depend to a great extent on how correctly they interpret the three-dimensional molecular diagrams.

The literature is abundant with research reports, comments and articles about the role of spatial visualisation in the learning of some of the more important chemical concepts. Some of these merely suggest ways of improving the learning of three-dimensional perception without first identifying what the difficulties are.

Often these are based on personal intuition or experience of the authors e.g. Shine (1957), Hoogenboom (1962), McGrew (1971), Nelson (1974), Shriver *et al* (1974), Remark (1975), Gelbard (1976), Bishop (1979), Moore (1980),

Chenier (1980), Murphy (1981), Streitwiser et al (1981), Epling (1982), Wintner (1983), Hargittai (1983), and Brady (1983).

For instance, Gelbard (1976) emphasises that "students may find some difficulties in visualising in space the molecules drawn in their handbook." Bishop (1979) says "students in organic chemistry usually have difficulty in visualising molecules in three-dimensions." According to Moore (1980), "One of the most difficult concepts for students to grasp in the study of chemistry is the three-dimensional structures of molecules."

Both Epling (1982) "students have difficulty in performing the required three-dimensional manipulations of the two-dimensional representation," and Hargittai (1983) "The representation of rotational isomerism by projection drawings is difficult for some students to grasp because of its abstract nature," stress the added difficulty of carrying out manipulation of two-dimensional representations.

Others have not only first emphasised that it is a difficult concept, but at the same time made practical suggestions for particular topics which they have investigated. Examples are Hayman (1963), Lapidus and Tye (1963), Lawson (1965), Yamana (1968), Freeland and O'Brien (1971), Ganeson and Renganatham (1971), Yamana and Kawaguchi (1982 a,b,c, 1983).

Baker and Talley (1974) demonstrated that spatial skills are important factors to success in certain areas of chemistry.

Talley (1973) has shown that training chemistry students in tasks which involve spatial visualisation produces

significant effects in learning chemistry.

Gabel and Sherwood (1980) mentioned the role of three-dimensional visualisation in chemistry and argue that chemistry achievement can be enhanced by allowing students to manipulate molecular models themselves rather than watch the teacher use them in demonstration.

Holford and Kempa (1970) argued that the recognition of spatial relationships in plane-drawings and photographs is often an essential prerequisite to the understanding and application of fundamental ideas in chemistry. For example, they are employed to assist the learning of structural chemistry and mechanistic concepts.

Barufaldi and Dietz (1975) emphasised the importance of visual perception skills for elementary science children, and recommended that "science educators should design experiences that would give children greater opportunity to utilise photographs and drawings in development of scientific skills since these types of two-dimensional representations are basic to educational and instructional materials."

Ritz and Raven (1970) have shown that prior perceptual training can enhance the ability of children to learn science.

Pallrand and Seeber (1984) have recently shown that spatial ability is important for the learning of some physics concepts.

Difficulties in performing this essential task have been identified in students from different age groups and cultures, e.g. Shepard and Metzler (1971), Piaget and Inhelder (1971), Tapley and Bryden (1977). Moreover, the reviews by

Miller (1973) and Walker (1979) indicate that students from developing countries and other deprived ethnic groups will have the greater difficulties.

1.5 RESEARCH STUDIES IN THIS AREA AT U.E.A.

Research investigations on students' difficulties in visualising three-dimensional spatial relationships in diagrams by Evans (1974), Nicholson (1974), Worsnop (1975), Cleary (1975), Nicholson (1976), Nicholson *et al* (1977), Ross (1977), Nicholson and Seddon (1977 a,b), Alonge (1977), Adeola (1978), Evans and Seddon (1978), Oyediji (1978), Jusoh (1979), Eniaiyejn (1981), Tariq (1982), El-Farra (1982), Shubber (1982,) Seddon *et al* (1982), Jusoh (1983), Patwary (1983), Seddon *et al* (1984 a,b), have all confirmed students' difficulties in interpreting two-dimensional diagrams of three-dimensional structures.

The findings from these studies will be discussed in the succeeding chapters.

1.6 AIMS OF THE RESEARCH

There were two main purposes of carrying out the present research. These were to:

(i) diagnose the nature of the difficulties which students encounter in failing to understand spatial relationships in diagrams of molecular structures,

(ii) develop, try out and evaluate remedial packages for students who show difficulty in understanding spatial relationships.

There are a number of areas of chemistry which call for three-dimensional perceptual skills. In particular the learning of simple static and dynamic organic and inorganic molecular structures is central to an understanding of chemistry. For this reason the focus of the study has been limited to these areas.

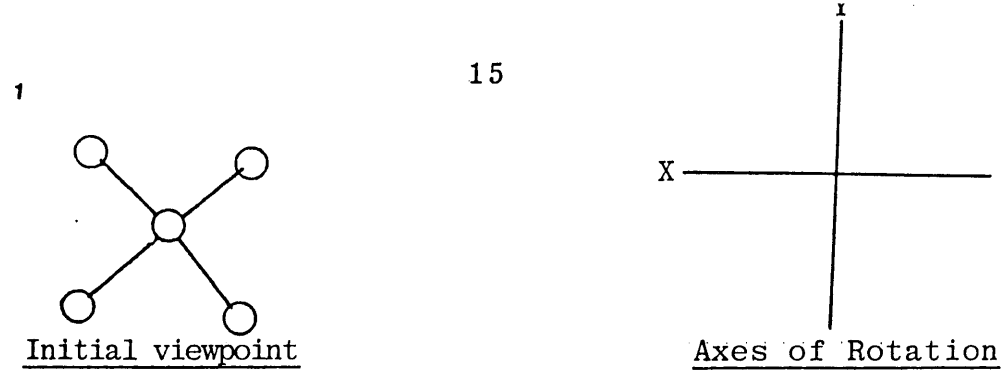
1.7 RESEARCH TASKS

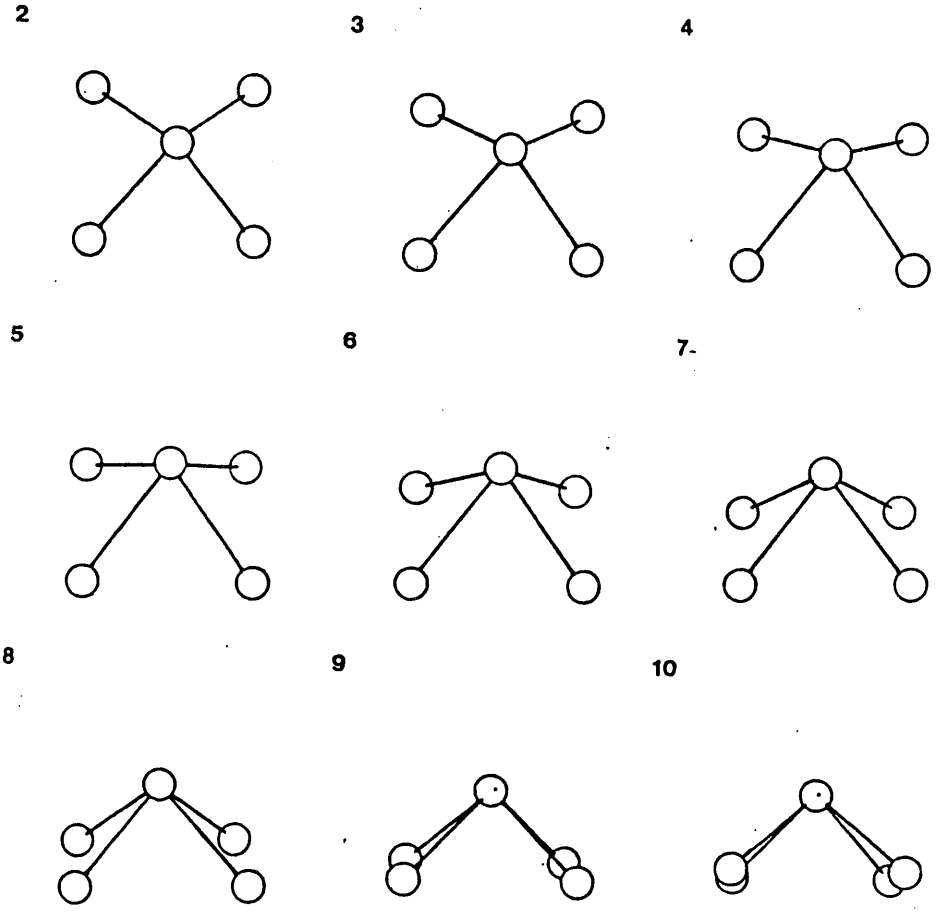
This research concentrated on the ability of students to:

1) match a static three-dimensional model with its corresponding cued diagram,

2) understand depth perception in diagrams of crystal structures,

3) visualise the diagrammatic representation of rotation in molecular structures (see Figs. 1.3 - 1.5).

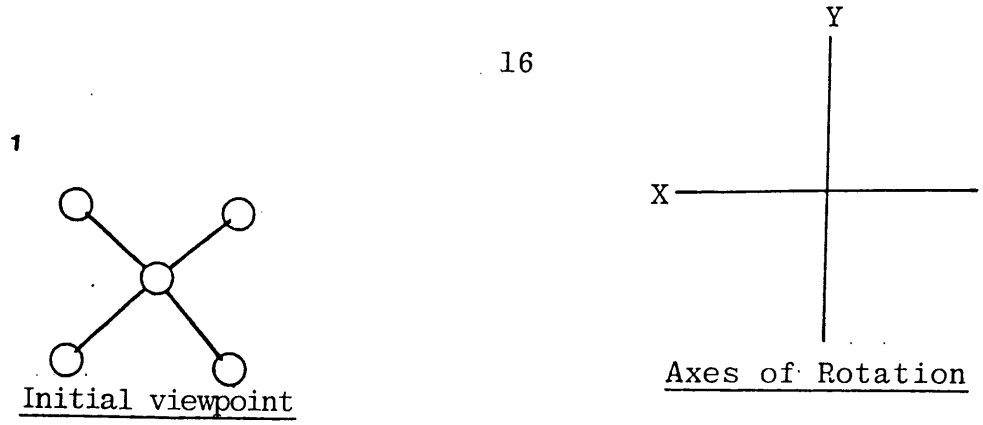




a. Diagram 1 represents the model of the square configuration molecule as seen from the initial viewpoint.

b. Diagrams 2-10 represent the same molecule after it has been rotated about the X-axis through successive 10° shifts.

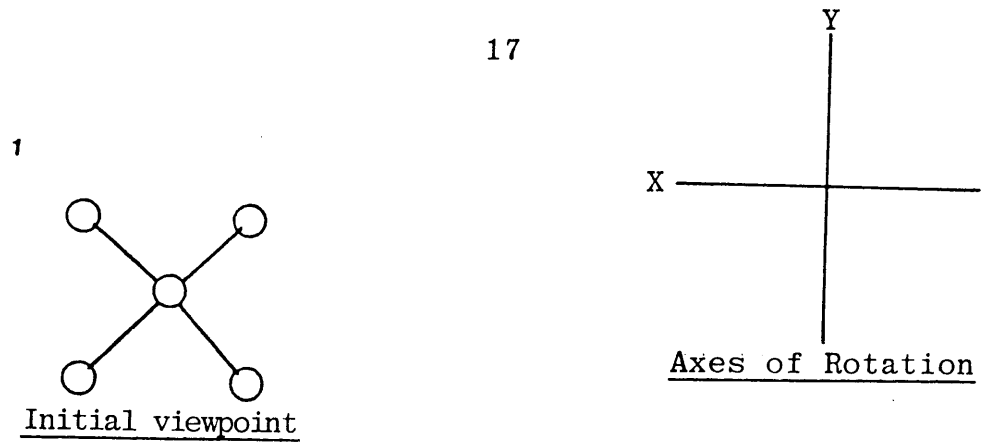
FIGURE 1.3 Diagrammatic representation of rotation of one of the molecular structures, about the X-axis.

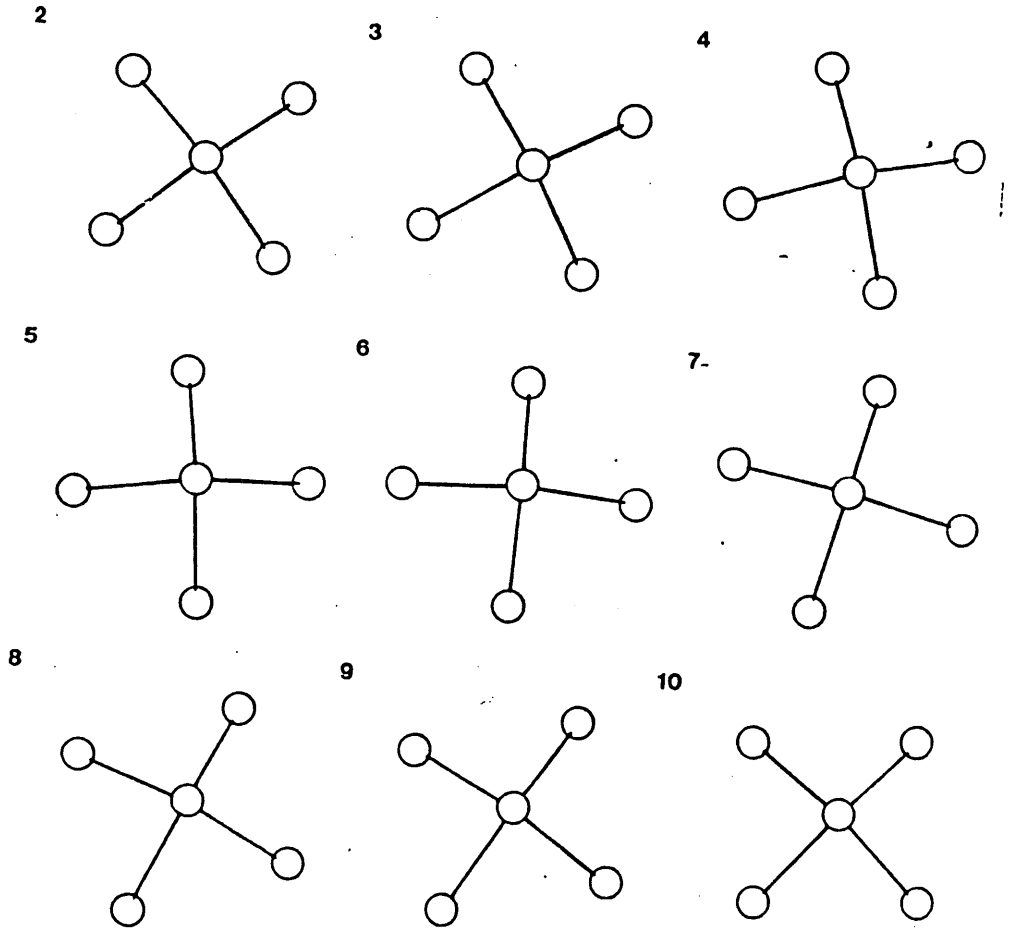


a. Diagram 1 represents the model of the square configuration molecule as seen from the initial viewpoint.

b. Diagrams 2-10 represent the same molecule after it has been rotated about the Y-axis through successive 10° shifts.

FIGURE 1.4 Diagrammatic representation of rotation of one of the molecular structures, about the Y-axis.





a. Diagram 1 represents the model of the square configuration molecule as seen from the initial viewpoint.

b. Diagrams 2-10 represent the same molecule after it has been rotated about the Z-axis through successive 10° shifts.

FIGURE 1.5 Diagrammatic representation of rotation of one of the molecular structures, about the Z-axis.

PART I

TEACHING THE VISUALISATION OF THREE-DIMENSIONAL SPATIAL RELATIONSHIPS IN DIAGRAMS AT DIFFERENT AGE GROUPS

CHAPTER 2

INTRODUCTION

2.1 AN OVERVIEW

This chapter gives the background to the present research. A review of relevant literature is made, the aim and statements of the research questions are given.

2.2 GENERAL INTRODUCTION

Many areas in chemistry as has been indicated earlier (see chapter 1, section 1.2) require from the students the ability to perform variety of spatial tasks in relation to diagrams of three-dimensional structures such as those illustrated earlier in chapter 1, Figures 1.1 and 1.2.

These tasks demand from the students first the ability to understand the spatial relationships portrayed in these diagrams, and secondly to visualise how the diagrams should change to represent the effects of rotating a structure i.e. visualising what the diagrams would look like if the structure is viewed from different direction.

In fact, the ability to perform these tasks depends on the understanding of the artistic devices or cues which are used to portray depth. As illustrated earlier in chapter 1, Figure 1.1, these cues respectively determine the relative sizes of the different parts of the diagrams, the foreshortening of lines, the overlapping of lines, and the representation of angle.

Nicholson and Seddon (1977a) demonstrated that the general level of understanding the spatial relationships in diagrams of molecular structures decreases as these cues are removed.

The structures of three-dimensional molecules may be illustrated by either a three-dimensional model or two-dimensional diagrams. In chemistry students are often exposed to a situation where they are required to work with two-dimensional diagrams or drawings of molecular structures, and this may be difficult for them. For example chemistry text books usually present diagrams of molecular structures with or without visual cues, which require students first to understand the depth cues and then interpret in terms of movements in three-dimensional representation.

Chemists have always emphasised the importance of the skills and knowledge needed to interpret two-dimensional diagrams of three-dimensional structures, and the ability to visualise the movement of molecular structures. They regard these tasks as prerequisites for understanding many areas of chemistry.

While the performance of similar tasks has been considered by Piaget and Inhelder (1971) in relation to the piagetian stages of cognitive development, there is yet no agreement as to the best point in the curriculum ladder where these tasks should be taught to students. The usual point in the curriculum ladder often suggested in the literature is the formal stage where a considerable degree of abstract thinking is involved. There may be certain chronological ages within this stage where, for all practical purposes, students can learn very little. However, arguing from a

constructivist point of view Piaget (1956, 1971, 1974) has maintained that there is continuous interaction between mental structures of an individual and representation of the external world, i.e. the teaching of spatial ability can occur at any developmental stage of the individual, depending on his mental structure and how this interacts with the external world.

The same area has been of interest for many research based studies here at U.E.A. as already indicated earlier (see chapter 1, section 1.4). However, they are not based on piagetian stages of cognitive development.

The present study is to add some understanding to this issue by finding out if age is a factor in learning of this abstract concept. The age range being focused on is 13 - 17 years where in piagetian terms the transition from the concrete to formal operations generally occurs. If this is a factor, it will then lead to teaching this concept at any early age.

2.3 INTRODUCTION TO THE PRESENT RESEARCH

Previous research in the understanding of depth in diagrams, and the movements of those diagrams in space does not include any studies which investigate the effect of ages on performance, if the students were exposed to a certain remediation programme.

Cleary (1975) developed and administered a rotation test to English students aged 13 - 14 years. This paper and pencil spatial visualisation test demands from the

student the ability to visualise the rotation for diagrams of molecular structures.

He demonstrated that a substantial number of English students find difficulty in visualising rotation in molecular diagrams. Jusoh (1979) confirmed Cleary's findings as a result of administering a modified version of Cleary's test to third and fourth form English students.

Eniaiyeju (1981), Shubber (1982) and El-Farra (1982) administered the same test to Nigerian, Bahrainian and Kuwaiti students respectively. Results showed the following:

1) Only 5 - 28% of Nigerian students achieved the criterion for the test (boys, aged 15-23 years).

2) Only 3.64 - 27.78% of Bahrainian students achieved the criterion for the test (boys and girls, aged 16-17 years).

3) Only 28% of the Kuwaiti students achieved the criterion of the test (boys, aged 15 years).

Evans and Seddon (1978) developed and administered a diagnostic test for depth cues to Nigerian students (see Figure 2.1). They found that a high proportion of students in Secondary Schools and Universities were unable to respond correctly to the various depth cues.

Nicholson and Seddon (1977b), demonstrated that more than 50% of the most able Secondary School students in Nigeria had difficulty in understanding diagrams in a frame-works diagram perception test based on cuboid and hexagonal prism models.

El-Farra (1982) administered the same tests used by Nicholson and Seddon (1977b) and Evans and Seddon (1978) to boys and girls in Kuwaiti Secondary Schools (age 15 years), having first translated the tests into Arabic.

He found the following:

1) A significant proportion of the Kuwaiti subjects in this age group had difficulty in understanding diagrams in the framework diagram perception test.

2) 50% of the same subjects (boys only) were unable to respond correctly to the various depth cues in the test.

These studies have shown that spatial problems are more pronounced in developing countries than in others.

Such problems could cause serious difficulties in teaching of chemistry if they are not remediated before students tackle parts of the syllabus that include stereochemistry.

The sooner these programmes can be usefully administered, the greater would be this value. It is therefore worthwhile to investigate the efficiency of similar programmes when used to remediate students of various ages. The programmes used were based on those used by Eniaiyeju (1981), Oyediji (1978) and Ross (1977), and were modified and translated for use in this study. The group of students tested were aged 13, 15 and 17 years.

Question:

Which one of these diagrams is the best representation of what you can see of the model?

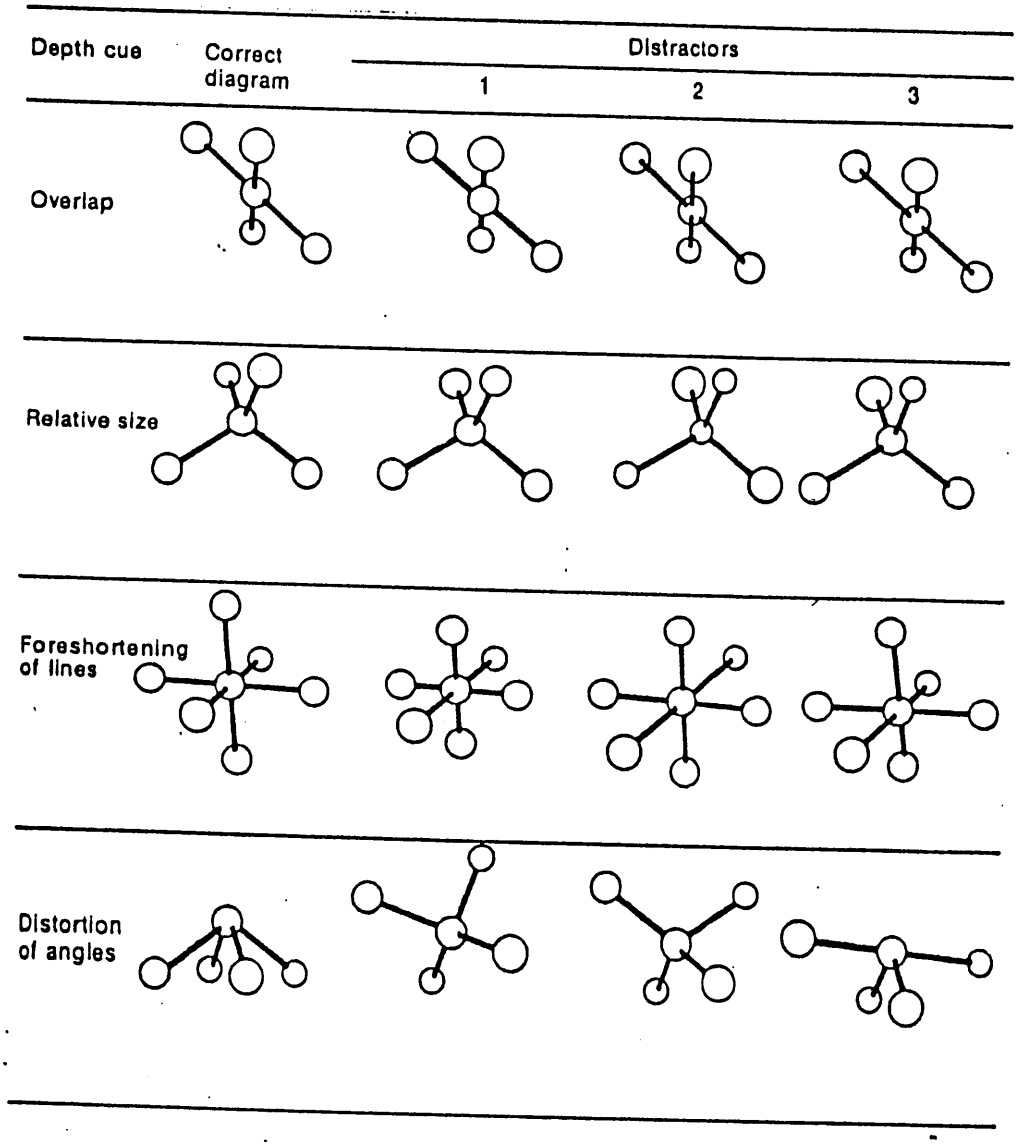


Figure 2.1 Examples of Questions Used in the Cues Test.

Evans & Seddon (1978)

2.4 RESEARCH QUESTIONS

The students' learning abilities at various ages were investigated by considering the following research questions:

1) Is there a positive relationship between the students' age and their performance on each of Cues Test, Frameworks Test and Rotations Test?

2) Do the different tasks in the tests discriminate between the students?

3) Is there any significant difference in the performance of students who have been exposed to remediation by either Cues, Frameworks or Rotations programmes?

CHAPTER 3

METHOD

3.1 AN OVERVIEW

In this chapter a description of the subjects, research instruments, experimental procedures and the treatments are made.

The investigation required samples of students taken from populations which varied only in terms of chronological age. The age groups chosen were 13 - 14, 15 - 16 and 17 - 18 years.

The first stage of the investigation was intended to determine the general level of performance on these tasks at each age group before teaching. It required the administration of six pre-tests concerned respectively with the ability to respond correctly to each of the four depth cues, the understanding of displacements in diagrams of three-dimensional frameworks, and the visualisation of rotations. In the second stage, the students within each age group were allocated at random to an experimental group or a control group. Each experimental group worked through one of six instructional programmes each designed to teach one of the six tasks. In the third stage, the experimental and control groups took a post-test of the appropriate task which had been taught in the programme. The various effects of interest were then assessed by a two-way analysis of variance in order to compare the means of the experimental groups with the controls and the means of the groups at each age level.

3.2 SUBJECTS

The subjects involved in the research were from the State of Bahrain. They were from two levels, the first level of students (N = 317) was taken from the Secondary Schools, the second level of students (N = 634) was drawn from intermediate School (Table 3.1). The subjects are thus of two distinct levels:

1. SECONDARY SCHOOL LEVEL:

The subjects were drawn from the second year Secondary School students from three schools (boys only). These students have had 10 years of schooling (6 primary, 3 intermediate, and 1 upper secondary) and aged 17 years.

Secondary School terminate after three years' study in the upper secondary level. The medium of instruction is Arabic. Secondary Schools are not co-educational institutions. The schools offer course leading to the general secondary school certificate (GSC) after three years' study at upper secondary level. This certificate is equivalent to the ordinary level of the General Certificate of Education (GCE) in Britain.

2. INTERMEDIATE LEVEL

The students at this level were drawn from the first and third years intermediate students, (aged 13, 15 respectively) from three intermediate schools, the first year students have had 6 years of primary schooling, while the third years have had 7 years of schooling (6 primary and 1 intermediate).

TABLE 3.1

Showing Composition of the Experimental Groups.

Sample Age (Years)	SCHOOL	Rotation Test		Frameworks Test		Cues Test	
		Pre (N)	Post (N)	Pre (N)	Post (N)	Pre (N)	Post (N)
13	Abdul Rahman Aldakel Intermediate School (AAIS)	112	100	-	-	-	-
15	Abdul Rahman Aldakel Intermediate School (AAIS)	103	100	-	-	-	-
17	Naim Boys Secondary School (NBSS)	112	100	-	-	-	-
13	Isa Town Secondary School (ITSS)	-	-	106	100	-	-
15	Isa Town Secondary School (ITSS)	-	-	113	100	-	-
17	Isa Town Secondary School (ITSS)	-	-	105	100	-	-
13	Awal Intermediate Boys School (AIBS)	-	-	-	-	100	100
15	Awal Intermediate Boys School (AIBS)	-	-	-	-	100	100
17	East Riffa Secondary School (ERSS)	-	-	-	-	100	100

The different age range, i.e. 13, 15 and 17 could not be drawn from same population due to the numbers to be used for the study. However, efforts were made to get a close approximation in terms of characteristics of the sample by drawing subjects from adjacent populations.

There were 3 tests: Frameworks, Rotations and Cues. Each of the tests was administered on sample drawn from two different populations.

The number of subjects in each experimental group is shown in Table 3.1.

3.3 DRAWING THE MOLECULAR STRUCTURES

The details of how the diagrams were drawn are contained in Appendix 1.

3.4 EXPERIMENTAL PROCEDURES (1)

The research instruments used to study the visualisation of Rotation in diagrams of three-dimensional structures are described below:

3.4.1 Rotations Test

The Rotations test used was the one administered previously in a study by Shubber (1982). It was based on Eniaiyeju (1981) and Jusoh (1979). However, some slight modifications were made as already described by Shubber (1982).

All the test items (Appendix 2) were of the form illustrated in Figure 3.1. The student was required to look at a diagram of a three-dimensional model, and select which of four other diagrams could represent the model, if the model were rotated about a particular axis. In answering the question, the student was always able to refer to a diagram showing the orientation of the X and Y axes and to a note explaining that the Z axis was to be imagined as being perpendicular to the other two, and projecting into the plane of the paper.

A total of ten different configurations were used in the test, each configuration being one adopted by actual molecules.

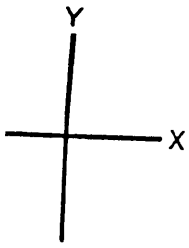
3.4.2 Rotations Programme

This programme was originally devised by Eniaiyeju (1981). It has been successfully administered in Nigeria by Eniaiyeju (1981) and in Pakistan by Tariq (1982).

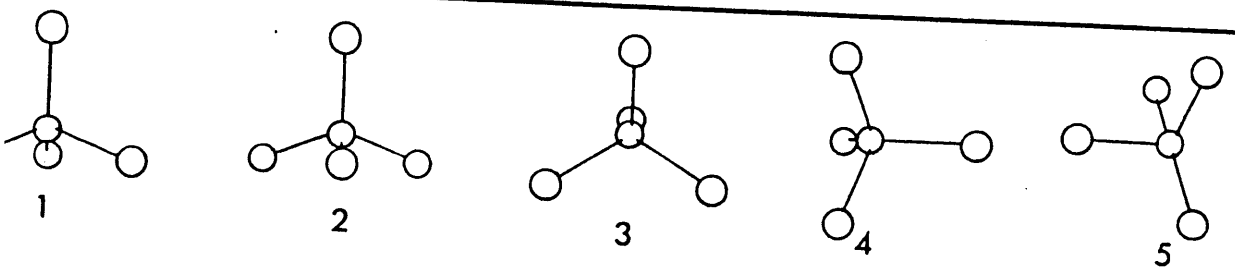
The programme consists of the following:

(i) 35 mm slides containing diagrams of rotated molecular models, 180 diagrams were transferred to 35 mm slides by the photography studio of the University of East Anglia.

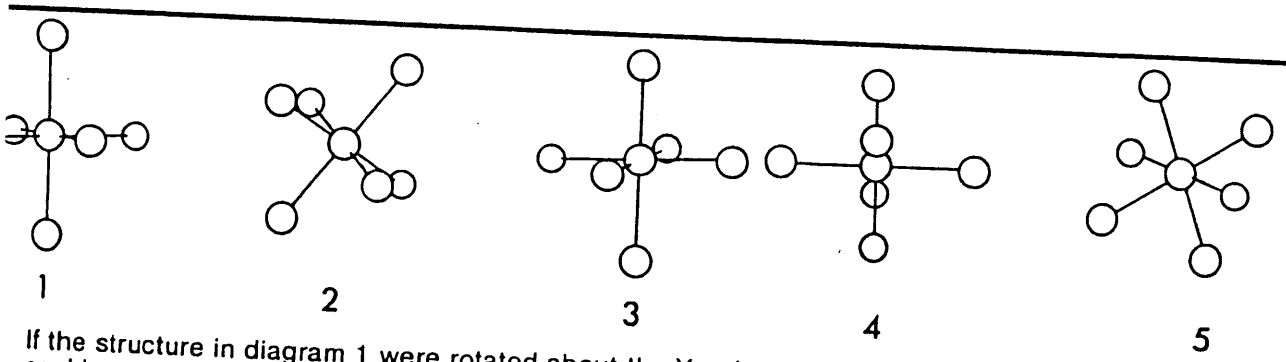
All the drawing of the diagrams was carried out using computer 'program HX 88' by Adamson and Cole (1969), to provide diagrams which are accurate in terms of perspective.



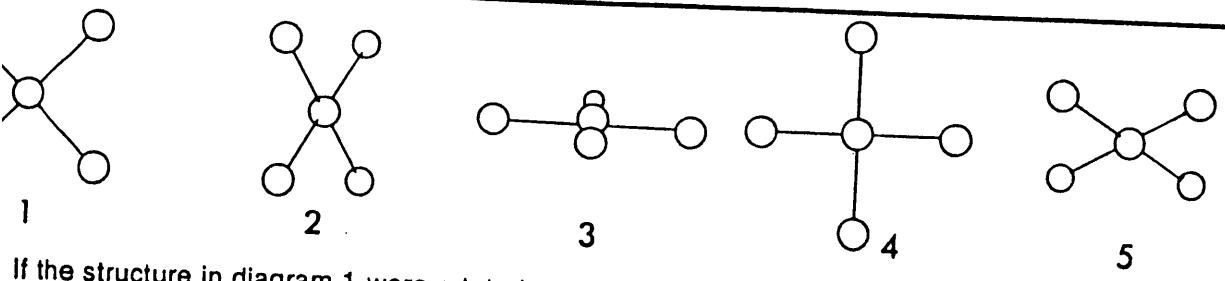
You need to refer to the axes in this diagram while answering the questions. The X- and Y- axes are drawn in the plane of the paper. You must imagine the Z-axis as being perpendicular to them coming out of the plane of the paper.



If the structure in diagram 1 were rotated about the X-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?



If the structure in diagram 1 were rotated about the Y-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?



If the structure in diagram 1 were rotated about the Z-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

FIGURE 3.1 Examples of the Questions Used in the Rotation Test for Each Axis.

Six molecular structures were drawn by the computer (Figure 3.2). Each molecular structure was drawn rotating from 0 through 90° in steps of 10° on all axes. A total of 216 slides were made. These include a series of numbered slides, each indicating structure number, a set which instruct the students how to attempt the question and another set giving the correct answer. All are reproduced in Arabic language version from the original.

(ii) Instructional booklets (Appendix 3) which provide guidance for the subjects during the remediation course. 18 instructional frames were incorporated, each consisting of a diagram of the structure which the student is asked to imagine rotating around a specific axis. This is followed by four diagrams as options for response. The correct answer is shown to the student after his attempt (see below).

3.4.3 The Molecular Rotation Programme Booklet (Instructional Booklet)

This booklet was originally developed by Tariq (1982). The content of the booklet was based on 6 diagrams of six different molecular structures (Figure 3.2), namely trigonal bipyramid, square planar, T-shape, square configuration, octohedral, and square pyramid.

The booklet was divided into three sections each consisting of 6 remedial items on either X, Y or Z axis. The items were arranged in random order. There are three

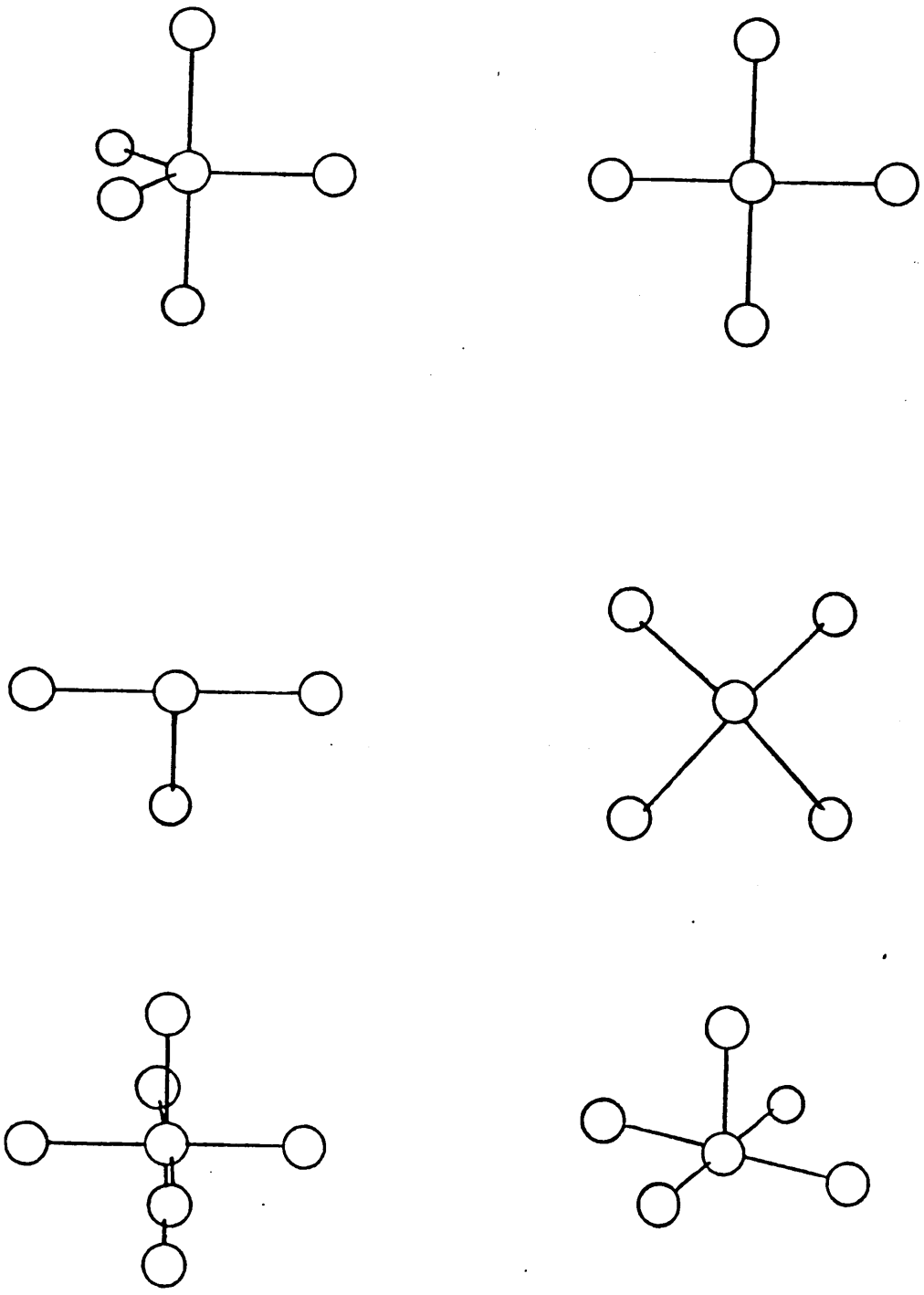
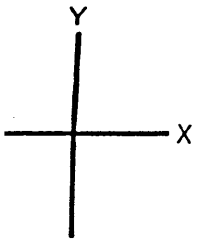
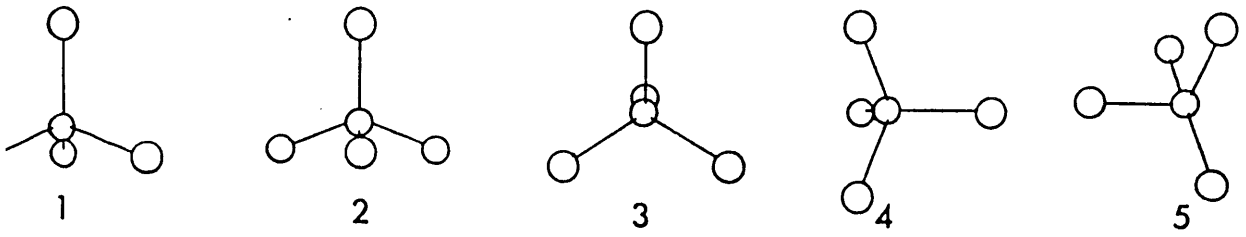


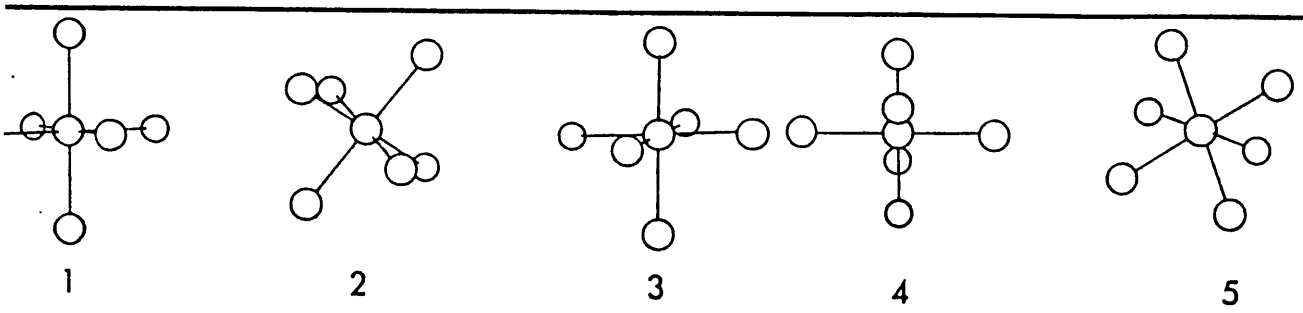
FIGURE 3.2 Diagrams Used in the Rotations Programme



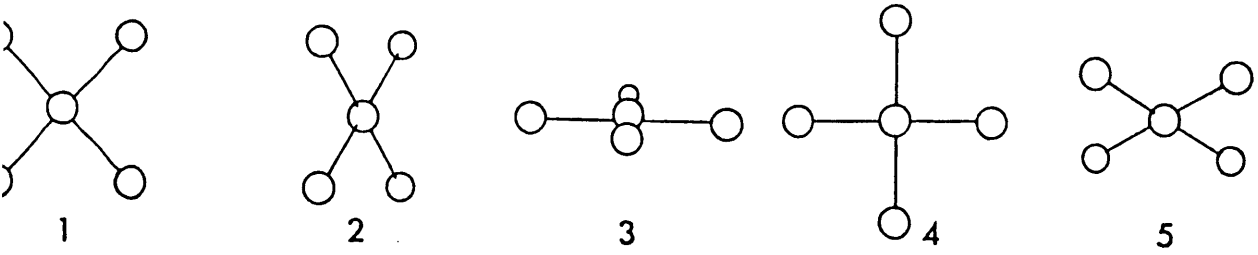
You need to refer to the axes in this diagram while answering the questions. The X- and Y- axes are drawn in the plane of the paper. You must imagine the Z-axis as being perpendicular to them coming out of the plane of the paper.



If the structure in diagram 1 were rotated about the X-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?



If the structure in diagram 1 were rotated about the Y-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?



If the structure in diagram 1 were rotated about the Z-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

FIGURE 3.3 Examples of Questions Used in the Rotation Programme Booklet

questions dealing with the rotation of each structure around the three mutually perpendicular axes (X, Y and Z), making a total of 18 remedial items in the booklet. Of the five diagrams, which make up each remedial item, the first represents the structure as seen from an initial viewpoint.

The question is then asked, and the student is required to select the correct structure from the four remaining diagrams. Only one shows the correct answer and the position of the correct answer was determined at random.

Each booklet contains an introduction explaining to the student the aim of the programme, and the instructions he has to follow. A note at the top of each page describes the axes of rotation.

The correct answer for each item was not provided in the booklet because this was to be projected on the screen at an appropriate point during remediation sessions.

All the correct answers of the rotation programme were fixed at 90° rotation.

Since the investigation was carried out in an Arabic speaking country, the programme booklet was translated into Arabic. Figure 3.3 shows a copy of the note, and a question from the Molecular Rotation programme booklet.

3.4.4 Experimental Designs

An experiment employing 2 x 3 factorial design (Winer, 1971) was used for data collection. The design involved two

remedial methods (Method A and Method B) crossed with three levels of age (13, 15 and 17 years).

The subjects were randomised into 6 factor-level combinations of the experimental design. There were eighty subjects in the experimental group (Method A) and twenty subjects in the control group (Method B) making a total of 100 subjects per remedial method.

3.4.5 Treatment

A complete set of slides showing successive 10° shift of rotation on 18 items were arranged sequentially in a Carousel Kodak S-AV2000 projector. Slide transport was by means of a remote control switch. A fifteen seconds interval was allowed in order to make a response to a question written in the booklet. The question was based on what has just been viewed. At the end of the 15 second interval, 70°, 80°, and 90° slides were shown in that sequence, to confirm the correct answer for the subjects. The correct answers were fixed at 90° rotation in all cases.

A time interval of 10 seconds was arbitrarily chosen for display of all slides. Twenty subjects per session were treated. The seating arrangement was carefully controlled so that the subjects were seated directly opposite the screen in as narrow an arc as possible. This is because the planar impression varies from place to place. The time to complete each session varied between 30 - 35 minutes.

The subjects were post-tested on the Rotation test as soon as the slide programme was over, subjects in the control groups also took the post-test. 60 minutes was allowed for the test, but the majority of them finished the test within 35-40 minutes.

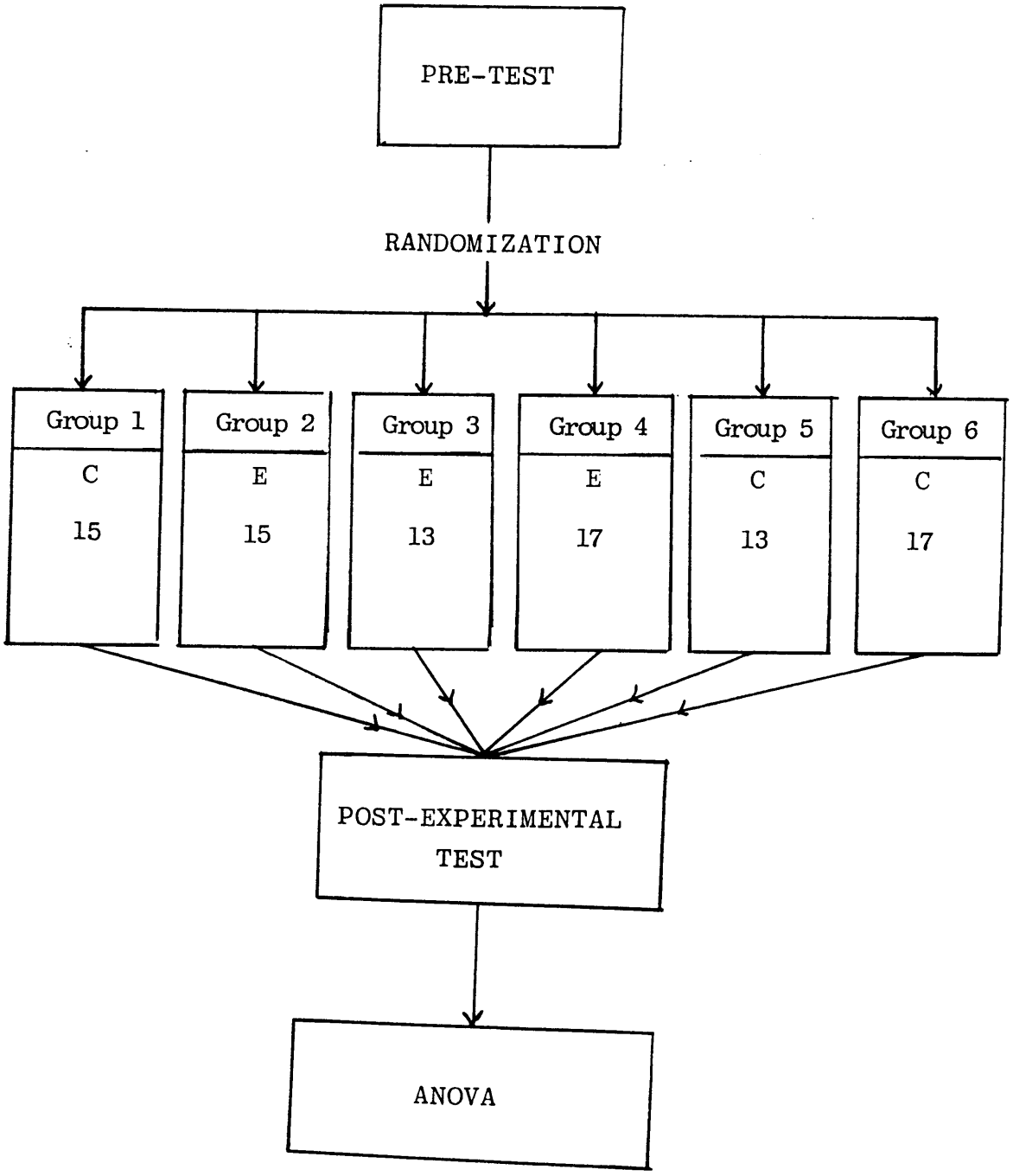
The remediation programme was conducted in the Science Laboratory or the Resource Room of each institution. The schematic representation of the experimental procedure is shown in Figure 3.4.

3.4.6 Statistical Analyses

A one-way analysis of variance with unequal cell frequencies (U.E.A. STAT package, 1982) was used to find out if there were significant differences due to age, on the performance of the pre-test.

A two-way analysis with unequal cell frequencies (Winer, 1971) was employed to find out if there were significant main effects attributable to treatment, Age or Interaction.

Dunnett's t-test and planned orthogonal comparison were performed where significant F ratios due to treatment or age were observed.



C = Control
E = Experimental

FIGURE 3.4 Schematic Representation of the Experimental Procedure in AAIS and NBSS

3.5 EXPERIMENTAL PROCEDURE (2)

The research instruments used to study the understanding of depth perceptions in diagrams of frameworks are described below.

3.5.1 Frameworks Test (Diagram Perception Test)

The diagram perception test (Appendix 4) was devised by Nicholson (1974). It has been successfully used in Nigeria by Nicholson, Seddon and Worsnop (1977), Ross (1977) and Alonge (1977). This test was also used in Kuwait by El-Farra (1982).

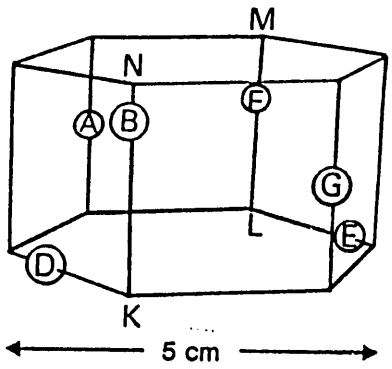
The 36-item test consists of questions which require the student to identify the diagonal, horizontal and vertical spatial relationships in diagrams of hexagonal and cuboid frameworks structures (see Figure 3.5).

Positions in each framework are defined by labelled balls, and multiple choice questions require the student to make a decision about the displacement of the balls relative to one another and to the framework. The position of the balls have been chosen such that a subject's response would indicate whether the diagram was being interpreted in two-dimensional or three-dimensional terms by him.

On the basis of this he or she can be classified as a two-dimensional or three dimensional perceiver.

The probability of obtaining a score of 24 out of 36 by guessing was calculated by Nicholson (1974) and estimated to be 0.05.

Hexagonal Framework



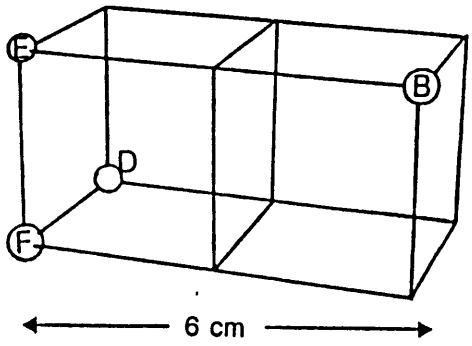
Horizontal displacement

1. Which ball, A or D, is nearer to the vertical plane KLMN?
2. Which ball, E or G, is nearer to the vertical plane KLMN?

Vertical displacement

1. Which ball, B or F, is higher on the framework?
2. Which ball, B or G, is at the same height as ball A?

Cuboid Framework



Diagonal displacement

1. Which ball, D or F, is further from ball B?
2. Which ball D or E is nearer to ball B?

FIGURE 3.5 Examples of Questions Used in the Frameworks Test

Hence those subjects who score 24 or more out of 36 on the test can be considered as three-dimensional perceivers with 95% confidence, whereas those who score less than 24 out of 36 can be regarded as two-dimensional perceivers with the same 95% confidence.

The reliability and validity of the test have been discussed by Nicholson (1974). He noted that the test requires linguistic and semantic skill as well as perceptual skills.

These skills are important for learning some concepts in chemistry by students. As a result, the test can be taken as valid for the purpose of the present study.

3.5.2 Frameworks Programme

The Frameworks programme was an adaptation of Ross (1977) Remedial Instructional programme.

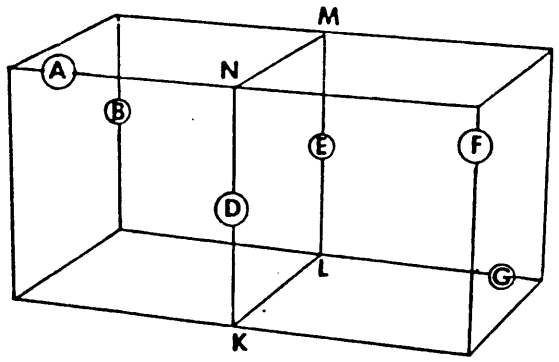
It consists of a series of practice questions displayed from an overhead projector.

Each question requires the student to identify diagonal, horizontal and vertical spatial relationships in diagrams of cuboid and hexagonal framework structures. The spatial relationships are based on the positions of labelled balls in each framework relative to one another and to the framework (see Figure 3.6).

A recorded sound track in Arabic was played to the students, which explained what each student was supposed to do.

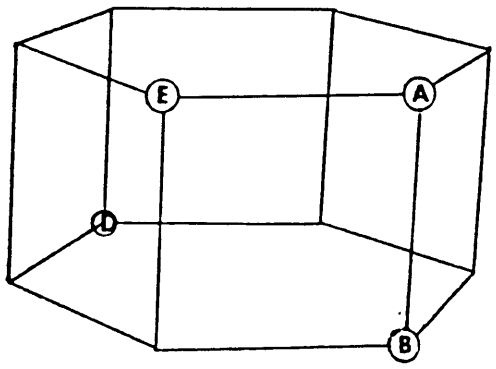
After attempting each question, the correct answer was shown to the student.

13



13.1 Which ball, A or B is nearer to the vertical plane KLMN?
13.1 Which ball, A or F is nearer to the vertical plane KLMN?

14



14.1 Which ball, A or B is nearer to ball E?
14.2 Which ball, B or D is further from ball E?

FIGURE 3.6 Examples of Questions Used in the Frameworks Programme

3.5.3 Experimental Design

A controlled experiment employing 2 x 3 factorial design (Winer, 1971) was followed for data collection. The design involved two remedial methods (Experimental and Control) crossed with three levels of ages (13, 15 and 17 years).

The subjects were randomized into 6 factor-level combinations of the experimental model. There were eighty subjects in the experimental group and twenty subjects in the control group, making a total of 100 subjects per remedial age group.

3.5.4 Treatment

Subjects went through the remediation programmes according to their assigned groups (Experimental and Control).

The remedial diagrams were projected on to the screen by the means of an overhead transparency. A time interval of 10 seconds was arbitrarily chosen for the display of each transparency, while 15 seconds interval was allowed in order to make a response to each question which was based on what had just been viewed. The correct answer was shown at the end of the time allowed to attempt the questions for each transparency; this was done to confirm the answer to the subjects.

All the remedial treatments were administered concurrently for 20 subjects per session, remediation was conducted in the science laboratory or the Resource room of each institution. Subjects were post-tested immediately after remediation.

The show time was varied between 15-20 minutes, although there was no time limit for the test. The majority of subjects (Experimental or Control) completed the test within 40-50 minutes. The schematic representation of the experimental procedure is shown in Figure 3.7.

3.5.5 Statistical Analyses

A one-way analysis of variance (U.E.A. package, 1982) was used to find out if there was significant difference in the pre-test performance attributable to the students' ages.

A two-way analysis of variance with unequal cell frequencies (Winer, 1971) was employed to find out if there were significant main effects attributable to treatment, age or interaction.

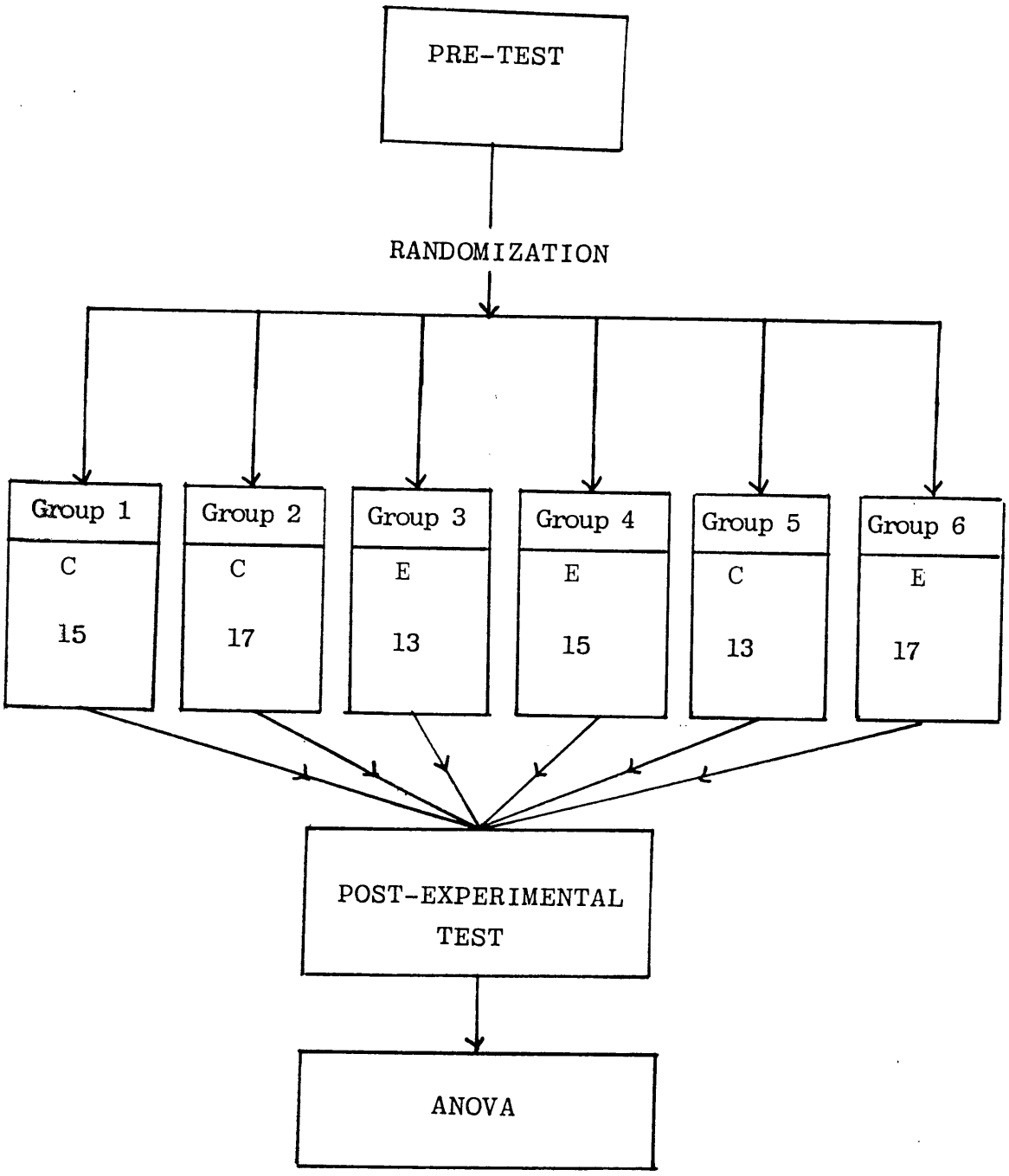
Dunnett's t-test and planned orthogonal comparison were performed where significant F ratios due to treatment or age were observed.

3.6 EXPERIMENTAL PROCEDURE (3)

The research instruments used to study the understanding of Depth in Diagrams of Molecular Models are described below.

3.6.1 The Cues-Test

The Cues-test (Appendix 5) was devised by Evans (1974) and has been successfully administered on Nigerian students by Evans and Seddon (1978), Oyediji (1978), Adeola (1978) and Eniaiyeju (1981).



C = Control
E = Experimental

FIGURE 3.7 Schematic Representation of the Experimental Procedure in ITSS

This test was also used in Kuwait by El-Farra (1982).

This diagnostic test is for depth cues, i.e. overlap, relative size, foreshortening of lines and distortion of angle. As Figure 3.8 illustrates, depth relationships are conveyed by the manipulation of four cues, which respectively determine the foreshortening of lines, the relative sizes of different parts of the structure, the representation of angle and the extent to which different parts of the diagram overlap. Therefore this test consists of four sub-tests, one for each of the four pictorial cues.

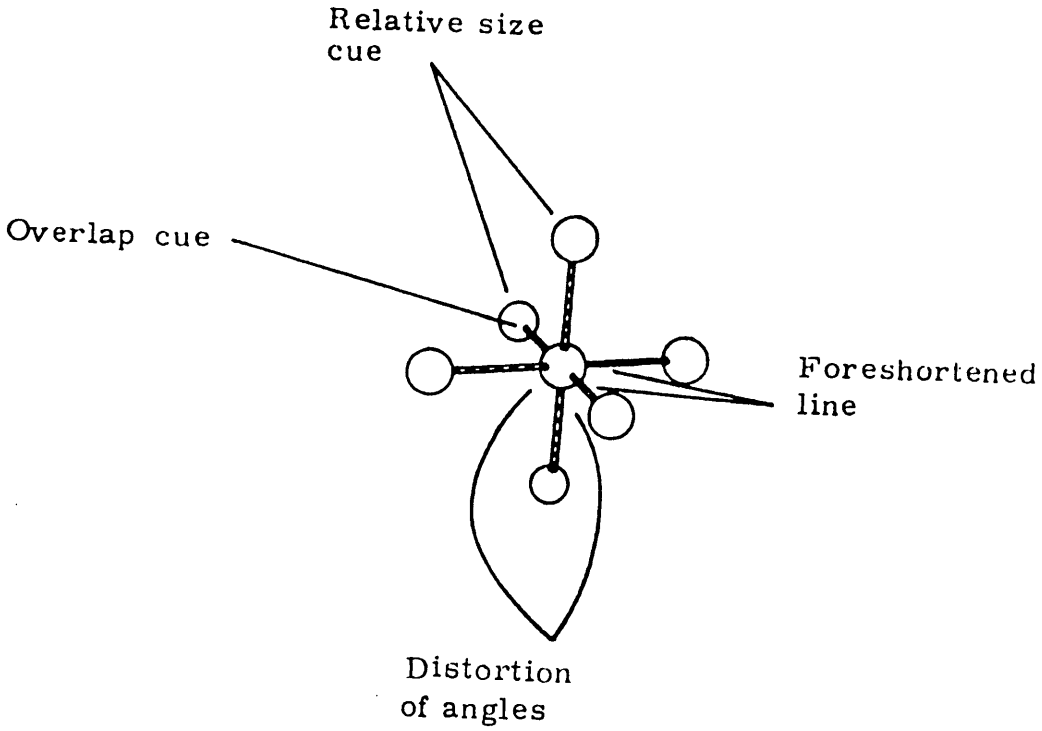
Each sub-test contains nine items testing a particular cue, making 36 items in all. The student is allowed to inspect a three-dimensional model from a fixed vantage point. Nine molecular models were used as stimulus materials. Figure 3.9 shows the diagrams of the models used in the Cues Test and Figure 2.1 shows an example of the diagrams used in the depth Cue Test (Evans and Seddon (1978)).

The models were made from 6.9 mm white plastic spheres. These spheres were connected by stainless steel rods 15 mm in length. All of the models were numbered on their aluminium base for reference.

Each item consists of instruction to the student, a verbal stem and four diagrams of a particular model.

Evans (1974) produced the drawing of the models by using an I.C.L. computer as described in Appendix 1.

A copy of the test was translated into Arabic from the original form, and from this ten copies were produced.



(In the actual model being represented all the spheres are the same size, all the rods are the same length, and all the angles between adjacent rods are 90°).

FIGURE 3.8 Example of Four Different Pictorial Depth Cues

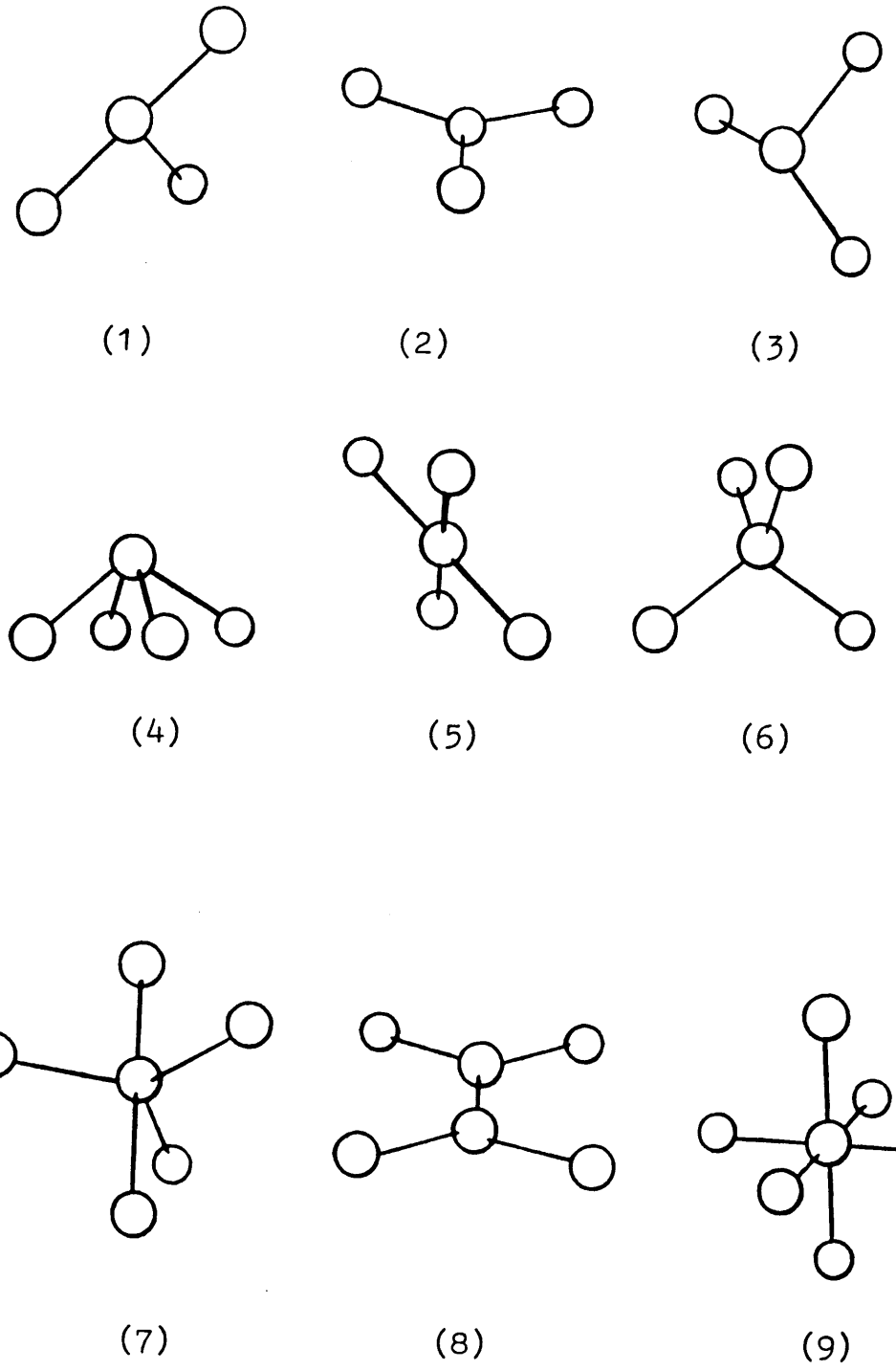


FIGURE 3.9 Diagrams of the Models used in the Cues Test

Note
The numerical labels correspond to the order in which the models were presented during testing.

The reliability and the validity of the test was discussed by Evans (1974). He found that the sub-tests on overlap and relative size cues were more reliable than those on foreshortened and angle cues.

The criterion of the cues sub-test was fixed at 6, the probability of scoring 6 out of 9 items by guessing was estimated to be 0.01 (Evans (1974) and Eniaiyeju (1981)).

3.6.2 Cues-Programme

This programme was originally devised by Oyediji (1978) and Eniaiyeju (1981). The programme was also used in Kuwait by El-Farra (1982).

The material and procedures were based on the following:

(i) Nine different molecular models, assembled from a combination of coloured (red, white, green, pink, blue, yellow and brown) plastic spheres 6.9 mm in diameter. The reason for the use of colours is to make it easy for students to match coloured models with coloured diagrams which are used in the instructional booklet (see Figure 3.10).

Every model was fixed to a cylindrical aluminium base bearing appropriate number of the models (1-9). A groove was made on the aluminium base so that the base slotted into the head of the viewing stand in only one way; this was done in order to fix the view from which the remedial subject saw the model.

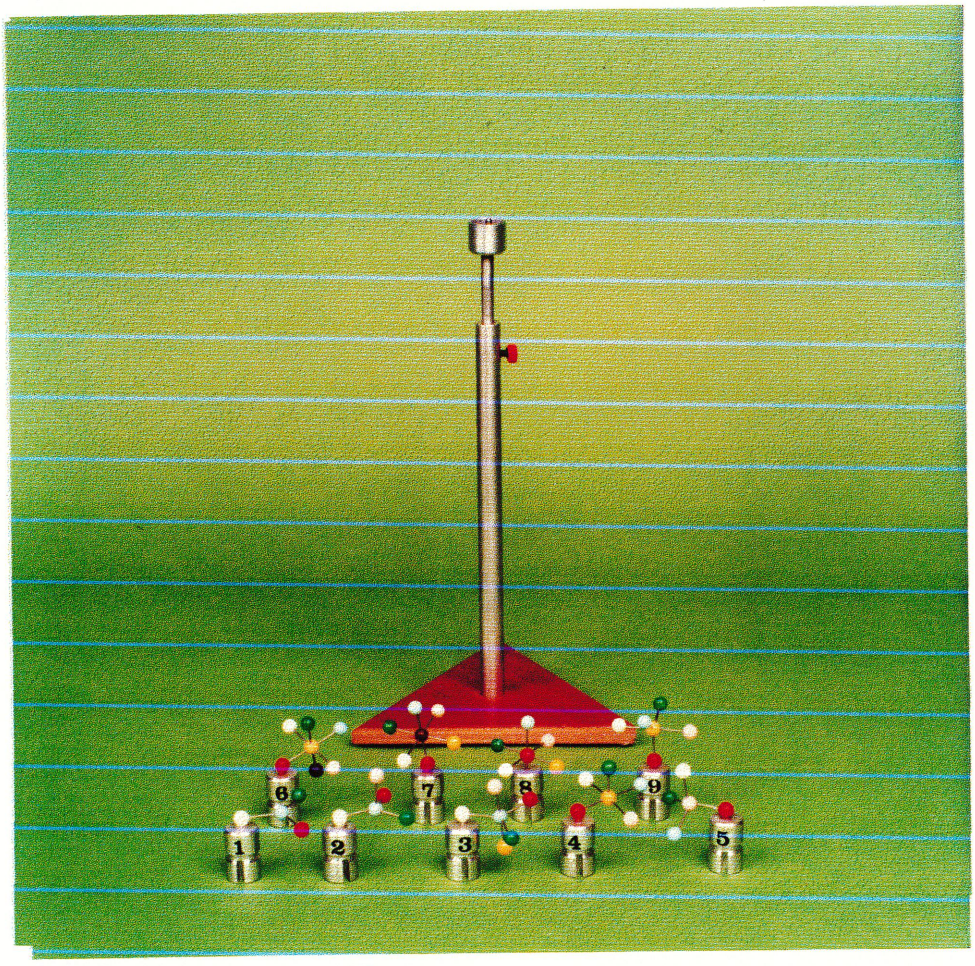


FIGURE 3.10 The Models and Viewing Stand Used in the Cue-Test

(ii) A self instructional booklet which consisted of four remedial programmes for each cue. Each booklet consists of four sections providing directions and illustrations on:

a) how to handle and view the models,

b) rules for the understanding of the cues, with appropriate examples,

c) the correct answer with explanations for each question,

d) a shadowgram to cast the shadow of a model on to a screen lying directly behind the model.

The shadow was provided to help in highlighting spatial relationships.

A copy of the cues-programme was translated into Arabic from the original and ten copies were produced.

3.6.3 Administration of the Cues-Programmes

Each of the four cues-programmes was administered separately. Each student was provided with the following:

1) Self-instructional programme.
2) A viewing stand fixed firmly 70 cm from the edge of the table.
3) A complete set of the remedial models (9 models).
4) Shadow projector (for the angle and foreshortened cues-programme only).
5) Two pointers.

A pre-recorded tape by the Author was used to explain to the subjects the procedure which was to be followed in answering the instructional questions, and also to instruct the subjects on how to use the shadow projection. This was done to avoid the personal involvement of the experimenter, which might have introduced some variables that could not be accounted for.

3.6.4 Experimental Design

Not only were the groups of students selected at random to occupy the six remedial groups in sequence, but the sequence of the remedial programmes was also randomly determined. Figure 3.11 shows the schematic diagram for the experimental procedure.

An experiment employing a 2 x 3 factorial design was followed for data collection (Winer, 1971). This design involved three levels of ages (13, 15 and 17 years), crossed with two remediation methods (experimental and control). Subjects for each remedial programme were randomized to 6 factor level combinations of the experimental model.

There were 15 subjects in the experimental group and 10 subjects in the control group, making a total of 25 subjects per remedial age group for each remedial cue-programme.

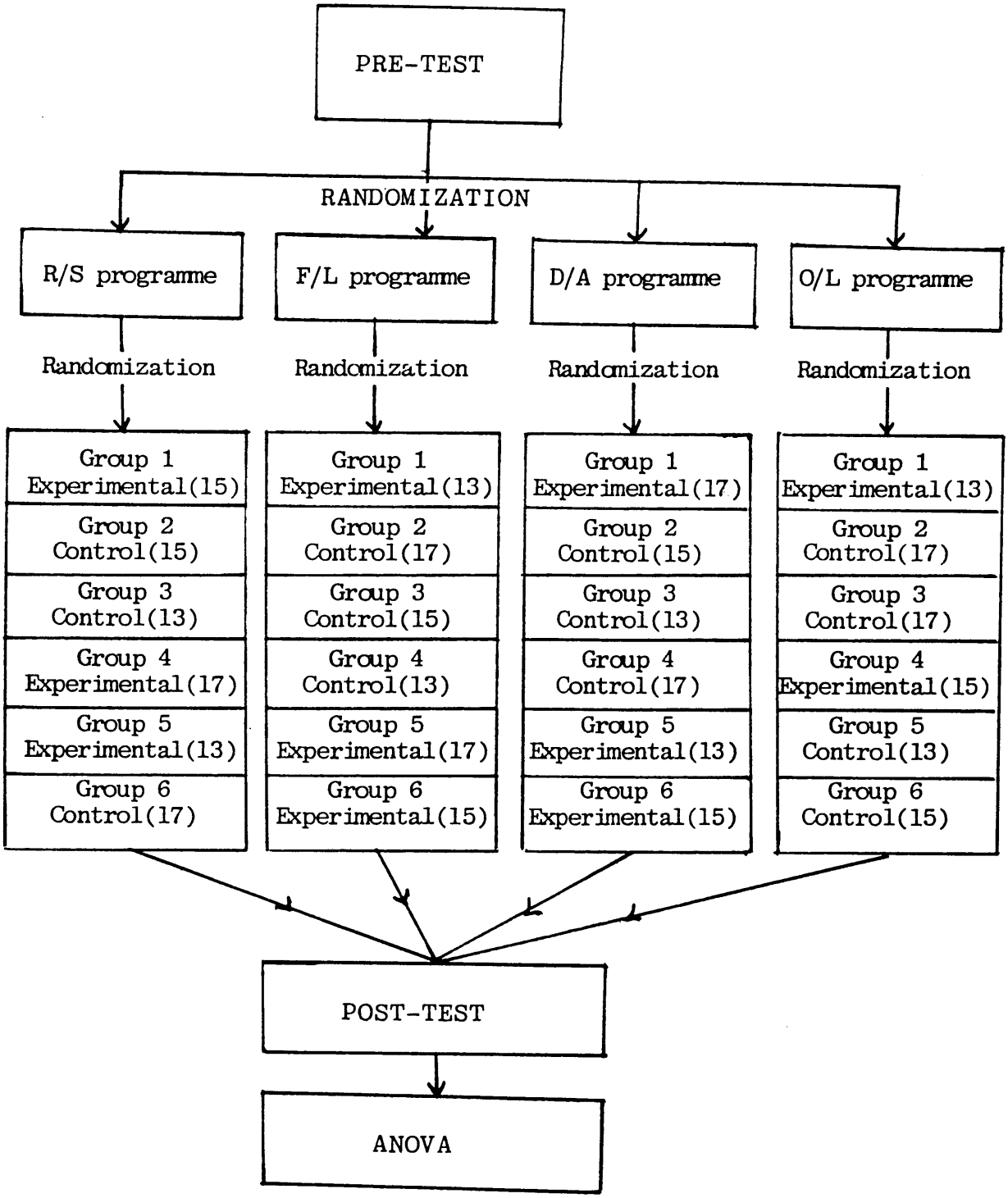


FIGURE 3.11 Schematic Representation of the Experimental Procedure in AIBS and ERBS

3.6.5 Treatment

Subjects went through the remediation programmes according to their assigned groups (experimental and control). All remedial treatments were administered concurrently for 10 subjects per session in the science laboratory of each institution.

Subjects were post-tested immediately after remediation. The majority of subjects completed the remediation and post-test within an 80 minutes double period.

3.6.6 Statistical Analyses

A one-way Analysis of variance (U.E.A. STAT package, 1982) was used to find out if there was any significant difference in the pre-test performance attributable to the subject age.

A two-way analysis of variance with unequal cell frequencies (Winer, 1971) was employed to determine significant main effects attributable to treatment, age or interaction.

Dunnett's t-test and planned orthogonal comparison were performed where significant F ratios due to treatment or age were observed.

CHAPTER 4

RESULTS

4.1 AN OVERVIEW

The results of the experimental data are analysed and summarised in tables. They can be classified into four types. The first type show the means and the standard deviations of the pre-tests' scores.

The second type is a detailed analysis of the pre-tests' scores, the third type gives the mean and the standard deviations of the post-tests' scores, and the fourth type is the detailed analysis of the post-tests' scores.

For the pre-tests significant F ratios are recorded and for the post-tests significant main effects due to treatments and age are also recorded.

4.2 EXPERIMENT (1)

ROTATIONS PROGRAMME

4.2.1 The Pre-Test Performance

The means, standard deviations, and the percentage of students attaining the criterion of the test for all samples are shown in Table 4.1.

The level of achievement of the test criterion was 14. A student is regarded as having failed the test if he or she scores less than 14.

The student is regarded as having passed the test if he or she scores 14 or more.

By employing a one-way analysis of variance attempts were made to identify the difference in the performance between different age groups, the results of each analysis for the groups of students examined are summarised in Table 4.2.

Planned orthogonal comparisons were carried out, as reported in Table 4.3, to identify the difference in performance between the different age groups.

4.2.2 The Post-Test Performance

Table 4.4 shows the means and standard deviations of the post-test scores. Table 4.5 summarises the analysis of variance carried out for all groups of subjects. The F ratios indicated that further analysis of the data was warranted to find out which of the differences between mean were significant.

The Dunnett's t test and planned orthogonal comparisons (Winer, 1971; Snodgrass, 1977) were carried out. The contrasts are shown in Tables 4.6 and 4.7.

4.3 EXPERIMENT (2)

FRAMEWORKS PROGRAMME

4.3.1 The Pre-Test Performance

The means, standard deviations, and the percentage of students attaining the criterion of the test for all samples are shown

in Table 4.8. The test criterion was 24. A student is regarded as having failed the test if he or she scores less than 24.

The student is regarded as having passed the test if he or she scores 24 or more.

By employing a one-way analysis of variance attempts were made to identify the difference in the performance between different age groups, the results of each analysis for the groups of students examined are summarised in Table 4.9. Planned orthogonal comparisons were carried out, as reported in Table 4.10, to identify the difference in performance between the different age groups.

4.3.2 The Post-Test Performance

Table 4.11 shows the means and standard deviations of the post-test scores. The results of the 3 x 2 analyses of variance are summarised in Table 4.12.

Because significant F ratios attributable to method of remediation and the age groups are observed in Table 4.12, further comparative tests were undertaken. The Dunnett's t test (Winer, 1971) was to contrast the mean scores of the experimental groups with the mean scores of the control for each age group (Table 4.14). The difference in the performance between each age group was assessed by the procedure of planned orthogonal comparison described by Snodgrass (1977). The result of these contrasts are shown in Table 4.13.

4.4 EXPERIMENT (3)

CUES-PROGRAMME

4.4.1 The Pre-Test Performance

The cues-test was divided into 4 sub-tests (Foreshortened, Overlap, Relative size and Angle test).

For each sub-test the criterion was 6. A student is regarded as having passed the test if he or she scores 6 or more. The student is regarded as having failed the test if he or she scores less than 6.

The means, standard deviations and the percentage of students attaining the criterion for each sub-test for all samples are shown in Table 4.15.

A one-way ANOVA was carried on each of the four sets of data, results are summarised in Tables 4.16, 4.18, 4.20 and 4.22. Planned orthogonal comparisons were carried out, as reported in Tables 4.17, 4.19, 4.21 and 4.23, to identify the difference in performance between the different age groups.

4.4.2 The Post-Test Performance

The means, standard deviations are shown in Table 4.28. The results of 3 x 2 ANOVA on each of the 4 groups are shown in Tables 4.29, 4.31, 4.33 and 4.35

The F ratios indicated that further analysis of the data was warranted to find out which of the differences between mean were significant. The Dunnett's t test and planned orthogonal comparisons (Winer, 1971; Snodgrass 1977) were carried out. The contrasts are shown in Tables 4.30, 4.32, 4.34, 4.36, 4.37 and 4.38.

All the significant effects that were found are summarised in Table 4.39 for pre-tests and Table 4.40 for post-tests.

TABLE 4.1

Means, Standard Deviations, and the % of Students Achieving the Criterion for the Molecular Rotation Pre-Test.

SAMPLE	SEX	AGE YEARS	No. of STUDENTS (N)	STATISTICS		
				Mean ($\bar{X}$)	S.D.	% Achieving Criterion
Abdul Rahman Aldakel Intermediate School (AAIS)	Boys	13	112	8.48	3.39	7.14
Abdul Rahman Aldakel Intermediate School (AAIS)	Boys	15	103	10.92	5.76	26.47
Naim Boys Secondary School (NBSS)	Boys	17	112	10.09	5.78	22.32

TABLE 4.2

Results of a One-Way ANOVA of Subjects' Scores in the Rotation Pre-Test in AAIS and NBSS.
(N = 326)

Source of Variation	SS	df	MS	F	p
Between Ages	332.19	2	166.09	6.44	<0.01
Experimental Error	8336.44	323	25.81		
Total	8668.63	325			

TABLE 4.3

Summary of Orthogonal Comparisons of the Rotation Pre-Test Means Scores Based on Subjects Ages.

Contrast	df	F	p
13 vs $(15 + 17)_{/2}$	323	11.48	<0.01
15 vs 17	323	1.39	>0.05

TABLE 4.4

Means and Standard Deviations of Post-Test Scores of AAIS and NBSS Remediated Groups on the Molecular Rotation Test.

Group Age (Years)	Statistics	Experimental	Control
13	$\bar{X}$	9.98	7.70
	S.D.	4.81	2.99
	N	80	20
15	$\bar{X}$	14.23	11.80
	S.D.	6.04	7.68
	N	80	20
17	$\bar{X}$	17.00	9.70
	S.D.	5.68	4.52
	N	80	20

Perfect Score = 30

TABLE 4.5

A 3 x 2 Analysis of Variance for Mean Scores of Subjects Remediated at AAIS and NBSS.

Source of Variation	SS	df	MS	F	p
A (Age)	799.68	2	399.84	15.17	<0.01
B (Methods)	769.28	1	769.28	29.19	<0.01
AB	269.44	2	134.72	5.11	<0.01
Within Cell	7747.50	294	26.35		

TABLE 4.6

Summary of Dunnett's t Test for the Comparison of Mean Scores of Subjects Remediated at AAIS and NBSS.

Contrast	df	t	p
13 vs Control (13)	98	1.88	<0.05
15 vs Control (15)	98	2.00	<0.05
17 vs Control (17)	98	6.03	<0.01

TABLE 4.7

Summary of Orthogonal Comparisons of the Mean Scores Based on Ages (AAIS and NBSS).

Contrast	df	t	p
13 vs $(15 + 17)_{/2}$	237	153.57	<0.01
15 vs 17	237	27.90	<0.01

TABLE 4.8

Means, Standard Deviations, and the % of Students Achieving the Criterion for the Frameworks Pre-Test.

SAMPLE	SEX	AGE YEARS	No. of STUDENTS (N)	STATISTICS		
				Mean ($\bar{X}$)	S.D	% Achieving Criterion
Isa Town Secondary School (ITSS)	Boys	13	106	21.42	7.42	45.28
Isa Town Secondary School (ITSS)	Boys	15	113	27.69	7.34	71.68
Isa Town Secondary School (ITSS)	Boys	17	105	29.12	8.37	84.76

Perfect Score = 36

Criterion = 24

TABLE 4.9

Results of a One-Way ANOVA of Subjects' Scores in the Frameworks Pre-Test in ITSS (N = 324).

Source of Variation	SS	df	MS	F	p
Between Ages	3572.35	2	1786.17	30.00	<0.01
Experimental Error	19109.29	321	59.53		
Total	22681.64	323			

TABLE 4.10

Summary of orthogonal Comparisons of the Frameworks Pre-Test Mean Scores Based on Subjects' Ages.

Contrast	df	F	p
13 vs $(15 + 17)_{/2}$	321	58.05	<0.01
15 vs 17	321	1.85	>0.05

TABLE 4.11

Means and Standard Deviations of Post-Test Scores of ITSS Remediated Groups on the Frameworks Test.

Group Age (Years)	Statistics	Experimental	Control
13	$\bar{X}$	27.65	22.95
	S.D.	6.28	7.92
	N	80	20
15	$\bar{X}$	32.01	28.40
	S.D.	5.18	10.01
	N	80	20
17	$\bar{X}$	34.35	31.40
	S.D.	2.64	5.80
	N	80	20

Perfect Score = 36

TABLE 4.12

A 3 x 2 Analysis of Variance for Mean Scores of Subjects Remediated at ITSS.

Source of Variation	SS	df	MS	F	p
A (Ages)	1889.60	2	944.80	29.12	<0.01
B (Methods)	676.48	1	676.48	20.85	<0.01
AB	24.64	2	12.32	0.37	>0.05
Within Cell	9538.78	294	32.44		

TABLE 4.13

Summary of Orthogonal Comparisons of the Mean Scores Based on Ages (ITSS).

Contrast	df	F	p
13 vs $(15 + 17)_{/2}$	237	60.61	<0.01
15 vs 17	127	8.11	<0.01

TABLE 4.14

Summary of Dunnett's t Test for the Comparison of Mean Scores of Subjects Remediated at ITSS.

Contrast	df	t	p
13 vs Control (13)	98	3.64	<0.01
15 vs Control (15)	98	2.79	<0.01
17 vs Control (17)	98	2.29	<0.05

TABLE 4.15

Means, Standard Deviations, and the Percentage of Students Achieving the Criterion for the Cues-Pre-Subtest

CUES-PRE-SUBTEST	FORESHORTENED CUE				OVERLAP CUE				RELATIVE SIZE CUE				ANGLE CUE			
STATISTICS	n	$\bar{X}$	S.D.	% > 6	n	$\bar{X}$	S.D.	% > 6	n	$\bar{X}$	S.D.	% > 6	n	$\bar{X}$	S.D.	% > 6
Awal Intermediate Boys School(AIBS) (13 years)	100 15	3.34 3.00	1.79 1.96	10.00 6.66	100 15	3.21 3.33	1.95 2.12	14.00 20.00	100 15	2.30 2.20	1.58 1.85	5.00 6.66	100 15	5.14 5.73	1.70 1.68	47.00 46.66
Awal Intermediate Boys School(AIBS) (15 years)	100 15	4.04 4.53	1.93 2.23	24.00 40.00	100 15	4.08 3.26	2.63 2.49	33.00 26.66	100 15	2.94 3.13	1.52 2.13	7.00 6.66	100 15	5.79 5.73	1.85 1.75	58.00 60.00
East Riffa Sec'ry Boys School(ERSS) (17 years)	100 15	4.21 3.86	2.16 2.32	30.00 20.00	100 15	4.54 4.93	2.58 3.03	36.00 46.66	100 15	2.88 2.20	1.87 1.26	8.00 0.00	100 15	6.08 6.13	1.76 1.68	70.00 80.00

Perfect Score = 9

Criterion = 6

TABLE 4.16

Results of a One-way ANOVA of Subjects' Scores in Foreshortened Cue pre-Subtest in AIBS and ERSS (N = 300).

Source of Variation	SS	df	MS	F	p
Between Ages	42.52	2	21.26	5.47	<0.01
Experimental error	1154.87	297	3.88		
Total	1197.39	299			

TABLE 4.17

Summary of Orthogonal Comparisons of the Foreshortened Cue Pre-Subtest Mean Scores Based on Subjects' Ages.

Contrast	df	F	p
13 vs $(15 + 17)_{/2}$	297	10.44	<0.01
15 vs 17	297	0.22	>0.05

TABLE 4.18

Results of a One-Way ANOVA of Subjects' Scores in Overlap Cue Pre-Subtest in AIBS and ERSS (N = 300).

Source of Variation	SS	df	MS	F	p
Between Ages	91.24	2	45.62	7.84	<0.01
Experimental Error	1728.79	297	5.82		
Total	1820.03	299			

TABLE 4.19

Summary of Orthogonal Comparisons of the Overlap Cue Pre-Subtest Mean Scores Based on Subjects Ages.

Contrast	df	F	p
13 vs $(15 + 17)_{/2}$	297	13.86	<0.01
15 vs 17	297	1.80	>0.05

TABLE 4.20

Results of a One-Way ANOVA of Subjects' Scores of Relative size Cue Pre-Subtest in AIBS and ERSS (N = 300).

Source of Variation	SS	df	MS	F	p
Between Ages	24.98	2	12.49	4.47	<0.01
Experimental Error	829.20	297	2.79		
Total	854.18	299			

TABLE 4.21

Summary of Orthogonal Comparisons of the Relative Size Cue Pre-Subtest Mean Scores on Subjects' Ages.

Contrast	df	F	p
13 vs $(15 + 17)_{/2}$	297	8.89	<0.01
15 vs 17	297	0.06	>0.05

TABLE 4.22

Results of a One-Way ANOVA of Subjects' Scores in Angle Cue Pre-Subtest in AIBS and ERSS (N = 300).

Source of Variation	SS	df	MS	F	p
Between Ages	46.34	2	23.17	7.34	<0.01
Experimental Error	937.99	297	3.15		
Total	984.33	299			

TABLE 4.23

Summary of Orthogonal Comparisons of the Angle Cue Pre-Subtest Mean Scores Based on Subjects' Ages.

Contrast	df	F	p
13 vs (15 + 17)/2	297	13.37	<0.01
15 vs 17	297	1.33	>0.05

TABLE 4.24

Results of a One-Way ANOVA of Subjects' Scores in Foreshortened Cue Pre-Subtest in AIBS and ERSS (N = 45).

Source of Variation	SS	df	MS	F	p
Between Ages	17.73	2	8.86	1.87	>0.05
Experimental Error	199.46	42	4.74		
Total	217.20	44			

TABLE 4.25

Results of a One-Way ANOVA of Subjects' Scores in Overlap Cue Pre-Subtest in AIBS and ERSS (N = 45).

Source of variation	SS	df	MS	F	p
Between Ages	26.71	2	13.35	2.01	>0.05
Experimental error	279.20	42	6.64		
Total	305.91	44			

TABLE 4.26

Results of a One-Way ANOVA of Subjects' Scores in Relative Size Cue Pre-Subtest in AIBS and ERSS (N = 45).

Source of variation	SS	df	MS	F	p
Between Ages	8.71	2	4.35	1.36	>0.05
Experimental error	134.53	42	3.20		
Total	143.24	44			

TABLE 4.27

Results of a One-Way ANOVA of Subjects' Scores of Angle Cue Pre-Subtest in AIBS and ERSS (N = 45).

Source of variation	SS	df	MS	F	p
Between Ages	2.80	2	1.40	0.48	>0.05
Experimental error	122.40	42	2.91		
Total	125.20	44			

TABLE 4.28

Means, Standard Deviations, and the percentage achieving the Criterion for the Cues post-Subtest at AIBS and ERSS.

REMEDIAL GROUPS		FORESHORTENED CUE		OVERLAP CUE		RELATIVE SIZE CUE		ANGLE CUE	
Remedial	Sub-Groups	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control
13 years	$\bar{X}$ S.D. % x > 6 N	3.93 2.01 26.66 15	3.30 1.67 10.00 10	7.53 1.99 73.33 15	4.00 2.14 30.00 10	5.93 2.01 60.00 15	2.10 1.70 0.00 10	6.20 1.60 66.66 15	5.00 1.26 50.00 10
15 years	$\bar{X}$ S.D. % x > 6 N	5.46 1.70 60.00 15	4.20 1.93 20.00 10	6.93 2.01 80.00 15	3.30 2.00 10.00 10	7.93 1.48 86.66 15	3.50 1.56 10.00 10	6.93 1.06 93.33 15	6.10 1.04 60.00 10
17 years	$\bar{X}$ S.D. % x > 6 N	5.06 2.17 40.00 15	4.20 1.83 30.00 10	7.66 1.53 93.33 15	4.20 2.08 20.00 10	8.46 0.61 100.00 15	2.40 1.56 0.00 10	7.86 1.14 93.33 15	5.70 1.41 50.00 10

Perfect Score = 9

Criterion = 6

TABLE 4.29

A 3 x 2 Analysis of variance of the Post-Test Scores of Subjects Remediated by the Foreshortened Cue Programme at AIBS and ERSS.

Source of variation	SS	df	MS	F	p
A (Age)	21.85	2	10.92	2.74	>0.05
B (Method)	16.29	1	16.29	4.09	<0.05
AB	2.06	2	1.03	0.25	>0.05
Within cell	274.89	69	3.98		

TABLE 4.30

Summary of Dunnett's t-Test for the Comparison of Mean Scores of Subjects Remediated by the Foreshortened Cue Programme at AIBS and ERSS.

Contrast	df	t	p
13 vs Control (13)	23	0.77	>0.05
15 vs Control (15)	23	1.54	>0.05
17 vs Control (17)	23	1.05	>0.05

TABLE 4.31

A 3 x 2 Analysis of Variance of the Post-Test Scores of Subjects Remediated by the Overlap Cues Programme at AIBS and ERSS.

Source of variation	SS	df	MS	F	p
A (Age)	9.56	2	4.78	1.15	>0.05
B (Method)	24.30	1	24.30	5.86	<0.01
AB	0	2	0	0	>0.05
Within Cell	285.69	69	4.14		

TABLE 4.32

Summary of Dunnett's t-Test for the Comparison of Mean Scores of Subjects Remediated by the Overlap Cues Programme at AIBS and ERSS.

Contrast	df	t	p
13 vs Control (13)	23	4.25	< 0.01
15 vs Control (15)	23	4.37	<.0.01
17 vs Control (17)	23	4.16	<0.01

TABLE 4.33

A 3 x 2 Analysis of Variance of the Post-Test Scores of Subjects Remediated by the Relative Size Cue Programme at AIBS and ERSS.

Source of variation	SS	df	MS	F	p
A (Age)	41.37	2	20.68	8.47	<0.01
B (Method)	440.52	1	440.52	180.5	<0.01
AB	18.61	2	9.30	3.81	<0.05
Within Cell	168.39	69	2.44		

TABLE 4.34

Summary of Dunnett's t-Test for the Comparison of Mean Scores of Subjects Remediated by the Relative Size Cue Programme at AIBS and ERSS.

Contrast	df	t	p
13 vs Control (13)	23	6.01	<0.01
15 vs Control (15)	23	6.95	<0.01
17 vs Control)17)	23	9.54	<0.01

TABLE 4.35

A 3 x 2 Analysis of Variance of the Post-Test Scores of Subjects Remediated by the Angle Cue Programme at AIBS and ERSS.

Source of variation	SS	df	MS	F	p
A (Age)	19.78	2	9.89	5.61	<0.01
B (Method)	37.88	1	37.88	21.52	<0.01
AB	5.94	2	2.97	1.68	>0.05
Within Cell	122.06	69	1.76		

TABLE 4.36

Summary of Dunnett's t-Test for the Comparison of Mean Scores of Subjects Remediated by the Angle Cue Programme at AIBS and ERSS.

Contrast	df	t	p
13 vs Control (13)	23	2.86	<0.01
15 vs Control (15)	23	1.98	<0.05
17 vs Control (17)	23	5.15	<0.01

TABLE 4.37

Summary of Orthogonal Comparisons of the Relative Size Cue-Post Subtest Mean Scores Based on Subjects Ages.

Contrast	df	F	p
13 vs $(15 + 17)_{/2}$	42	21.05	<0.01
15 vs 17	42	0.86	>0.05

TABLE 4.38

Summary of Orthogonal Comparisons of the Angle Cue-Post-Subtest Mean Scores Based on Subjects Ages.

Contrast	df	F	p
13 vs $(15 + 17)_{/2}$	42	8.18	<0.01
15 vs 17	42	3.70	>0.05

TABLE 4.39

Summary of Orthogonal Comparison of the Pre-test Mean Scores of Groups of Subjects Examined.

Pre-test	N	13 vs $(15 + 17)/2$		15 vs 17	
		F	p	F	p
Rotation	326	11.48	<0.01	1.39	>0.05
Framework	324	58.05	<0.01	1.85	>0.05
Foreshortened Cue	300	10.44	<0.01	0.22	>0.05
Overlap Cue	300	13.86	<0.01	1.80	>0.05
Relative Size Cue	300	8.89	<0.01	0.06	>0.05
Angle Cue	300	13.37	<0.01	1.33	>0.05
Foreshortened Cue	45	-	>0.05	-	>0.05
Overlap Cue	45	-	>0.05	-	>0.05
Relative Size Cue	45	-	>0.05	-	>0.05
Angle Cue	45	-	>0.05	-	>0.05

TABLE 4.40

Summary of Orthogonal Comparison of the Post-test Scores of Different Groups of Subjects Remediated.

Post-test	N	13 vs $(15 + 17)/2$		15 vs 17	
		F	p	F	p
Rotation	300	153.57	<0.01	27.90	<0.01
Framework	300	60.61	<0.01	8.11	<0.01
Foreshortened Cue	45	-	>0.05	-	>0.05
Overlap Cue	45	-	>0.05	-	>0.05
Relative Size Cue	45	21.05	<0.01	0.86	>0.05
Angle Cue	45	8.18	<0.01	3.70	>0.05

CHAPTER 5

DISCUSSION

5.1 AN OVERVIEW

The Results from this experiment are discussed and necessary interpretation made. A summary of findings is given.

Over all the analyses of variance performance on these results, a total of 24 main and interaction effects are tested. If the 0.05 level were used to assess statistical significance, it would be expected that at least one of these effects would achieve significance simply as a result of random fluctuations in the sampling. Hence as an attempt to avoid making such type 1 errors, the significance level was set at 0.01.

5.2 RELATIVE DIFFICULTY OF PRE-TESTS

The Tables 4.1, 4.8 and 4.15 show the percentage of students in 13-14, 15-16 and 17-18 age groups achieving the criterion in each of the pre-tests for the three age groups. The results indicate that the general level of performance for these students on all the pre-tests is very low. Most students in each age group fail on each test.

On carrying out a one-way analysis of variance on the pre-test data (Tables 4.2, 4.9, 4.16, 4.18, 4.20 and 4.22) the effect of age was found to be significant for all tests. This reveals that the difficulty differs from one group to another as indicated by the significant F ratios recorded for the age groups. However, as the results of the analysis

of variance reveal, there is a significant increase in performances with chronological age. This effect could arise as a result of maturation or as a result of vicarious learning which has occurred after the age of 13 years.

The follow-up planned orthogonal comparisons Tables 4.3, 4.10, 4.17, 4.19, 4.21 and 4.23 reveal that, in every case the mean scores for the 13 year olds were significantly less than those of the other two age groups combined, i.e. the combined mean scores of 15 and 17 year olds is significantly better than the mean scores of the 13 year olds. This contrast:

$$M13 \text{ vs } (M15 + M17)_{/2}$$

is important in that it highlights the effect of the age factor on differences in the performance; there was no significant difference between the means of the 15 year olds and the 17 year olds ($p > 0.05$). This indicates that the students' performance improves as they get older, but then levels off, so that there is no further improvement above the age of 15 unless remediation is given.

5.3 RESULTS OF THE POST-TESTS

The results of the analysis performed on the post-test data (Tables 4.5, 4.13, 4.29, 4.31, 4.33 and 4.35) revealed that for every test except the Foreshortening Cues Test the mean of the experimental groups were always higher than those of the controls. Significant age effects were observed for all tests except the Foreshortening and Overlap Cues. The only case of a significant method X age interaction concerned the Rotations Test.

The Dunnett's t Test (Tables 4.6, 4.14, 4.30, 4.32, 4.34 and 4.36) show all experimental groups are significantly better than the control groups, except for the Foreshortening programme where the method used failed to teach. The reason for this one failure is unclear. This result contrasts markedly with that of Seddon et al (1984a) who found that this programme taught successfully.

The Interaction concerning the Rotations test occurred because, as illustrated in Figure 5.1, the 17 year olds had learned significantly more than the other age groups.

Thus, using the rotation defined in Figure 5.1, the means of groups E (17) and C (15) combined was significantly greater than that of groups C (17) and E (15) combined.

In contrast the mean of groups E (15) and C (13) combined and of groups C (15) and E (13) combined were not significantly different ($p > 0.05$).

It is possible that better results for younger students would be obtained using the more concrete approach of Seddon et al (1984b), in which students observed real models rotating, and compared their changing profiles with shadows of the same models.

The fact that there are no method X age interactions with the other cues tests indicates that the different age groups effectively increase their scores by the same amount. Thus in one sense, the programmes can be said to be equally effective at each age group. However, the pre-existing differences between the different age groups remains.

The absence of a significant age effects for the foreshortening and overlap cues contrasts with the significant effects observed for the corresponding pre-tests. The lack of effects on first and second cues could reflect the high facility index for these tasks. The lack of significant effects in the cues-tests also reflects the small number of subjects tested compared to the other two tests. When the scores of the same group of subjects in the pre-test were analysed, no significant differences between any of the age groups were found (Tables 4.24 - 4.27).

The absence of a significant method X age interaction for the Frameworks programme shows that the mean gains are equal over all these age groups.

The results also show that students learn significantly from the Frameworks and Rotations programmes. However, the performances achieved here are not the best which can be achieved. For example, they would be expected to have been better if these programmes had been preceded by one or more of the cues programmes. From the results of the previous experiments by Seddon et al (1984b) it is likely that the mean scores would be increased further by as much as 3 - 4 points.

The difference in performance on the cues test compared to the other two tests, could reflect the more complex nature of the tasks involved in the Frameworks and Rotations tests.

Both these tests require the students to be able to differentiate between X, Y and Z axes or horizontal, vertical and diagonal displacements.

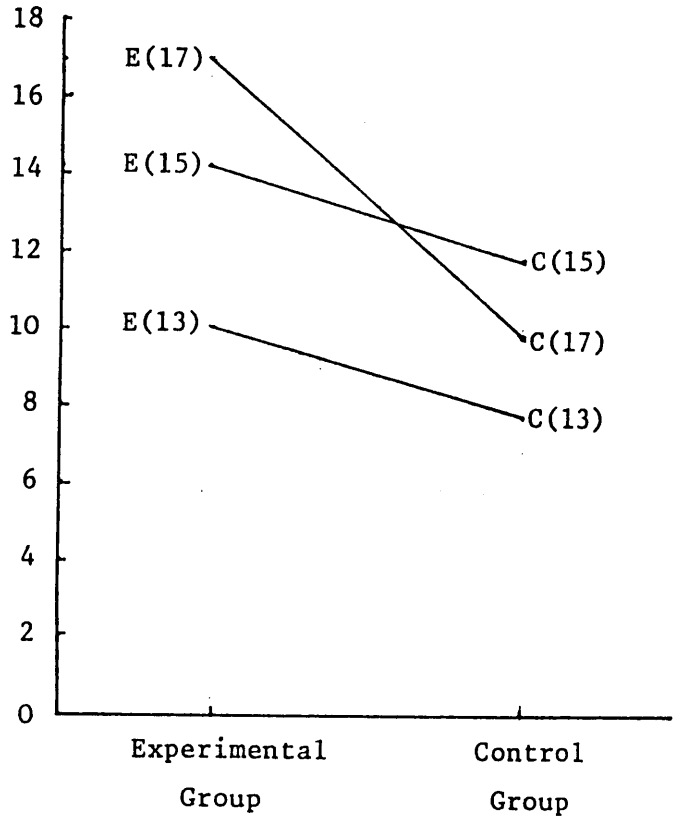


FIGURE 5.1 Schematic Representation of the Mean Score on the Rotations Post-Test

5.4 SUMMARY OF FINDINGS

The data gathered and the analyses carried out suggest that:

1. Without remediation performance improves with age up to about 15 years old.
2. Remediation is effective with all age groups.
3. Remediation is more effective for older students, so that performance improves with age up to at least 17 years old.
4. Performance in the different tests used appear to show similar relationship with age, although there may be a difference between the cues test and the other two tests. The difference found could, however, just reflect the different numbers of students tested in the cues test.

PART II

THE USE OF OVERHEAD TRANSPARENCIES IN TEACHING THE VISUALISATION OF ROTATION IN DIAGRAMS OF MOLECULAR STRUCTURES.

CHAPTER 6

INTRODUCTION

6.1 AN OVERVIEW

The overhead-projection transparencies are considered as a method of teaching the visualisation of rotation in molecular diagrams.

The major aims of the research and the postulated research questions which relate to the experimental testing of overhead-projection transparencies as a remedial approach are given.

6.2 BACKGROUND TO THE STUDY

In several areas in chemistry, students at higher secondary and lower tertiary levels are required to visualise the effects of performing rotation on diagrams of three-dimensional molecular structures. Seddon, Tariq and Santos Veiga (1983) reported the results of an investigation which demonstrated that an alarmingly high proportion of science students in English sixth forms and a Portuguese University had difficulty in performing this essential task. There is a large amount of experimental evidence showing that students from a range of different age groups and cultures find it very difficult to perform with similar tasks (e.g. Shepard and Metzler, 1971; Piaget and Inhelder, 1971; Tapley and Bryden, 1977).

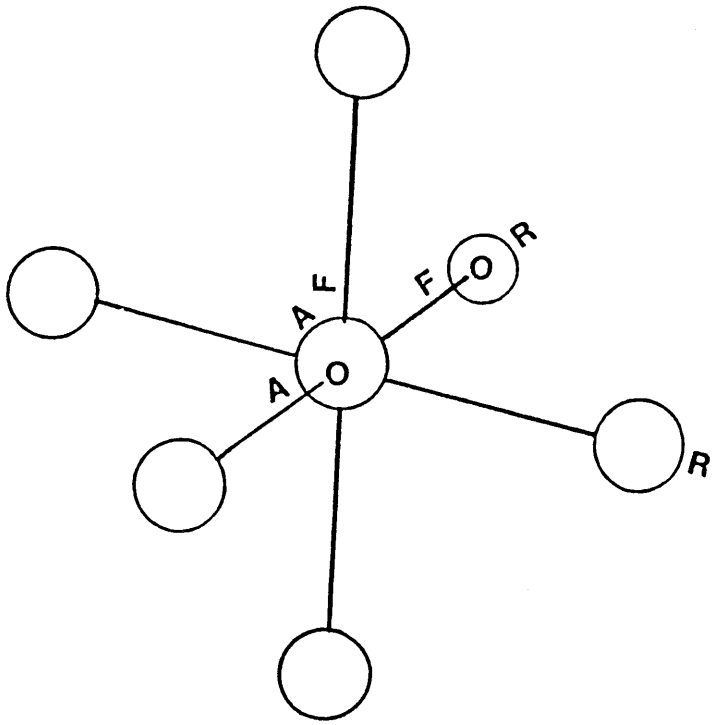
In designing a remedial instruction for students who show difficulty in visualising the effects of rotation in diagrams of molecular structures, it is useful to analyse the overall task involved. This is composed of two simple tasks:

1. Understanding the overall depth relationships portrayed by any diagram. (This is shown in Figure 6.1).
2. The change in depth relationships as a result of the rotation.

Since there are a number of areas of chemistry which call for three-dimensional perceptual skills, Seddon et al (1984b) have developed two different methods of remedial instruction which have been shown to bring about a significant improvement on students' ability to perform this task.

In one method, the students observe the changes which occur in the shadows of molecular models as the models themselves are rotated. The other attempts to simulate the effect of motion using sequences of projected diagrams, each of which shows the same molecular structures at a successive stage in a rotation. The overall visual effect is similar to watching individual successive frames in a cartoon film showing the structure rotating in discrete stages.

The present study follows up the previous work on the projected diagrams, and concentrates on the students' difficulties in visualising the effect of rotation in molecular diagrams, where Shubber (1982) has found Bahrainian students find it very difficult to perform this task.



Note

A = Distortion of Angles

O = Overlap Cue

F = Foreshortened line

R = Relative size cue

In the actual model represented by this two-dimensional computer drawing, all the spheres are the same size, all the connecting rods are the same length, and all the angles between adjacent rods are 90°.

FIGURE 6.1 Examples of Four Depth Cues

It also focused on the use of overhead-projection transparencies with all the diagrams in a sequence drawn on one transparency instead of using expensive 35 mm slide made by Seddon et al (1984b). A complete instructional programme will then comprise a whole set of such transparencies, each dealing with a different molecular structure or different axis of rotation.

On the whole it is intended to investigate two aspects, the first concerned with the method of presenting those transparencies and the second is the method of preparing them.

Seddon et al (1984b) have found that the Lap-dissolve technique is significantly more effective at remediating students than the conventional slide projection technique. This is because the first method uses equipment which caused one diagram to fade from view, while the next gradually grew in intensity. The second method uses the usual way of changing slides, where one diagram disappears abruptly and completely, before the next comes abruptly into view.

It is possible that the students in the first method gain more by being able to make direct comparisons between successive diagrams where one diagram dissolves into the next.

By employing the overhead-projection transparencies it is therefore thought that the student can compare the later diagrams in the sequence directly with earlier ones. This can be achieved by exposing each diagram in turn while leaving all the previous ones still in view, or by exposing the whole sequence of diagrams simultaneously.

There have been many investigations which have set out to compare the effectiveness of the multiple-image approach, as described here, with the approach in which only one diagram is presented at a time.

Whitley and Moore (1979) concluded that the relative effects of those two approaches are probably strongly dependent upon the characteristics of the students which affect the way they perceive diagrams.

Students from different cultures perceive pictures in different ways, (e.g. Miller, 1973, Petterson, 1982). Hence, the effects of the two teaching approaches are unlikely to be predictable in Bahrain. It is therefore the first aim of this study to compare the effects of different modes of presenting an instructional programme, for example to compare the effectiveness of two multiple-image methods of presenting the sequence of diagrams with each other, and with a method of exposing each diagram on a transparency in turn, but only when all the other diagrams in the sequence are hidden.

Many research studies have reported the role of colour in learning. Chute (1980) demonstrated that students learn significantly better from colour film than from monochrome film; he also reported that colour was an important variable for learning.

Lamberski and Dwyer (1983) found that use of colour was an important information acquisition.

Kanner (quoted in Lamberski and Dwyer, 1983) emphasised the limit to which colour can help learners. Hence, it is possible that comparisons between the diagrams can be made easier by using different colours in drawing of different

parts of the structure. Students may then be able to follow more closely the path taken by each part of the structure during a rotation.

Meanwhile, colour may be less or over-used and may not help students in visualising the effect of rotation. Therefore, the second aim of this experiment is to investigate the effect of instructional programmes which vary in terms of the proportion of the transparencies containing multi-coloured diagrams used. The investigation is to be made on programmes in which none, half and all the transparencies are coloured.

6.3 RESEARCH QUESTIONS

In the use of this technique, the research questions posed for the satisfying of the aims of the study are:

1. Do students who have been exposed to a remediation programme perform significantly better on the Rotation Test?
2. Is the half-colour (H/C) or full-colour (F/C) approach more effective at remediating students than the black and white (B/W) approach?
3. Is the F/C approach more effective at remediating students than the H/C approach.
4. Is the incremental exposure (I/E) or complete exposure (C/E) method more effective at remediating students than the single exposure (S/E) method?
5. Is the I/E method more effective at remediating students than the C/E?

CHAPTER 7

METHOD

7.1 AN OVERVIEW

In this chapter the descriptions of the subjects, research instruments and experimental procedure are presented.

7.2 SUBJECTS

The study was carried out at Sheikh Abdul Aziz Secondary School (SASS). The subjects (N = 120) were randomly selected from the first year classes and all were studying chemistry as one of their subjects. Their average age was 16 years.

7.3 INSTRUCTIONAL PROGRAMME

One hundred and eighty diagrams were drawn onto 18 transparencies, each consisting of ten diagrams successively rotated by 10°, from 0 through 90° on a specific axis (see Figure 7.1).

Six molecular structures were drawn using the computer (Figure 7.2) and used in this remediation programme. Each of the six structures was drawn rotating around each of the three axes, making a total of 18 remediation items. An example showing the half-colour version of the programme is included as Appendix 6.

The transparencies were produced at the Library of the University of East Anglia. Colour was introduced using a felt-tip pen, and taking great care not to obliterate the depth cue in which the ends of the lines overlap the

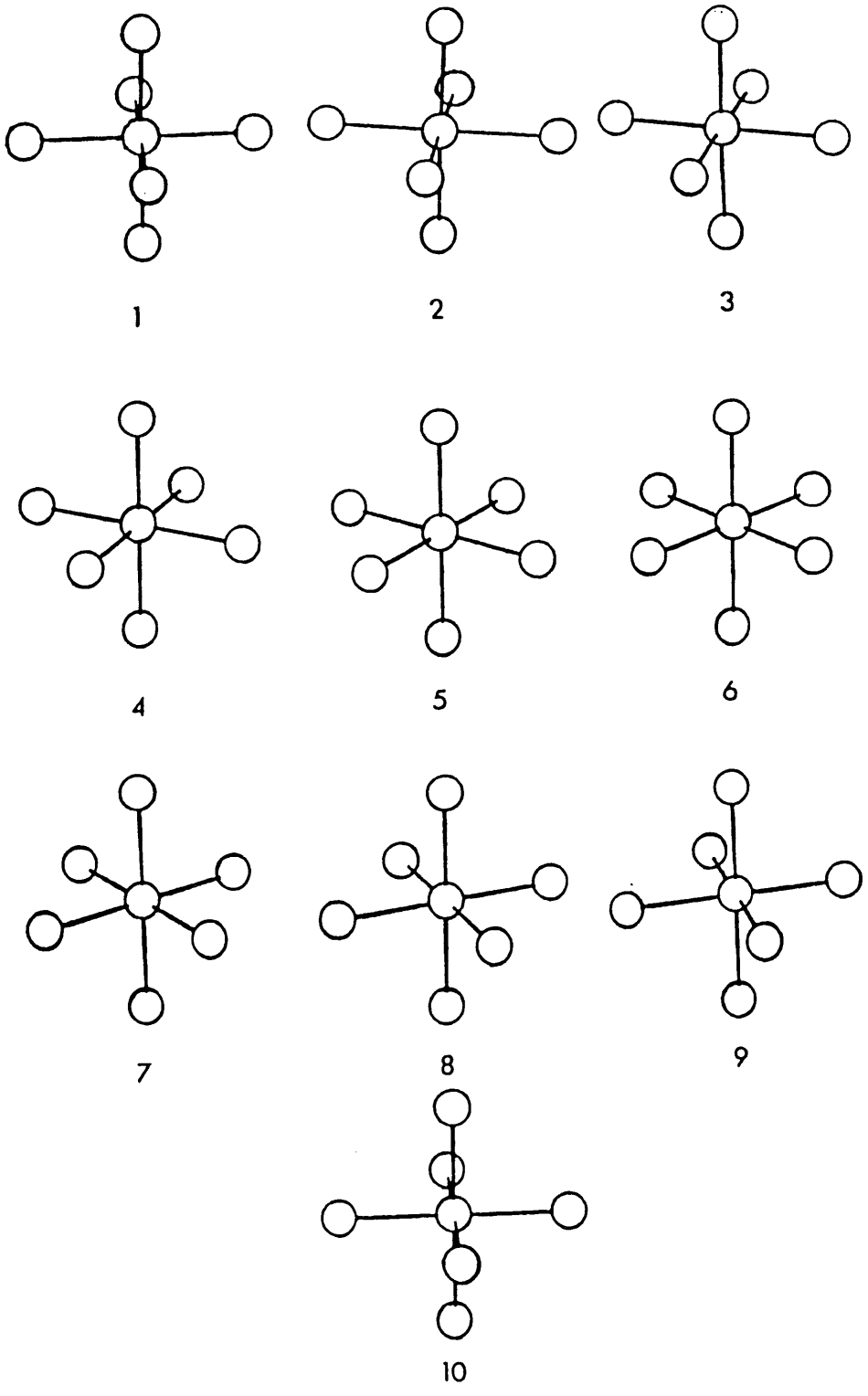


FIGURE 7.1 An Example of One of the Transparencies Used to Represent Rotation About the Y-axis in the Black and White Version of the Programme.

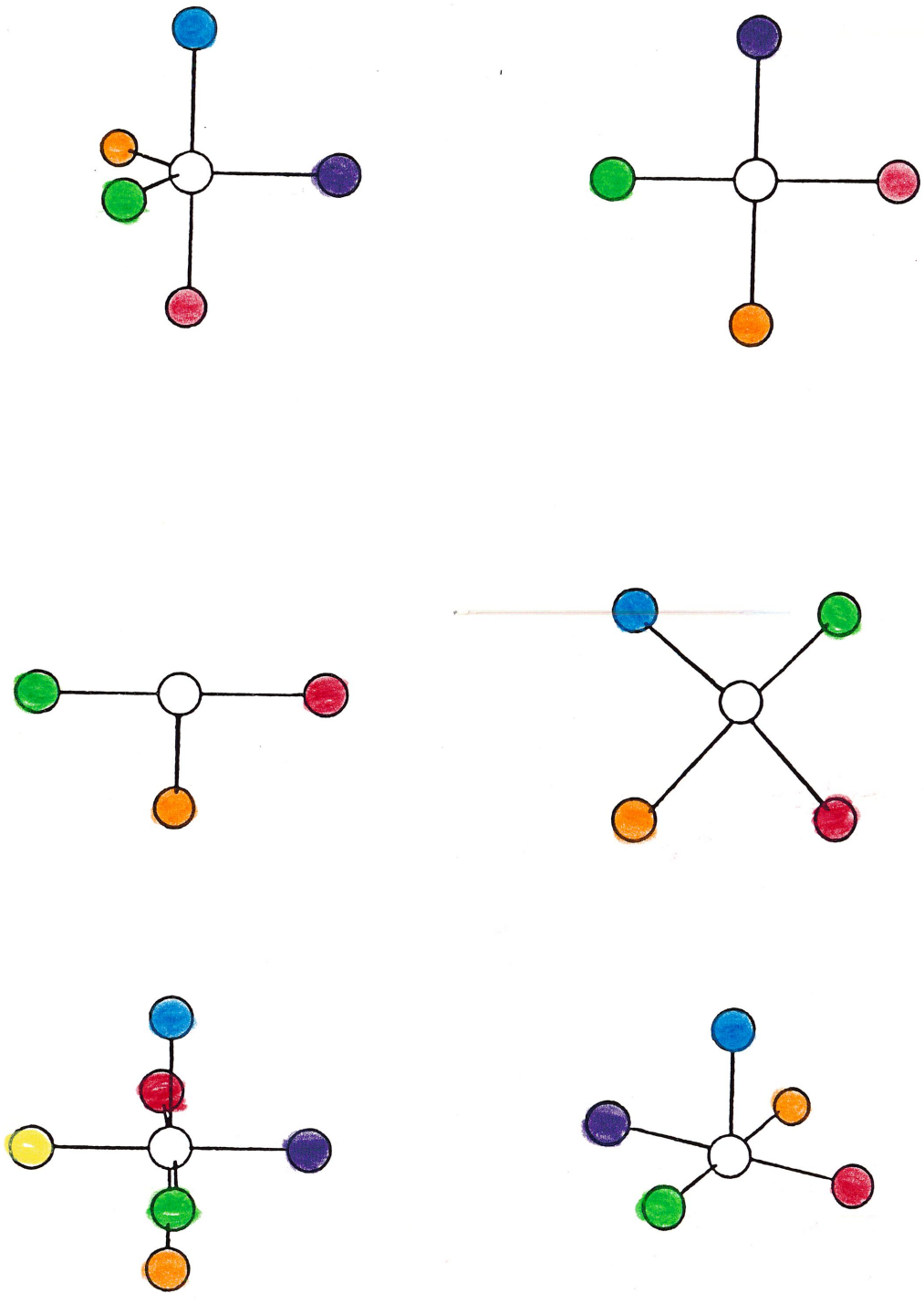


FIGURE 7.2 Basic Diagram Employed in the Instructional Programme Showing the Colours Used on the Overhead Transparencies.

circumference of the circles. Each ball in a structure had a different colour. The central ball was always colourless. The other colours used were violet, blue, yellow, orange, red and green. There was no coded meaning attached to the colours. For example red and green did not stand for an oxygen or halogen atom.

There were three sets of transparencies:

(i) Black and white (B/W) set; in which no colouring was used.

(ii) Half-colour (H/C) set; in which half of the transparencies (9) were coloured and the other half left black and white. The structures to be coloured were selected on a random basis.

(iii) Full-colour (F/C) set; in which all the (18) transparencies were coloured.

Each transparency was fixed on a cardboard frame specially designed for this investigation. A rectangular hole was made for each diagram on the transparency with a "door" cut carefully so that no light was projected out from it.

The investigation which was carried out in this experiment was on the effect of the degree of colouring (B/W, H/C and F/C) and on the method of remediation, these were:

1. Single-exposure (S/E): in which each diagram in the sequence was projected on the screen and then covered up in turn till all had been projected. The duration of exposure for each diagram was 12 seconds.

2. Incremental-exposure (I/E): in which each diagram was exposed in turn, and was left exposed until all the diagrams had been projected. The same duration of 12 seconds was taken for the exposure.

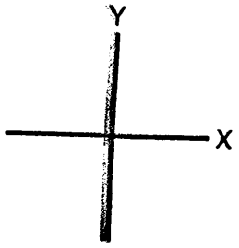
3. Complete-exposure (C/E): in which, the first seven diagrams were exposed simultaneously for a period equal in length to the total time during which the students could observe the first seven diagrams in the other two methods (i.e. 84 seconds).

For all three methods, the diagrams on each transparency were initially exposed in the defined manner to represent a total rotation of 60^{o} about a particular axis. The students were then asked to attempt a question of the same type as illustrated in Figure 7.3, and presented to each student in a special booklet (See Appendix 3). After a period of 15 seconds, the exposure of the remaining three diagrams was continued in the same way to reveal the correct answer, which always correspond to a total rotation of 90^{o}.

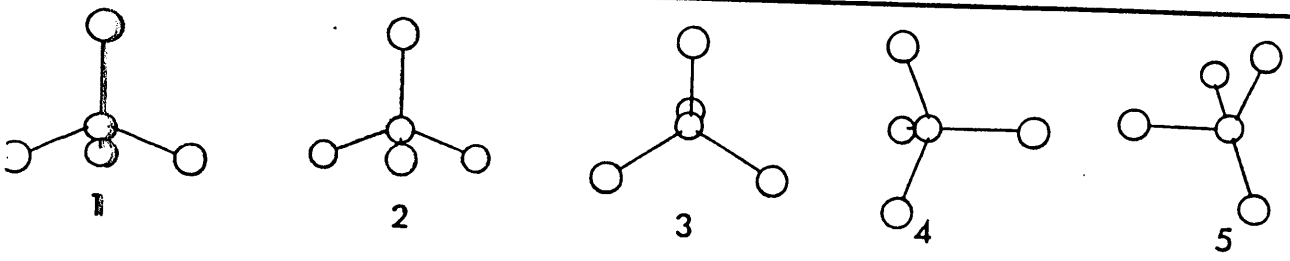
All diagrams in each transparency were numbered to show the stage of rotation for a particular molecular structure.

In addition, the same instructional booklets which were used in the earlier remedial rotation programme were also used in this study.

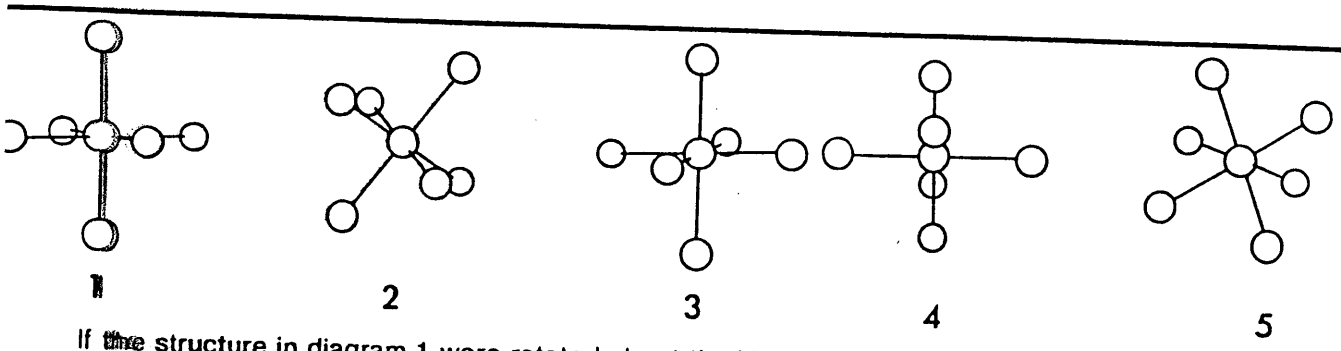
A pre-recorded tape in Arabic was used. This gave the students the necessary information about the question as well as telling them the correct answer after they had attempted it.



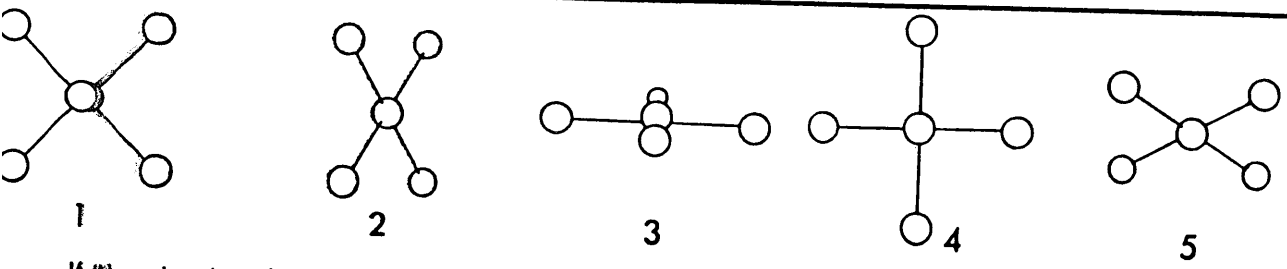
You need to refer to the axes in this diagram while answering the questions. The X- and Y- axes are drawn in the plane of the paper. You must imagine the Z-axis as being perpendicular to them coming out of the plane of the paper.



If the structure in diagram 1 were rotated about the X-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?



If the structure in diagram 1 were rotated about the Y-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?



If the structure in diagram 1 were rotated about the Z-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

FIGURE 7.3 Examples of Questions Used in the Instructional Booklet.

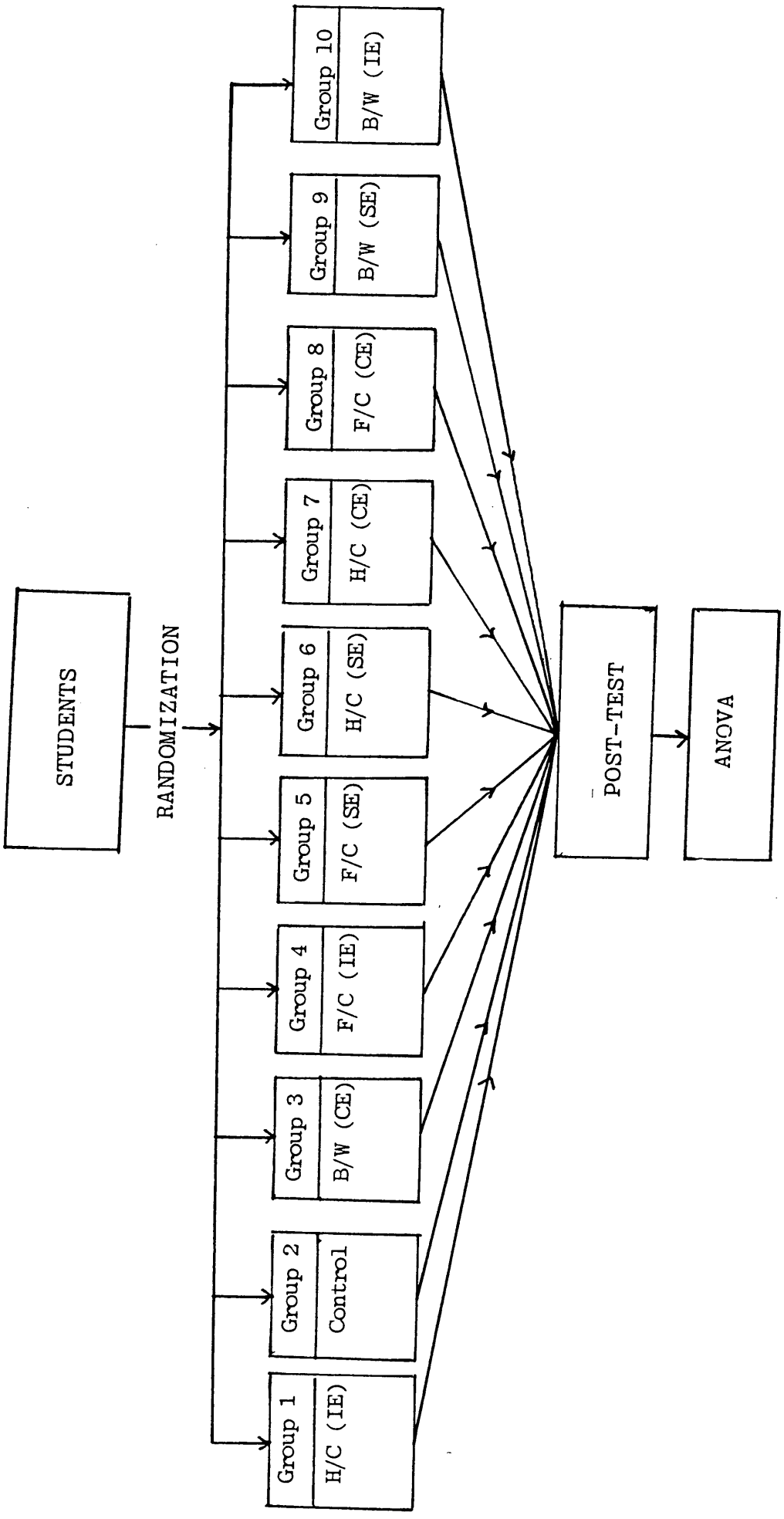


FIGURE 7.4 Schematic Representation of the Experimental Procedure in SASS.

7.4 ROTATIONS TEST

The Rotations test is the same as has been described earlier in Section 3.4.1.

7.5 EXPERIMENTAL DESIGN

A 3 x 3 factorial experiment with a single control group (Winer, 1971) was used for the data collection.

The factorial experiment involved three approached (B/W, H/C and F/C), crossed with three remedial methods, namely S/E, I/E and C/E.

The subjects were equally randomized to the 9 factorial-level combinations, and one control group. There were 10 subjects in each of the nine cells, but the number of subjects in the control group was 30.

Not only were the groups of students selected at random to occupy the ten groups in sequence, but the sequence of the groups was also randomly determined. Figure 7.4 shows the schematic diagram for the experimental procedure.

7.6 TREATMENT

It was shown in Part I that about 7 - 26% of Bahrainian students were achieving the Rotation Test Criterion. Because the small percentage of students achieving the criterion will be randomly distributed within the experimental groups, it was thought unnecessary to administer the pre-test again on another set of students.

For each degree of colour, and method of exposure, the procedure was as follows:

Each diagram was shown to the students for 12 seconds. A pre-recorded tape was played to the students which contained information on what the student was expected to do as well as describing to him the axis of rotation.

After the diagram had rotated 60° the student was told to attempt the question - 15 seconds was allowed for this. He was then shown the remaining diagrams rotating until the angle of rotation had reached 90°, which was the correct answer.

For all structures and each axis of rotation, the correct answer was fixed at 90°.

The total time for each programme was for about 40-45 minutes.

7.7 STATISTICAL ANALYSES

A two-way analyses of variance with single control group having equal cell frequencies was employed (Winer, 1971) to determine significant main effects attributable to the remediation as a whole (i.e. treatment), and also to determine if there was a significant difference between the three methods of remediation, the different degree of colouring or any interaction between these factors.

Dunnett's t Test (Winer, 1971) and planned orthogonal comparisons (Snodgrass, 1977) were performed where significant F ratios due to methods or degree of colouring were observed.

CHAPTER 8

RESULTS

8.1 AN OVERVIEW

The experimental data gathered are analysed and summarised in Tables.

The result can be classified into two types. The first type shows the means and the standard deviations of the post-tests' score, the second type is the detailed analysis of the post-tests' scores.

Significant F ratios due to treatment, methods and degree of colouring are observed.

8.2 THE POST-TEST PERFORMANCE

The means and standard deviations of the post-test scores for each experimental group are shown in Table 8.1.

The analyses of the post-test scores was based on the experimental design, thus a 3 x 3 factorial experiment with a single control group having equal cell frequencies (Winer, 1971 pp.468-473) was used to determine the significant main effect attributable to the remediation as a whole, and to determine if there was a significant difference between the three methods of remediation, and the three different degrees of colouring, or any interaction between these factors.

Table 8.2 summarises the analyses of variance carried out for all groups of subjects.

Because significant F ratios attributable to methods of remediation and the degree of colouring are observed in Table 8.2, further comparative tests were undertaken.

TABLE 8.1

Means and Standard Deviations of Post-Test Scores of SASS Remediated Groups on the Molecular Rotation Test.

EXPERIMENTAL GROUP	STATISTICS	S/E	I/E	C/E	ROW MEAN	CONTROL
B/W	$\bar{X}$	11.6	14.90	14.50	13.67	12.77
	S.D.	3.92	7.03	4.84		6.45
	N	10	10	10		30
H/C	$\bar{X}$	15.10	23.10	22.60	20.27	
	S.D.	6.72	5.15	3.60		
	N	10	10	10		
F/C	$\bar{X}$	16.20	21.80	17.50	18.5	
	S.D.	6.96	3.97	3.10		
	N	10	10	10		
Column Mean		14.30	19.93	18.20		12.77

Perfect Score = 30
Criterion = 14

TABLE 8.2

Results of a 3 x 3 Analysis of Variance of Remediated Subjects' Scores in SASS.

SOURCE OF VARIATION	SS	df	MS	F	p
Between Cell	1838.13	9			
Experimental vs Control	499.38	1	499.38	14.74	<0.01
Degree of Colouring	700.43	2	350.22	10.34	<0.01
Methods	499.49	2	249.75	7.37	<0.01
Interaction	138.84	4	34.60	1.02	>0.05
Within Cell	3727.07	110	33.88		

The Dunnett's t Test (Winer, 1971) was used to contrast the mean scores of the experimental groups with the mean scores of the control for each method and approach (Table 8.3).

The differences in the performance for each method and approach were assessed by the procedure of planned orthogonal comparisons described by Snodgrass (1977). The results of these contrasts are shown in Table 8.4 and 8.5.

TABLE 8.3

Summary of Dunnett's t Test for the Comparison of Mean Scores of Subjects Remediated at SASS.

CONTRAST	df	t	p
S/E vs Control	58	0.72	>0.05
I/E vs Control	58	3.37	<0.01
C/E vs Control	58	2.56	<0.05
B/W vs Control	58	0.42	>0.05
H/C vs Control	58	3.53	<0.01
F/C vs Control	58	2.70	<0.01

TABLE 8.4

Summary of Orthogonal Comparisons of Treatment Mean Scores of Subjects Remediated at SASS

CONTRAST	df	F	p
S/E vs $(I/E+C/E)_{/2}$	87	13.41	<0.01
I/E vs C/E	87	1.33	>0.05

TABLE 8.5

Summary of Orthogonal Comparisons of the Mean Scores Based on Degree of Colouring

CONTRAST	df	F	p
B/W vs $(H/C+F/C)_{/2}$	87	19.29	<0.01
H/C vs F/C	87	1.38	>0.05

KEY:

S/E = Single Exposure
I/E = Incremental Exposure
C/E = Complete Exposure
B/W = Black and white
H/C = Half Colour
F/C = Full Colour

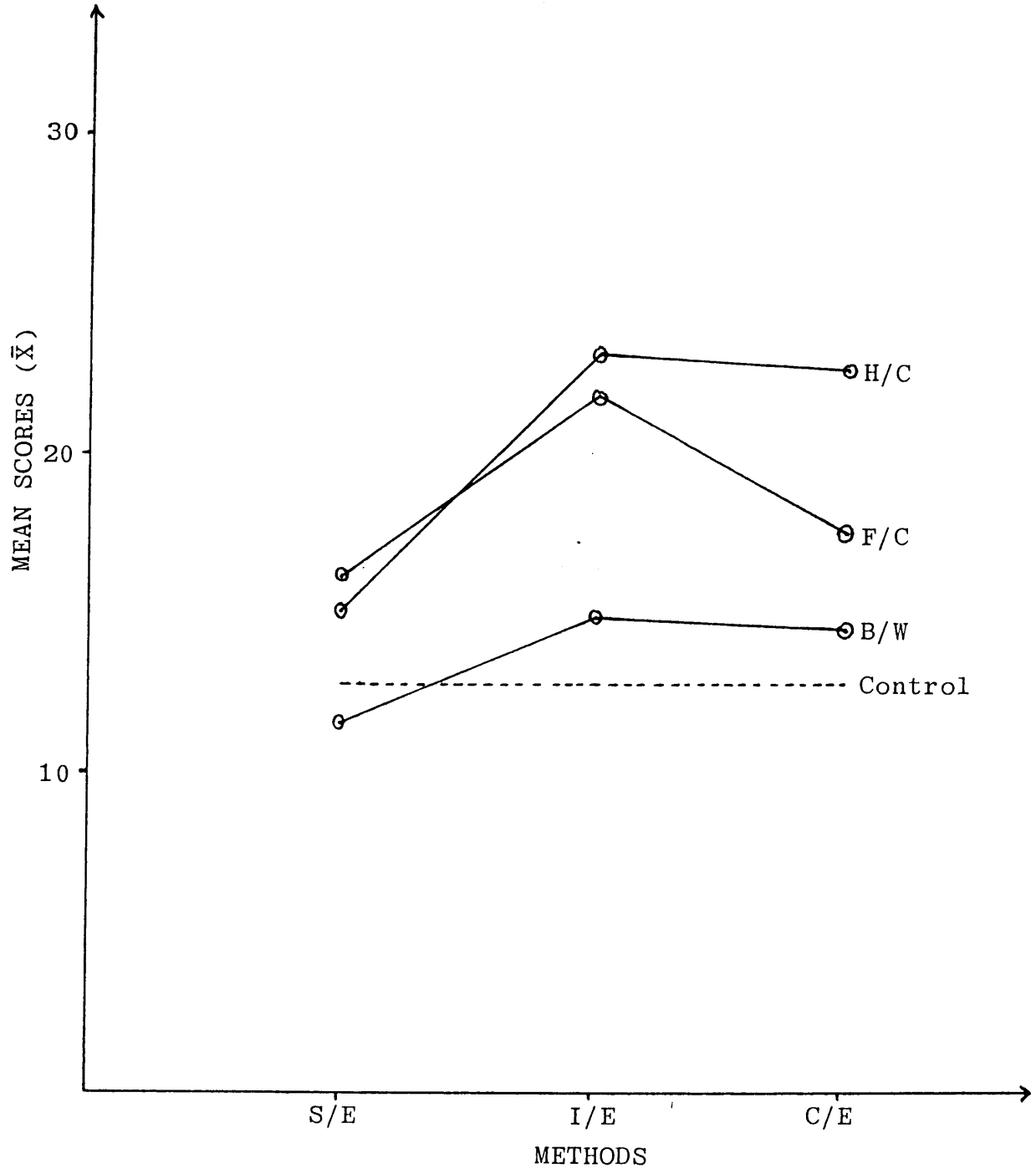


FIGURE 8.1 Graph of Mean Scores Against Method for the Different Approaches.

CHAPTER 9

DISCUSSION

9.1 AN OVERVIEW

The results gathered from the remediation experiment are evaluated and their implications are interpreted with respect to the research questions being asked. A summary of findings and conclusions is given.

9.2 THE POST-TEST SCORES

An examination of the means in Table 8.1 gives a first impression about the effects of the method used in remediation.

I/E has the highest mean scores followed by C/E and S/E. A trend is also observed in mean scores as one moves from black and white to colour, H/C has higher mean scores than F/C for I/E and C/E. These mean scores are shown graphically on Figure 8.1.

The analyses of variance (Table 8.2) shows that the experimental groups are significantly better than the control. The analyses also show that some of the colouring and remedial methods are more effective than the others in helping students to visualise rotation in molecular diagrams. There are no significant interaction effects.

The Dunnett's t Test reported in Table 3.3 shows that each of the I/E, C/E, H/C and F/C groups is significantly better than the control whereas S/E and B/W groups show no significant difference. In other words, the overall

significance was due to the effects of only those groups in which the diagrams were incrementally or completely exposed, i.e. the teaching methods based upon single-exposure, and black and white diagrams did not teach at all.

The contrast: S/E vs $(I/E + C/E)_{/2}$, shown in Table 8.1, reveals the highly significant F ratio for all remediated groups. This implies that compared with the single exposure method only, incremental and complete exposure methods are more effective for teaching the visualisation of rotation in molecular diagrams, whereas the contrast (I/E vs C/E) shows no significant F value for any group of subjects. This suggests that both methods are equally effective.

These results confirm the conclusions from Dunnett's t Test, as regards the relative effects of the single-exposure and the other exposure methods. These results therefore support the idea that the teaching should be designed to facilitate the students in making comparisons between successive diagrams. The fact that there is no significant difference between the methods of incremental exposure and that of complete exposure, suggest that from the point of view of classroom practice, this result is most helpful as there is no doubt that the method of complete exposure is much easier to implement than the incremental exposure, and therefore it is the one recommended for use.

The contrast B/W vs $(H/C + F/C)_{/2}$ shows a significant F value for all remediated groups (Table 8.5). This implies that compared with the black and white approach only the half-colour and full-colour approaches are more effective for teaching the visualisation of rotation in molecular diagrams,

whereas the contrast (H/C vs F/C) show no significant F value for any group of subjects. This suggests that both approaches are equally effective.

This result again confirms the conclusions from Dunnett's t Test as regards the relative effect of black and multi-coloured diagrams.

The fact that there was no significant difference between the two levels of colouring gives no support for the hypothesis about the dangers of having too many coloured diagrams. However, the results have some important practical implications.

From the point of view of classroom practice it makes sense to use the programmes which use only a proportion of the transparencies with multi-coloured diagrams, since the preparation of multi-coloured transparencies involves more work and expense than the preparation of black and white transparencies.

9.3 SUMMARY OF FINDINGS

On the strength of the analyses carried out, the data gathered suggest that:

1. H/C and F/C approaches were effective in teaching rotation in molecular diagrams, but there was no significant difference between their effectiveness.
2. The B/W approach was ineffective in teaching rotation in molecular diagrams.

3. Of the three teaching methods S/E, I/E and C/E, the S/E was ineffective whereas both the I/E and C/E methods were effective. There was no significant difference between the effectiveness of method I/E and C/E.

9.4 CONCLUSIONS

The findings from this research lead to the following conclusions:

1. The use of overhead transparencies as a means of presenting sequences of diagrams has been shown to be effective. It is recommended that they are presented using the method of complete-exposure.
2. No more than half of the transparencies should be multi-coloured.

PART III

INVESTIGATING THE EFFECTS OF VARYING THE DEGREE OF COLOURING IN TEACHING ROTATION OF MOLECULAR DIAGRAM USING CONVENTIONAL SLIDES PROJECTION.

CHAPTER 10

INTRODUCTION

10.1 AN OVERVIEW

This chapter introduces the research problem. It covers the background ideas that underlie the research. A review of relevant literature is also made.

10.2 REVIEW OF RELATED LITERATURE

A survey of the literature shows that many research studies have reported the role of colour in learning. The findings of many of these studies indicate that although learners prefer colour to black and white versions of media presentation, students do not learn significantly better from colour versions. Chute (1979) has quoted a number of studies to support this, e.g. Kanner and Rosenstein (1960), Link (1961), May & Lumsdaine and Kanner (1961), Vander Meer (1952, 1954), Zuckerman (1954).

Samuels et al (1974) investigated children's attitudes towards colour pictures to those with outline drawings. He reported that children significantly preferred those with colour pictures to those with outline drawings. Chute (1980) demonstrated that students learn significantly better from colour film than from monochrome film. He also reported that colour was an important variable for learning.

As already reported in Part II of the present study, the teaching methods based upon monochrome diagram did not show effective learning, but the teaching methods based upon

multi-coloured transparencies were highly effective. However, there was no significant difference between the two levels of colouring (half colour and full colour).

The observed ineffectiveness of the programme using only monochrome diagrams implies that there is a lower limit to the number of multi-coloured transparencies which should be used, and that teaching will be less effective below this limit. This experiment was designed to throw more light on what this limit may be. On the other hand it is also intended to examine the effect of increasing the number of coloured diagrams.

It has been stressed in Part I and Part II of the present research that an alarmingly high proportion of science students in general and chemistry students in particular find it very difficult to visualise the effect of performing essential spatial operations (i.e. rotation, reflection and inversion) on diagrams of three-dimensional structures such as molecules. These problems are very severe in developing countries, where it is well known that many students have difficulty in understanding spatial relationships which do not even require the visualisation of an operation (e.g. Miller (1973)).

The present research on students who show difficulty in understanding diagrammatic representation of rotation in molecular diagrams is therefore of particular relevance and importance to students in developing countries. Seddon et al (1984b) have developed a method of remedial instruction which has been shown to bring about significant improvement on students' ability to perform the task (understanding rotation

in molecular diagrams). This method attempts to simulate the effects of motion using sequences of projected diagrams, each of which show the same molecular structure at a successive stage in a rotation. The overall visual effect is similar to watching individual successive frames in a cartoon film showing the structure rotating in discrete stages. This method was mainly based on use of a conventional slide projector to project 35 mm slides; Tariq (1982) administered the same experiment in Pakistan and reported similar results. In Part I of the present research it has been shown that this method was highly effective in teaching the same task to a Bahrainian student at different age levels. It was therefore thought that the use of different levels of colouring in the same type of programme might have an effective influence on teaching the task.

The present study follows up the previous work on the projected diagrams, and concentrates on teaching the task with different degree of colouring at different age groups. Thus instead of using black and white 35 mm slides, colour slides are also used. The research questions which the present study wishes to answer in order to test the above assumptions are as follows:

10.3 RESEARCH QUESTIONS

1. Do the students who are exposed to the coloured slides rotation programme (CSRP) perform significantly better than the control group?
2. Is the degree of colouring a significant factor affecting learning.
3. Is there a relationship between the age of the students and the effect of different degrees of colouring?
4. Is there a relationship between the age of the students and their performance in the CSRP?

CHAPTER 11

METHOD

11.1 AN OVERVIEW

This chapter is devoted to the description of the subjects, research instruments and the experimental design.

11.2 SUBJECTS

The subjects (N = 120) were all boys aged 13-17 years drawn at random from two schools. They are from two levels, the first level of students (N = 40) was taken from Secondary School (17 years old), the second level of students (N = 80) was drawn from Intermediate School (13 and 15 years old).

11.3 ROTATIONS TEST

The Rotation test is the same as that used by Shubber (1982), Seddon *et al* (1984b) to measure a student's ability to visualise the effect of performing rotations on three-dimensional structures represented as diagrams. The test consists of 30 items, each item asking the students to look at a diagram of a three-dimensional model, and select which of four other diagrams could represent the model, if the model were rotated about a particular axis. At the top of each page of the test, there is a note for students to refer to before attempting each question, showing the axis of rotation (see Appendix 2). A total of ten different configurations were used in the test. They are as follows:

1. trigonal
2. octohedral
3. ethane
4. tetrahedral
5. square pyramid
6. ethylene
7. trigonal pyramid
8. phosphorus tetrahedron
9. square planar
10. ammonia

All the diagrams in the test were drawn by computer programme Adamson and Cole (1969) and are accurate in terms of perspective.

11.4 THE COLOUR SLIDE ROTATION PROGRAMME (CSRP)

This programme consists of two parts.

11.4.1 The CSRP Instructional Booklet

This instructional booklet (Appendix 3) consists of 18 remedial questions, each dealing with a different molecular structure or axis of rotation. The three cartesian axes were equally represented in the sequence of the booklet.

Six molecular structures which are often used in chemistry text books were incorporated in this instructional booklet. Two of the structures were planar and the other four were three-dimensional. All the structures chosen had a central atom connected to two, three, four, five or six ligands, the structures are as follows:

1. Square planar
2. T-shape
3. Trigonal bipyramid
4. Out of plane square
5. Square pyramid
6. Square bipyramid

(see Figure 11.1)

11.4.2 The Coloured Slides

180 diagrams, drawn by computer programme, Adamson and Cole (1969) to ensure that they are accurate in terms of perspective, were transferred into 35 mm coloured slides in the photography studios of the University of East Anglia (Appendix 7). Great care was taken to ensure that the slides were similarly registered. This was done by taking all the pictures from a fixed point so that there were no variations in the positioning of the camera which took the pictures of the diagrams. In addition the central atom of the diagram of structure was located in the constant grid of the lens of the camera. Colour was introduced by hand-colouring with fibre tip pens and care was taken not to obliterate the depth cue in which the ends of the lines overlap the circumferences of the circles. Each ball in a structure had a different colour, the central ball was always colourless. The other colours used were pink, blue, yellow, orange, green and brown (see Figure 11.1).

Every slide was labelled for easy identification and clarity of instruction. Thirty-nine new slides were made.

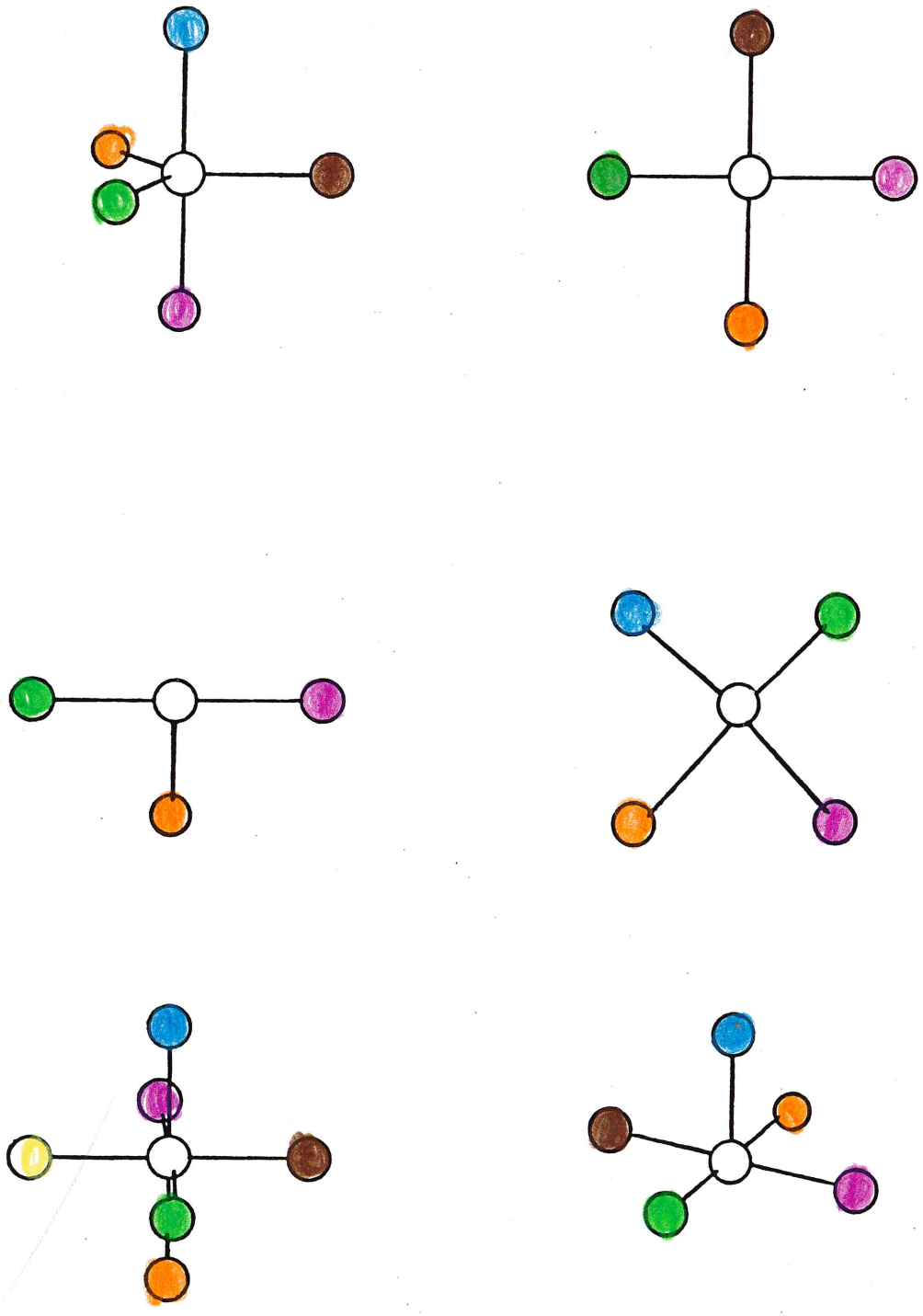


FIGURE 11.1 Basic Diagrams Employed in the Rotation Programme Showing the Colours Used for the Atoms in Each Structure.

They include, three made to show the type of rotation that would be projected (e.g. X, Y and Z axes), 18 slides to show the number of structures that would also be projected. A further series of 18 slides were made which directed the student to attempt a question in the instructional booklet. In all a total of 219 slides were made for this programme.

Since the investigation was carried out in Bahrain, an Arabic speaking country, all the writing on the slides was in the Arabic language.

11.5 EXPERIMENTAL DESIGN

The basic plan was to use a fully crossed two-dimensional design in which one dimension represented different ages of students, and the other represented the different proportions of coloured structure slides being used in different versions of the programme. Subjects were therefore to be randomly assigned to one of the seven experimental treatment groups or to a control group which did not work through any programme. A 3 x 7 factorial experiment (Winer 1971) was used for the data collection. The factorial experiment involved three chronological age groups crossed with seven degrees of colouring, namely 0 coloured structures, 3, 6, 9, 12, 15 and 18 coloured structures. This is illustrated in the Table below (Table 11.1). Not only were the groups of students selected at random to occupy the eight groups in sequence but the sequence in which the groups were tested was also randomly determined. This also applied to the different age groups tested. Figure 11.2 shows the schematic diagram for the experimental procedure.

DEGREE OF COLOURING	0	3	6	9	12	15	18
COMPOSITION OF COLOURING	All Structures B/W	3 CS 15 B/W	6 CS 12 B/W	9 CS 9 B/W	12 CS 6 B/W	15 CS 3 B/W	All 18 CS

CS = Coloured Structure

B/W = Black and White

TABLE 11.1 Showing the Composition of the Programmes for Different Degrees of Colouring.

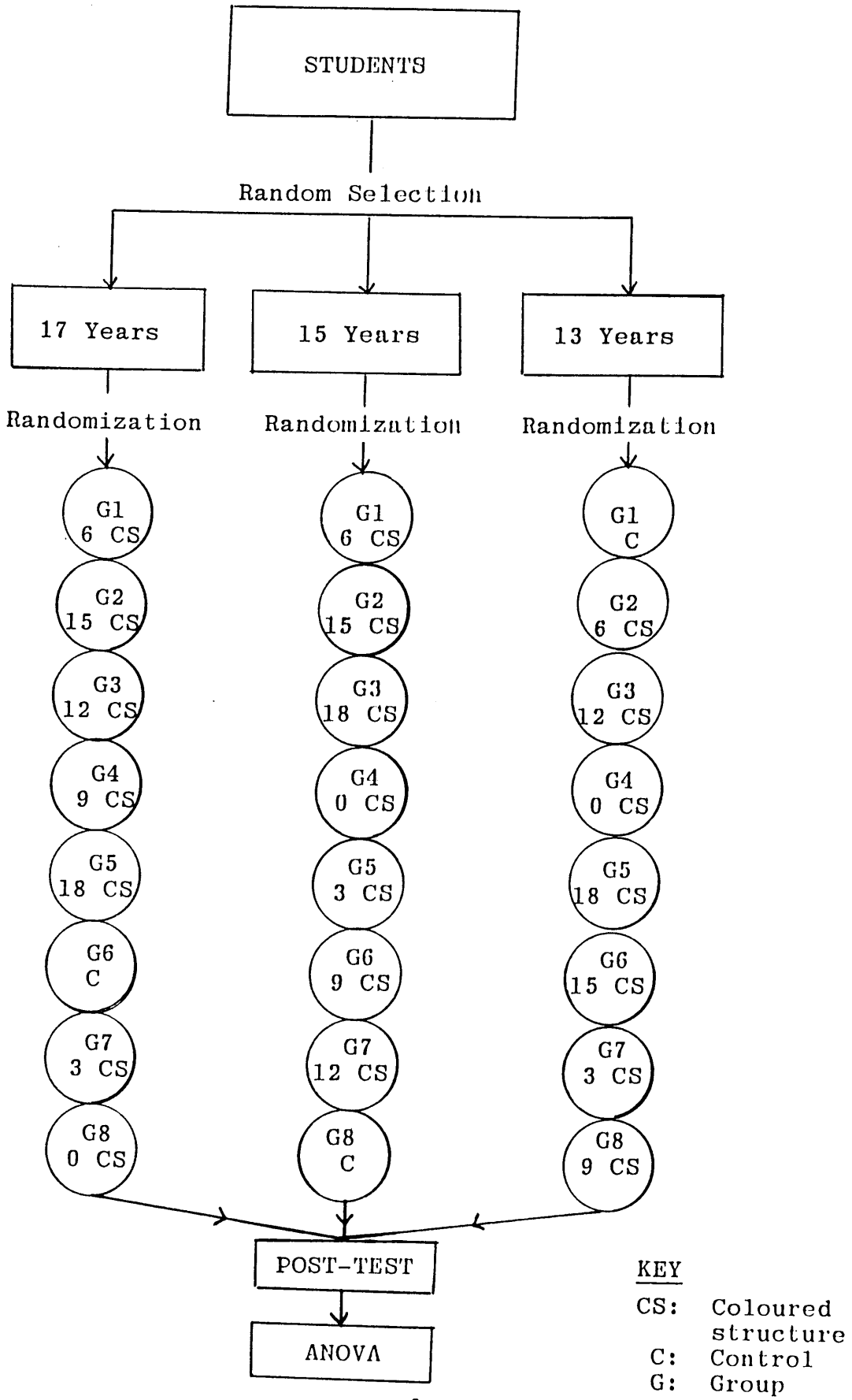


FIGURE 11.2 Schematic Representation of the Experimental Procedure of CSRP.

11.6 TREATMENTS

For each age group the randomization of the students was performed by allotting five students to each of the eight groups. Before the students began the programme or the test, the investigator read out the simple procedural instructions which were printed on the front cover of the programme and the test booklets. These instructions also emphasised to the students that the diagrams represented three-dimensional structures. Small models of the six structures represented in the booklet were shown briefly to the students to further emphasise this. Then after the investigator had demonstrated the orientation of each axis, using a large model of labelled cartesian axes, the students answered the questions in the test under normal examination conditions, using a specially prepared answer sheet. There was no time limit for the test but all students finished in less than one hour. However, for the programme, the diagrams were initially exposed in the defined manner to repeat a total of 60° rotations about a particular axis. The students then attempted a question of the same type as originally described for the test. The question referred to the structure in the current slide projection, and required the student to predict what the diagram would look like if the rotation were continued beyond the stage represented by the last diagram exposed on the projector. After a period of 15 seconds, the exposure of the remaining three diagrams was continued in the same way to reveal the correct answer, which always corresponded to a total rotation of 90°.

The total time for any one slide to be projected on the screen was 12 seconds. The slides were shown to groups of 5 students in any one session. Although the room was darkened to allow students to view the projected slides clearly, the overall illumination was sufficient for students to write their answers to the programme questions. All slides were presented using a Kodak Carousel S-AV 2000 automatic projector.

11.7 STATISTICAL ANALYSES

One-way analysis of variance with equal cell frequencies (U.E.A. STAT package 1982) was used to find out if there were significant differences due to treatment for every age group.

Dunnett's t test (Winer, 1971) was performed where significant F ratios due to treatment were observed. A two-way analysis of variance with equal cell frequencies (Winer, 1971) was employed to determine significant main effects attributable to degree of colouring, age or interaction. Planned orthogonal comparison, Snodgrass (1977) was performed where significant F ratios due to age were observed. Tukey's test (Winer, 1971) was performed where significant F ratios due to degree of colouring were observed.

CHAPTER 12

RESULTS

12.1 AN OVERVIEW

Results of the experimental data are analysed and summarised in the tables.

Significant main effect due to treatments, age and degree of colouring are recorded.

12.2 THE POST-TEST PERFORMANCE

Table 12.1 gives the results of the different groups of students involved in the post-test.

Tables 12.2 - 12.4 summarise the Analysis of variance carried out for all groups of subjects. The F ratios indicated that further analysis of the data was necessary to find out which of the differences between means were significant.

Thus the effectiveness of the different experimental groups was examined further using Dunnett's t Test to compare the means of the experimental with the means of the control. The results are summarised in Table 12.5. The results of the 3 x 7 Analysis of variance are summarised in Table 12.6. Because significant F ratios attributable to degree of colouring and the age groups are observed in Table 12.6, further comparative tests were undertaken. The difference in the performance between each age group was assessed by the procedure of planned orthogonal comparisons described by Snodgrass (1977). The results of these contrasts are shown in Table 12.7.

The Tukey Test was employed to compare the mean scores of successive pairs of experimental groups, where a significant F ratio due to the degree of colouring was observed. The results are summarised in Table 12.8.

TABLE 12.1

Means and Standard Deviations of the Post-Test Scores of Subjects Remediated by the CSRP.

DEGREE OF COLOURING	13 Years	15 Years	17 Years	Row Mean
0	$\bar{X}$ = 16.60 SD = 2.79 N = 5	15.60 2.96 5	17.00 3.53 5	16.40
3	$\bar{X}$ = 14.00 SD = 4.63 N = 5	12.00 3.08 5	22.40 6.38 5	16.13
6	$\bar{X}$ = 16.80 SD = 3.42 N = 5	18.60 1.81 5	19.20 3.70 5	18.20
9	$\bar{X}$ = 14.00 SD = 3.08 N = 5	18.40 3.04 5	21.40 4.72 5	17.93
12	$\bar{X}$ = 16.00 SD = 2.82 N = 5	17.20 5.02 5	20.80 3.83 5	18.00
15	$\bar{X}$ = 13.60 SD = 4.35 N = 5	11.80 3.70 5	14.80 4.60 5	13.40
18	$\bar{X}$ = 16.40 SD = 6.14 N = 5	14.60 3.36 5	16.40 3.84 5	15.80
CONTROL GROUP	$\bar{X}$ = 7.60 SD = 2.41 N = 5	7.20 3.19 5	8.80 2.28 5	7.86
COLUMN MEAN	$\bar{X}$ = 14.38	14.43	17.60	

Perfect Score = 30

TABLE 12.2

Results of a One-Way ANOVA of Subjects' Scores Remediated by the CSRP (13 years).

Source of Variations	SS	df	MS	F	p
Methods	321.77	7	45.96	3.03	<0.01
Experimental errors	485.60	32	15.17		
Total	807.37	39			

TABLE 12.3

Results of a One-Way ANOVA of Subjects' Scores Remediated by the CSRP (15 years).

Source of Variations	SS	df	MS	F	p
Methods	536.57	7	76.65	6.72	<0.01
Experimental errors	365.20	32	11.41		
Total	901.77	39			

TABLE 12.4

Results of a One-Way ANOVA of Subjects' Scores Remediated by the CSRP (17 years).

Source of Variations	SS	df	MS	F	p
Methods	686.80	7	98.11	5.41	<0.01
Experimental errors	580.80	32	18.15		
Total	1267.60	39			

TABLE 12.5

Summary of Dunnett's t-Test for the Comparison of Mean Scores of Subjects Remediated by the CSRP.

A: 13 YEARS

GROUP/CONTRAST	df	t	p
0 vs Control	32	3.65	<0.01
3 vs Control	32	2.60	<0.05
6 vs Control	32	3.73	<0.01
9 vs Control	32	2.60	<0.05
12 vs Control	32	3.41	<0.01
15 vs Control	32	2.44	<0.05
18 vs Control	32	3.57	<0.01

B: 15 YEARS

GROUP/CONTRAST	df	t	p
0 vs Control	32	3.94	<0.01
3 vs Control	32	2.25	>0.05
6 vs Control	32	5.35	<0.01
9 vs Control	32	5.25	<0.01
12 vs Control	32	4.69	<0.01
15 vs Control	32	2.15	>0.05
18 vs Control	32	3.47	<0.01

C: 17 YEARS

GROUP/CONTRAST	df	t	p
0 vs Control	32	3.04	<0.05
3 vs Control	32	5.05	<0.01
6 vs Control	32	3.86	<0.01
9 vs Control	32	4.68	<0.01
12 vs Control	32	4.46	<0.01
15 vs Control	32	2.23	>0.05
18 vs Control	32	2.82	<0.05

TABLE 12.6

A 3 x 7 ANOVA of Scores of the Subjects Remediated by the CSRP.

Source of Variations	SS	df	MS	F	p
Ages	261.30	2	130.65	12.49	<0.01
Degree of Colouring	279.11	6	46.51	4.45	<0.01
Interaction	280.76	12	23.39	2.34	<0.05
Within Cell	878.80	84	10.46		
Total	1699.97	104			

TABLE 12.7

Summary of Orthogonal Comparisons of the CSRP Means Scores Based on Subjects' Ages.

Group/Contrast	df	F	p
13 vs $(15 + 17)/2$	102	7.34	<0.01
15 vs 17	102	19.33	<0.01

TABLE 12.8

Summary of Tukey's Test for the Comparison of Mean Scores of Subjects Remediated by the CSRP.

A: 13 YEARS

GROUP/CONTRAST	df	t	p
0 vs 3	28	1.05	>0.05
3 vs 6	28	1.13	>0.05
6 vs 9	28	1.13	>0.05
9 vs 12	28	0.81	>0.05
12 vs 15	28	0.97	>0.05
15 vs 18	28	1.13	>0.05

B: 15 YEARS

0 vs 3	28	1.69	>0.05
3 vs 6	28	3.09	<0.01
6 vs 9	28	0.09	>0.05
9 vs 12	28	0.56	>0.05
12 vs 15	28	2.53	<0.01
15 vs 18	28	1.31	>0.05

C: 17 YEARS

GROUP/CONTRAST	df	t	p
0 vs 3	28	2.00	<0.05
3 vs 6	28	1.18	>0.05
6 vs 9	28	0.81	>0.05
9 vs 12	28	0.22	>0.05
12 vs 15	28	2.20	<0.05
15 vs 18	28	0.59	>0.05

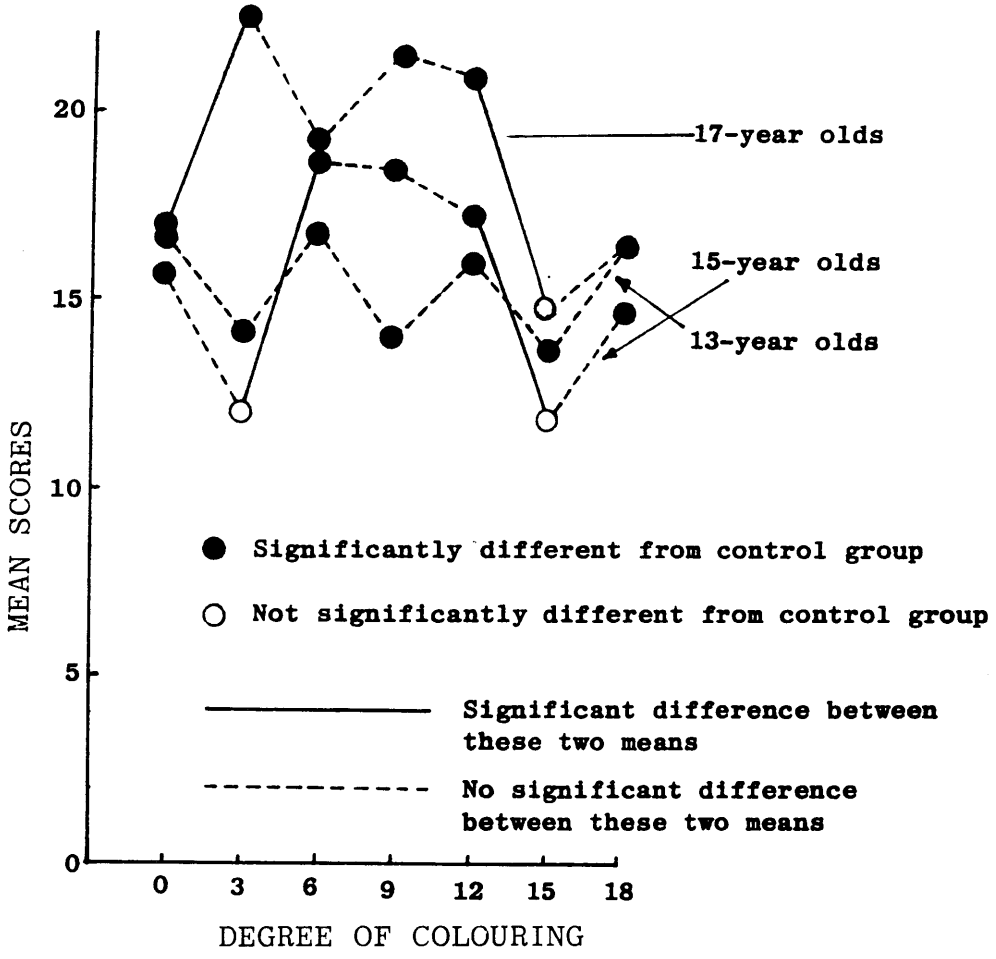


FIGURE 12.1 A graph of Mean Scores for Each Age-Group Against Degree of Colouring for CSRP.

CHAPTER 13

DISCUSSION

13.1 AN OVERVIEW

Results are evaluated and their implications are discussed with respect to the four research questions being tested.

A summary of findings is also given.

13.2 THE POST-TEST RESULTS

The one-way analysis of variance (Tables 12.1 - 12.3) showed a significant effect ($p < 0.01$) due to the differences among the means of the eight columns for each age group.

Dunnett's t-Test (Table 12.4) also showed that for subjects of 13 years of age, each experimental group was significantly better than the control group.

For subjects of 15 years of age, every experimental group was significantly better than the control group except for the two degrees of colouring (3 and 15), whereas for 17 year old subjects, all experimental groups were significantly better than the control group, except in one case where the degree of colouring is 15. The 3 x 7 Analysis of variance Table 12.6 revealed two significant main effects ($p < 0.01$ in each case).

Planned orthogonal comparisons between the means of the three age groups (Table 12.7) indicated that the means for the 13 year old subjects was significantly less than the mean for the other two age groups combined (15 and 17 years old) ($p < 0.01$) and that the mean for the 17 year old subjects was significantly greater than that for the 15 year old subjects ($p < 0.01$).

The graph shown in Figure 12.1 shows the result of the Tukey test carried out to contrast the mean score for each degree of colouring successively. The continuous lines connect points for pairs of experimental groups where there is a significant difference between the means ($p < 0.05$) on a two-tailed test. The dashed lines connect points corresponding to pairs of means which are not significantly different. The black circles represent means which were significantly better than the control group mean, whereas the white circles refer to cases where there was no such significant difference. In addition Table 12.8 gives the same comparison in tabular form.

From the graph:-

There is a statistically significant maximum in the means for the 17 year olds at 3, 6, 9 and 12 degree of colouring. This means that using any combination within this range will have approximately the same effects, since there is no significant difference between the means.

For the 15 year olds, the maximum means are at 6, 9 and 12 degree of colouring. However for the 13 year olds the maximum at 6 degree of colouring does not show a significant difference from the other means. From the analysis it is evident the use of too much or too little colour will be less effective. It is probable that use of colour cues provides additional information to facilitate the understanding of the structural cues.

Older students appear to be able to make use of this additional information more easily than the younger age group. This is in line with the findings of Chute (1980), and

suggests that information handling capacity of students may depend on age, as that some types of cues may be more readily understood than others in different age groups.

Working with older students, Lamberski and Dwyer (1983) found that use of colour was an important factor in improving student information acquisition but stressed that their conclusions should not necessarily be generalised to younger learners.

The fall-off in performance as the degree of colouring increases towards full colour could be attributable to a number of factors. The extra information provided by full colour could lead to a saturation of information processing capacity of students. More probably, the use of colour on only a limited number of the slides could serve to emphasise its use, so that the students pay more attention to the colour on these slides which are coloured, and make better use of the additional information which it conveys.

Also the use of some monochrome slides may make them easier to relate to the test questions which are in monochrome.

These findings are consistent with previous studies, such as those referred to by Kanner (quoted in Lamberski and Dwyer, 1983).

> "A consistent finding is that as the number of colour coded items increases, the value of colour as a cue for selecting important information decreases. As the total number of items decreases, the value of colour decreases. In other words, in a very dense visual display, colour coding at some minimal level helps in picking out important information, but if you increase this use of colour, its value as a selection cue diminishes."

13.3 CONCLUSIONS

The conclusions of the experiment are as follows:

1. There is a significant difference in the overall performance of the groups remediated as against the control group.

2. For 15 and 17 year olds there is a marked increase in mean performance as the degree of colouring is increased, up to an optimum point, beyond which performance deteriorates.

3. There is a significant improvement in performance with increasing age for the groups tested.

PART IV

TEACHING THE VISUALISATION OF ROTATION IN DIAGRAMS OF MOLECULAR STRUCTURES USING THE DIAGRAM DIAGRAM ROTATION PROGRAMME.

CHAPTER 14

INTRODUCTION

14.1 AN OVERVIEW

The Diagram Diagram Rotation programme is considered as a method of teaching the visualisation of rotation in molecular diagrams.

A statement of the research questions which relate to the experimental testing of the Diagram Diagram Rotation programme as a remedial approach is given.

14.2 INTRODUCTION

This part of the study investigated the usefulness of a third method of remedial instruction in teaching students to visualise the effect of rotation in molecular diagrams. Eniaiyeju (1981) used a diagram diagram approach to teach the students how to visualise rotation in molecular diagrams. In this approach, the student was asked to look at a diagram and then choose from four other diagrams which one could represent the model in the first diagram if it were rotated around a named axis. The right answer was provided at the reverse side of the items page in the instructional booklet. If the wrong response was made the student was asked to visualise the rotation again as best he could. The instructional booklet had 36 remedial items. Eniaiyeju (1981) reported that this approach produced a significant learning effect.

The present experiment follows up the previous work on the use of computer drawn diagrams, and focuses on the use of teaching methods which are cheap to prepare, and easy to administer in the classroom situation as an alternative to expensive audio-visual aid. The present study is to investigate the use of much cheaper computer drawn diagrams of molecular structures with all the diagrams in a sequence drawn on one page, as illustrated in Figures 15.1 - 15.3.

This experiment differs mainly from the approach used by Eniaiyeju (1981) which emphasised only the use of remedial questions, in that sequences of diagrams were used as well as the remedial questions. The importance of this experiment was to expose the students to a series of remedial diagrams, each showing molecular structures at different stages separated by rotation in 10^{o} intervals. This interval was found to be the most effective by Seddon et al (1984b). Since the use of colours was shown to be successful in Part II and III of the present study, it was thought that the use of colour would facilitate learning. Hence three types of self-instructional Diagram Diagram Rotation programme booklets (DDRP) were administered to 13, 15 and 17 year old students. These booklets differ only in the number of remedial diagrams and in the degree of colouring.

14.3 THE RESEARCH QUESTIONS

The present study was designed to answer the following questions:

1. Is this Diagram Diagram Rotation programme (DDRP) an effective method of teaching rotation in molecular diagrams?
2. What is the relationship between the number of diagrams used, and the effectiveness of learning?
3. To what extent does the use of colour improve learning?
4. Does learning performance improve with age of the students?
5. Are the effects of number of diagrams, and degree of colouring related to the age of the students?

CHAPTER 15

METHOD

15.1 AN OVERVIEW

This chapter gives the descriptions of the subjects, the self-instructional booklets, experimental procedure and the experimental design.

15.2 SUBJECTS

The subjects (N = 240) came from the State of Bahrain. They were all boys aged 13-17 years drawn from two schools, one of the schools is an Intermediate School while the other is a Secondary School. Subjects were therefore from two distinct levels, the first level of the students (N = 80) was drawn from Secondary School, the second level (N = 160) was drawn from Intermediate School. All the students were following courses in science subjects.

15.3 THE MOLECULAR ROTATION TEST

The test used in this part of the study was the same as that already outlined in Chapter 3, Section 3.4.1.

15.4 THE DIAGRAM DIAGRAM ROTATION PROGRAMME (DDRP) BOOKLETS

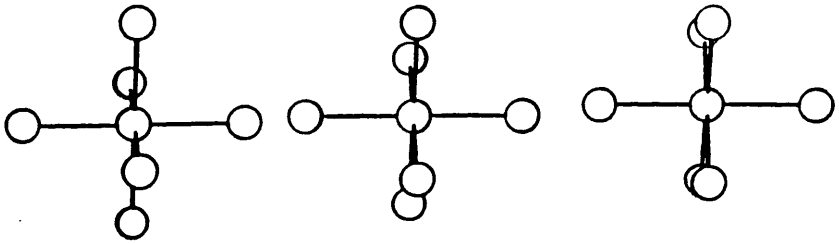
The booklets used in this programme each has an introductory section with three diagrams describing the axis of rotation by means of arrows to indicate the direction in which rotation would occur around each of the three cartesian axes. It also explains what the students are supposed to do.

The introduction is the same for all versions of the booklets. This is followed by a series of explanatory remedial diagrams showing a rotation around a specific axis. The series of diagrams show six molecular structures which are successively rotated by 10^{o} about one of the cartesian axes.

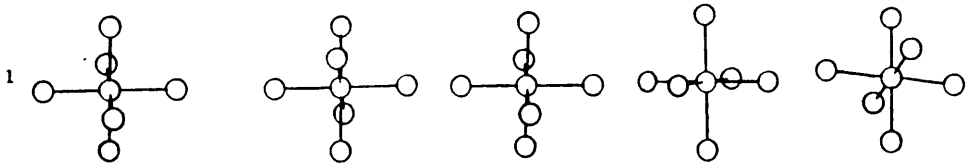
The booklets are named as Method 3D, 6D and 9D respectively, i.e. 3D stands for 3 of these remedial diagrams, 6D for 6 remedial diagrams and 9D for 9 remedial diagrams per page for one of the six molecular structures (Appendix 8). Figures 15.1 - 15.3 show a copy of the 3D, 6D and 9D methods respectively, which were used in the DDRP booklets.

The students are expected to visualise these diagrammatic representations of rotation in whichever booklet they are using and use the information therefrom to answer the remedial question which follows immediately. The correct answer to each question is provided on the following page to act as reinforcement to the students. There are 18 of such remedial questions in all. Both the remedial diagram and the remedial question are based on six different molecular structures, commonly used in Chemistry textbooks (see Figure 11.1).

Section – X



1 2 3



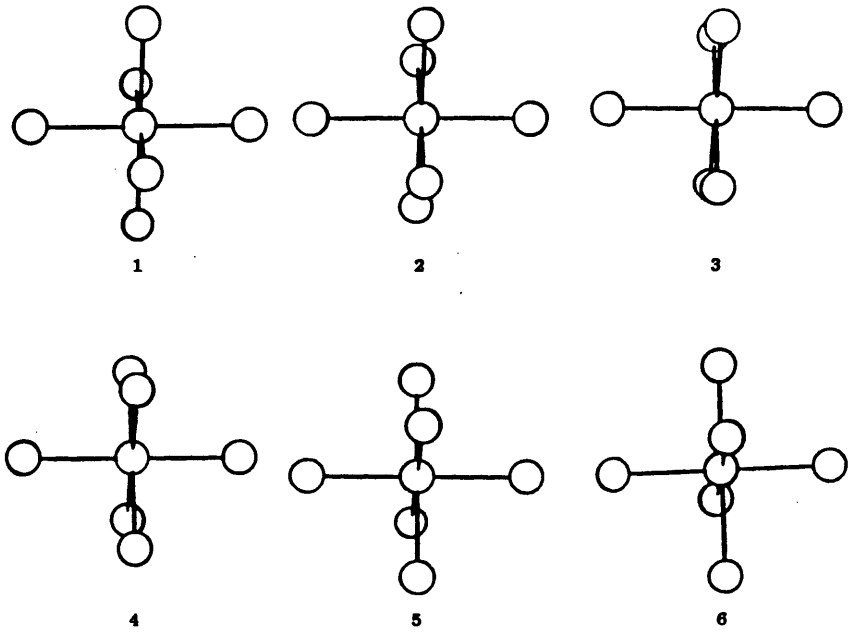
1 2 3 4 5

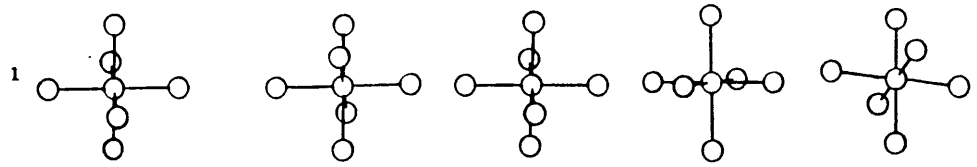
If the structure in diagram 1 were rotated about the X-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

-3-

FIGURE 15.1 An Example Showing the Remedial Diagrams from a Page of the 3D Booklet.

Section – X





If the structure in diagram 1 were rotated about the X-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

-3-

FIGURE 15.2 An Example Showing the Remedial Diagrams from a Page of the 6D Booklet.

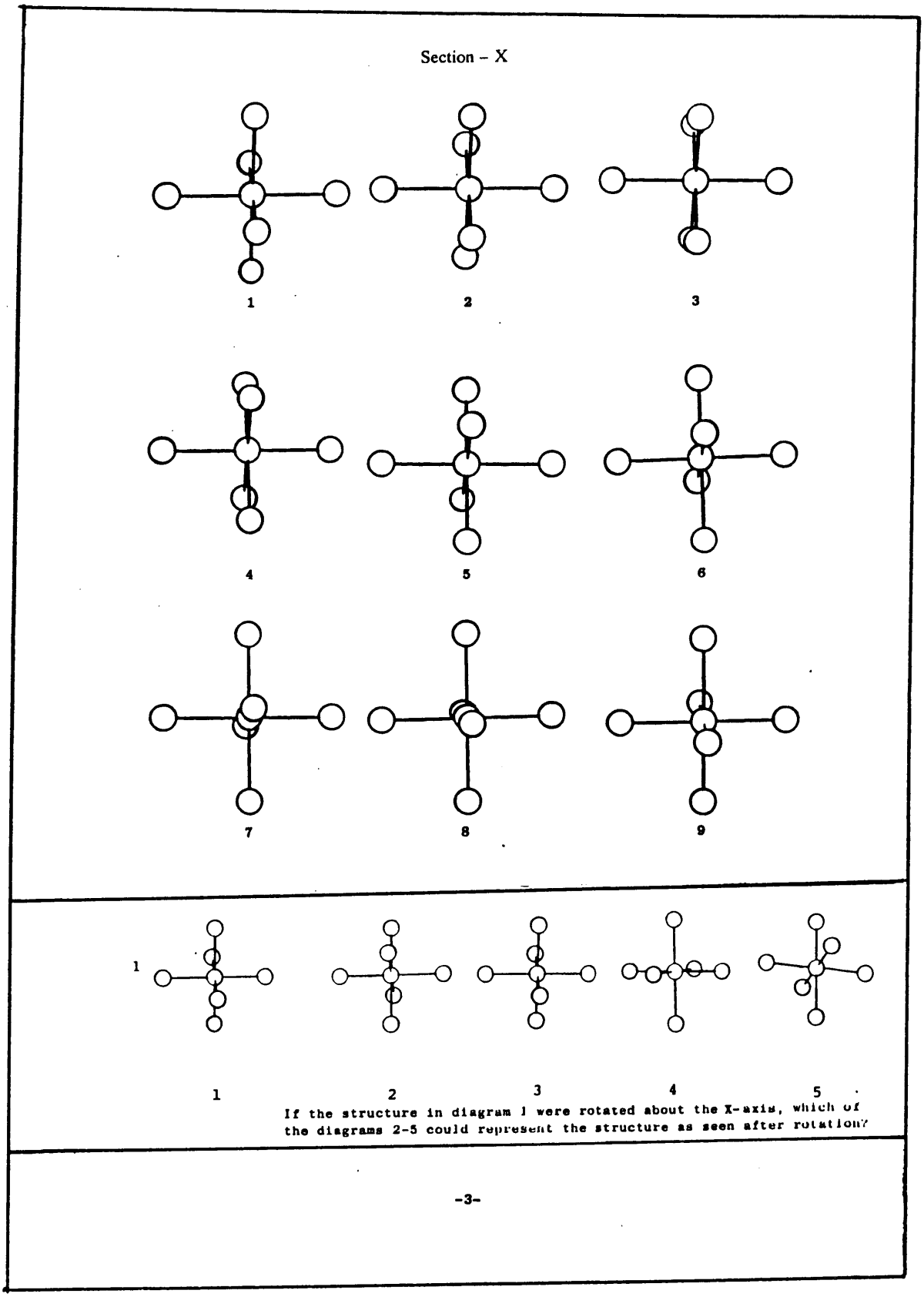


FIGURE 15.3 An Example Showing the Remedial Diagrams from a Page of the 9D Booklet.

15.5 VARIABLES INVESTIGATED IN THE PROGRAMME

There are three variables being investigated in the programme. These are:

(i) The methods (number of diagrams used), i.e. 3D, 6D and 9D.

(ii) The degree of colouring, i.e. 0, 3, 6, 9 and 18.

(iii) The age of the students, i.e. 13, 15 and 17 years old.

15.6 DEGREES OF COLOURING

The degrees of colouring represented by 0, 3, 6, 9 and 18 are as follows:

(i) (0) means that all remedial diagrams are black and white.

(ii) (3) means that three of the remedial diagrams are coloured and the rest are black and white.

(iii) (6) means that six of the remedial diagrams are coloured and the rest are black and white.

(iv) (9) means that nine of the remedial diagrams are coloured and the rest are black and white.

(v) (18) means that all eighteen remedial diagrams are coloured.

The particular diagrams that were coloured in each case, were chosen at random. In all the diagrams, the central atoms are uncoloured and the colours used for the other atoms were orange, yellow, brown, pink, green and blue. These colours were carefully chosen because they will not obliterate the cues in the diagrams.

At the same time they are easily distinguishable by the students. No conventional coding such as green for chlorine, red for oxygen has been used (see Figure 11.1).

15.7 EXPERIMENTAL DESIGN

The basic plan is to use a fully crossed three-dimensional design in which one dimension represented the three different methods and the others represented the different proportions of coloured structures, and the different age of the students respectively.

Subjects were therefore randomly assigned to one of the five experimental groups or to a control group which did not work through any of the programmes. This was repeated for each method and for each age group.

A 3 x 3 x 5 factorial experiment described by Winer (1971, p.452) was used for data collection. This factorial experiment involved three age groups crossed with three remedial methods and five degrees of colouring respectively.

Not only were the five groups of students selected at random to occupy the five groups in sequence, but the sequence in which all of the experimental groups were to be remediated was also randomly determined.

Figure 15.4 shows the schematic diagram for the experimental procedure.

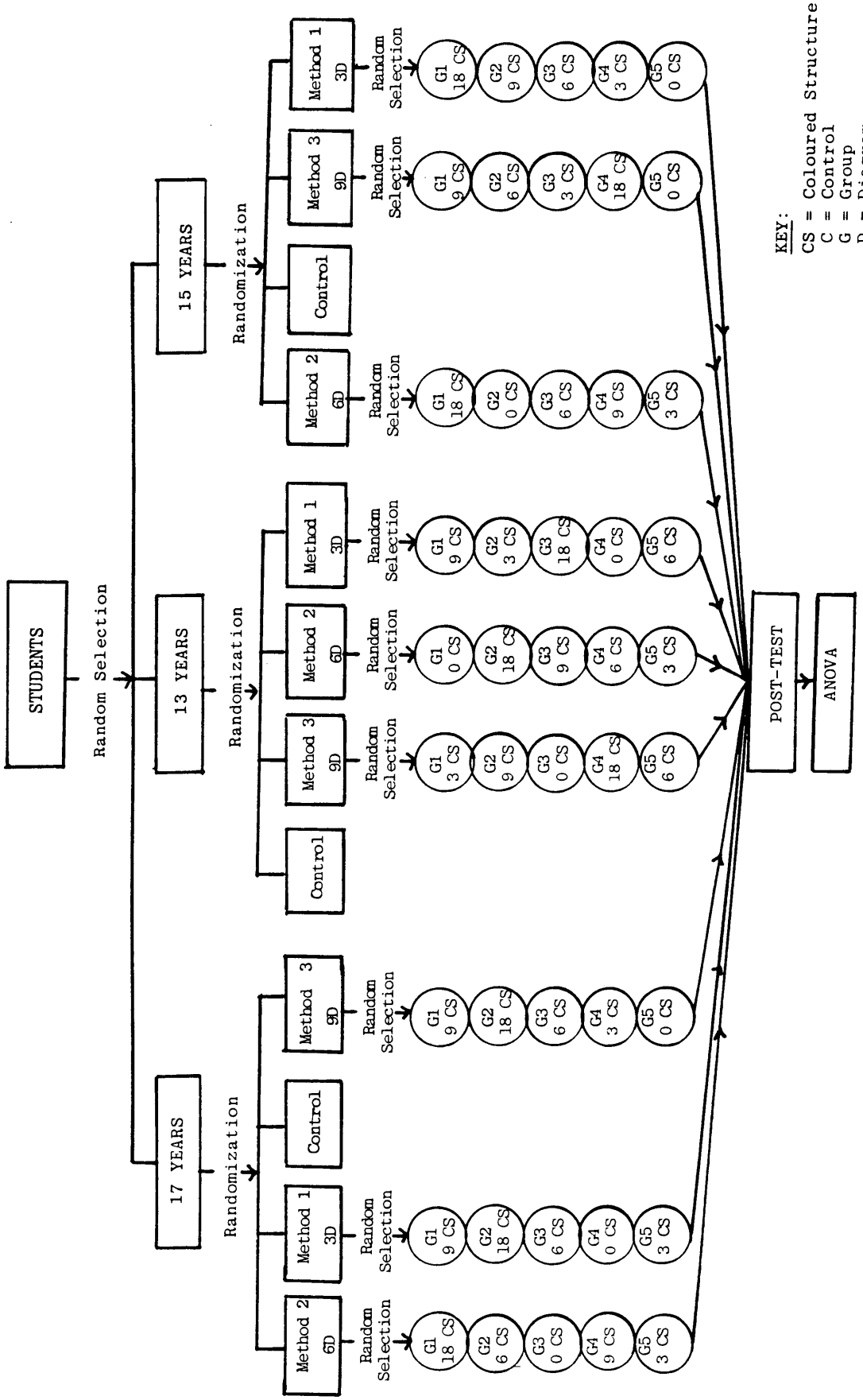


FIGURE 15.4 SCHEMATIC REPRESENTATION OF THE EXPERIMENTAL PROCEDURE OF DDRP.

15.8 ADMINISTRATION OF THE BOOKLETS

For each age group the randomization of the students was performed by allotting five students to each of the experimental groups and to the control groups.

Before the students began the programme, the author read out the simple procedural instructions which were printed on the front cover of the programme booklets. These instructions also emphasised to the students that the diagrams represented three dimensional structures. The author then demonstrated the orientation of each axis, using a large model of labelled cartesian axes. In addition, the students were shown six models of the molecular structures on which the diagrams in the instructional booklets were based. These were withdrawn immediately after the introduction, before they started the programme. The students then worked through the booklet at their own speed, writing down their answers to each question. No time limit was set for the programme. However most of the students completed the programmes as outlined below.

1. 3D took 35 minutes for completion.
2. 6D took 45 minutes for completion.
3. 9D took 60 minutes for completion.

For the test the students answered the questions under normal examination conditions. There was no time limit for the test but all students finished within 40 minutes.

All students in the experimental groups were post-tested immediately after completing the programmes.

15.9 STATISTICAL ANALYSES

A 3 x 5 factorial experiment with a single control group as described by Winer (1971, p.468) was used to find out if there were significant differences due to treatment, age or the degree of colouring.

Dunnett's t Test (Winer 1971) was performed where significant F ratios due to treatment were observed.

Tukey's test (Winer 1971) was performed where significant F ratios due to degrees of colouring were observed.

A 3 x 3 x 5 factorial experiment (Winer 1971, p.452, SPSS manual 1975) was employed to find out if there were significant differences due to age, degrees of colouring or number of diagrams used (methods).

CHAPTER 16

RESULTS

16.1 AN OVERVIEW

The results of the experimental data are analysed and summarised in Tables. The results can be classified into two types. The first type shows the means and the standard deviations of the post-tests' scores, the second type is the detailed analysis of the post-test scores. Significant main effects due to treatments, number of diagrams used and the degrees of colouring are recorded.

16.2 THE POST-TEST SCORES

Table 16.1 shows the means and the standard deviations of the post-test scores for the Rotation Test. The Table also shows the number of observations for the experimental and the control groups within each of the remedial groups.

16.3 ANOVA RESULTS

Tables 16.2 - 16.4 summarise the 3 x 5 factorial experiment with a single control group for the post-test scores of the experimental groups.

An examination of the data in Tables 16.2 - 16.4 indicate the following about the effectiveness of the treatments.

(i) There are significant differences between the mean scores of the experimental groups and the control group for each age group, i.e. $p < 0.05$ for 13 year olds, $p < 0.01$ for 15 year olds and $p < 0.01$ for 17 year olds.

(ii) For 13 and 15 year old students there were no significant differences between the mean scores for the different degrees of colouring used, but a significant difference was observed for 17 year olds.

(iii) For 15 and 17 year olds there was a significant difference between the mean scores for the three different methods used (i.e. 3D, 6D and 9D). However, the 13 year olds show no significant difference for this effect.

Tables 16.5 - 16.7 summarise the Dunnett's t Test performed to contrast each of the experimental groups versus the control group for each group and for each of the methods used.

Because a significant F ratio attributable to degree of colouring was observed for 17 year old students, the Tukey test was employed to compare the mean scores of successive pairs of experimental groups. The results are summarised in Table 16.8.

Because F ratio attributable to number of diagrams (methods) was observed for 15 and 17 years old, planned orthogonal comparisons were performed to find out which differences among the means were the real ones. The contrasts are shown in Table 16.9.

Table 16.10 provides the results of a 3 x 3 x 5 factorial experiment for all subjects combined together. Examination of the data in Table 16.10 indicates that there are significant differences between the mean scores of the experimental groups due to degrees of colouring and number of diagrams used in the self instructional booklets. However, no significant difference was observed between the mean score for the different age groups studied.

TABLE 16.1

Summary of Means and Standard Deviations of the Post-Test Scores for the Experimental Groups and the Control Groups for DDRP.

Degree of Colouring	13 YEARS METHOD			Row Mean	15 YEARS METHOD			Row Mean	17 YEARS METHOD			Row Mean
	3D	6D	9D		3D	6D	9D		3D	6D	9D	
0	$\bar{X}$ = 10.00 SD = 2.34 N = 5	13.00 2.00 5	14.00 2.74 5	12.33	9.00 2.45 5	9.40 4.16 5	14.20 2.60 5	10.86	12.00 5.29 5	12.00 3.80 5	10.20 4.14 5	11.40
3	$\bar{X}$ = 10.40 SD = 3.30 N = 5	12.00 2.00 5	9.60 1.95 5	10.66	10.00 5.15 5	13.00 1.87 5	10.80 2.86 5	11.26	13.40 3.21 5	9.80 3.27 5	11.40 3.05 5	11.53
6	$\bar{X}$ = 10.00 SD = 1.87 N = 5	12.40 1.95 5	14.80 5.02 5	12.40	10.00 1.41 5	12.60 2.50 5	13.60 1.82 5	12.00	13.20 2.86 5	16.40 1.51 5	14.00 4.06 5	14.53
9	$\bar{X}$ = 11.40 SD = 3.40 N = 5	13.60 5.64 5	9.00 2.12 5	11.33	11.60 5.32 5	12.40 2.07 5	15.00 3.24 5	13.00	9.40 2.60 5	12.60 4.16 5	20.20 5.97 5	14.06
18	$\bar{X}$ = 15.20 SD = 4.44 N = 5	11.40 3.97 5	13.00 4.42 5	13.20	8.00 2.64 5	14.40 2.40 5	15.20 2.59 5	12.53	8.60 1.82 5	13.40 1.14 5	16.20 0.84 5	12.73
Row Mean	11.40	12.48	12.08		9.72	12.36	13.76		11.32	12.84	14.40	
Control Group		$\bar{X}$ = 7.40 SD = 5.08 N = 5				$\bar{X}$ = 6.60 SD = 1.02 N = 5				$\bar{X}$ = 6.80 SD = 1.16 N = 5		

Perfect Score = 30

TABLE 16.2

Summary of a 3 x 5 Factorial Experiment with a Single Control Group of Subjects' Scores Remediated by the DDRP (13 years).

Source of Variation	SS	df	MS	F	p
Between Cell	262.81	15			
Control vs all others	98.61	1	98.61	6.85	<0.05
Degree of Colouring	58.99	4	14.74	1.02	>0.05
Method (No. of Diagrams)	14.91	2	7.45	0.52	>0.05
Interaction	190.29	8	23.78	1.61	>0.05
Within Cell	921.00	64	14.39		

TABLE 16.3

Summary of a 3 x 5 Factorial Experiment with a Single Control Group of Subjects' Scores Remediated by the DDRP (15 years).

Source of Variation	SS	df	MS	F	P
Between Cell	510.20	15			
Control vs all others	134.00	1	134.00	17.58	<0.01
Degree of Colouring	46.46	4	11.61	1.52	>0.05
Method (No.of Diagrams)	210.43	2	105.21	13.80	<0.01
Interaction	119.31	8	14.91	1.96	>0.05
Within Cell	487.80	64	7.62		

TABLE 16.4

Summary of a 3 x 5 Factorial Experiment with a Single Control Group of Subjects' Scores Remediated by the DDRP (17 years).

Source of Variation	SS	df	MS	F	p
Between Cell	861.20	15			
Control vs all others	179.40	1	179.40	18.60	<0.01
Degree of Colouring	147.25	4	36.81	3.81	<0.01
Method (No.of Diagrams)	138.59	2	69.29	7.18	<0.01
Interaction	395.95	8	49.49	5.15	<0.01
Within Cell	444.00	64	9.64		

TABLE 16.5

Summary of Dunnett's t Test for the Comparisons of Treatment Mean Scores of the Subjects Remediated by the DDRP (13 years).

A: 3D METHOD

GROUP/CONTRAST	df	t	p
0 vs Control	24	1.08	>0.05
3 vs Control	24	1.25	>0.05
6 vs Control	24	1.08	>0.05
9 vs Control	24	1.67	>0.05
18 vs Control	24	3.26	<0.01

B: 6D METHOD

GROUP/CONTRAST	df	t	p
0 vs Control	24	2.34	>0.05
3 vs Control	24	1.92	>0.05
6 vs Control	24	2.09	>0.05
9 vs Control	24	2.59	<0.05
18 vs Control	24	1.67	>0.05

C: 9D METHOD

GROUP/CONTRAST	df	t	p
0 vs Control	24	2.76	<0.05
3 vs Control	24	0.92	>0.05
6 vs Control	24	3.09	<0.05
9 vs Control	24	0.69	>0.05
18 vs Control	24	2.34	>0.05

TABLE 16.6

Summary of Dunnett's t-Test for the Comparisons of Treatment Mean Scores of the Subjects Remediated by the DDRP (15 years).

A: 3D METHOD

GROUP/CONTRAST	df	t	p
0 vs Control	24	1.37	>0.05
3 vs Control	24	1.95	>0.05
6 vs Control	24	1.95	>0.05
9 vs Control	24	2.87	<0.05
18 vs Control	24	0.80	>0.05

B: 5D METHOD

GROUP/CONTRAST	df	t	p
0 vs Control	24	1.60	>0.05
3 vs Control	24	3.67	<0.01
6 vs Control	24	3.44	<0.01
9 vs Control	24	3.33	<0.01
18 vs Control	24	4.48	<0.01

C: 9D METHOD

GROUP/CONTRAST	df	t	p
0 vs Control	24	4.36	<0.01
3 vs Control	24	2.41	<0.05
6 vs Control	24	4.02	<0.01
9 vs Control	24	4.82	<0.01
18 vs Control	24	4.94	<0.01

TABLE 16.7

Summary of Dunnett's t-Test for the Comparison of Treatment Mean Scores of the Subjects Remediated by the DDRP (17 years).

A: 3D METHOD

GROUP/CONTRAST	df	t	p
0 vs Control	24	2.65	<0.05
3 vs Control	24	3.36	<0.01
6 vs Control	24	3.26	<0.01
9 vs Control	24	1.32	>0.05
18 vs Control	24	0.91	>0.05

B: 6D METHOD

GROUP/CONTRAST	df	t	p
0 vs Control	24	2.65	<0.05
3 vs Control	24	1.53	>0.05
6 vs Control	24	4.89	<0.01
9 vs Control	24	2.95	<0.05
18 vs Control	24	3.36	<0.01

C: 9D METHOD

GROUP/CONTRAST	df	t	p
0 vs Control	24	1.73	>0.05
3 vs Control	24	2.34	>0.05
6 vs Control	24	3.67	<0.01
9 vs Control	24	6.83	<0.01
18 vs Control	24	4.79	<0.01

TABLE 16.8

Summary of Tukey's Test for the Comparison of Mean Scores of Subjects Remediated by the DDRP.

A: 3D METHOD

GROUP/CONTRAST	df	t	p
0 vs 3	20	0.71	>0.05
3 vs 6	20	0.10	>0.05
6 vs 9	20	1.93	<0.05
9 vs 18	20	0.40	>0.05

B: 6D METHOD

GROUP/CONTRAST	df	t	p
0 vs 3	20	1.12	>0.05
3 vs 6	20	3.36	<0.01
6 vs 9	20	1.94	<0.01
9 vs 18	20	0.40	>0.05

C: 9D METHOD

GROUP/CONTRAST	df	t	p
0 vs 3	20	0.61	>0.05
3 vs 6	20	1.33	>0.05
6 vs 9	20	3.16	<0.01
9 vs 18	20	2.04	<0.05

TABLE 16.9

Summary of Orthogonal Comparisons of Treatment Mean Scores of Subjects Remediated by the DDRP based on the Methods (No. of Diagram).

A: 15 YEARS

GROUP/CONTRAST	df	t	p
$(9 + 6)D_{/2}$ vs 3D	72	24.39	<0.01
9D vs 6D	72	3.21	>0.05

B: 17 YEARS

$(9 + 6)D_{/2}$ vs 3D	72	9.79	<0.01
9D vs 6D	72	4.58	<0.01

TABLE 16.10

A Summary of the 3-Way ANOVA for Subjects Remediated by the DDRP

Source of Variation	SS	df	MS	F	p
A (Age)	39.36	2	19.68	1.71	>0.05
B (Degree of Colouring)	130.64	4	32.66	2.84	<0.02
C (No. of Diagram) (Method)	263.47	2	131.73	11.47	<0.01
AB	97.25	8	12.15	1.05	>0.05
AC	80.44	4	20.11	1.75	>0.05
BC	124.74	8	15.59	1.35	>0.05
ABC	592.79	16	37.05	3.22	>0.01
Within Cell (experimental error)	2066.77	180	11.48		
Total	3395.50	224			

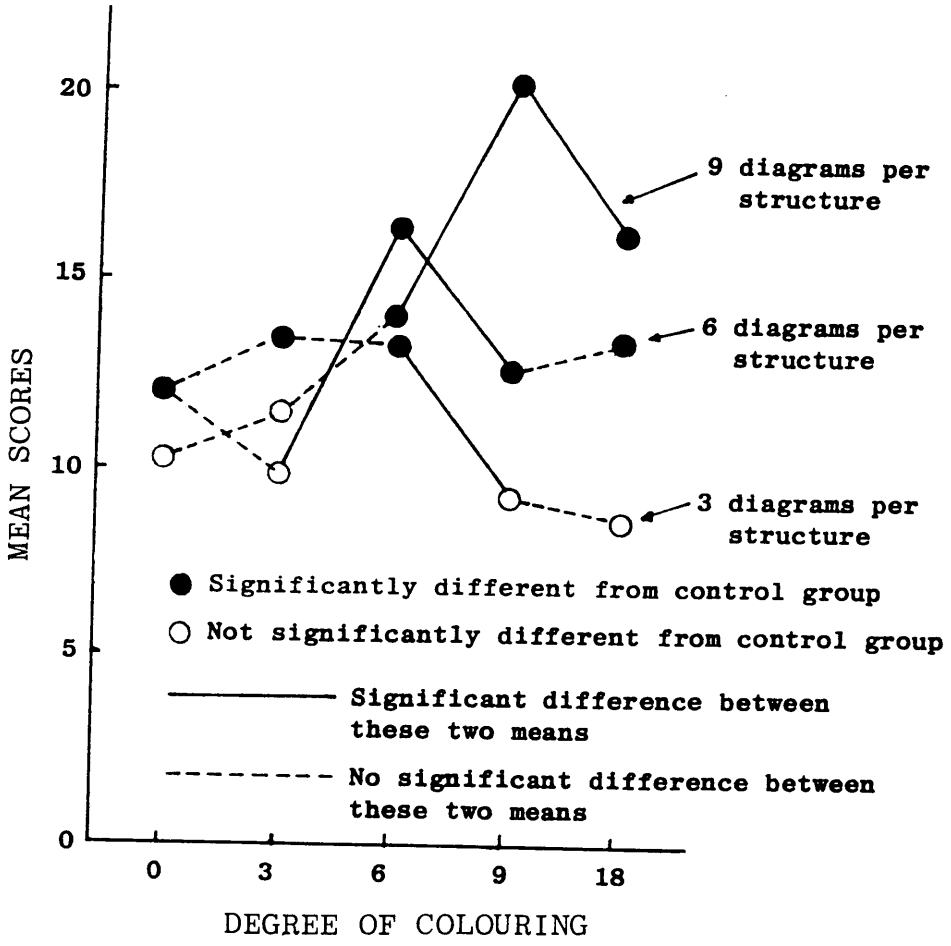


FIGURE 16.1 Graph of Mean Scores Against Degree of Colouring for the 17 Year old Students.

CHAPTER 17

DISCUSSION

17.1 AN OVERVIEW

The results from this experiment are discussed and interpreted, and their implications are also considered with respect to the research questions being tested.

A summary of the conclusions is given.

17.2 THE RELATIVE EFFECTIVENESS OF THE APPROACH

The research questions which were being investigated have been stated in Section 14.3. The first was concerned with the overall effect of using the DDRP booklets for teaching diagrammatic representation of rotation in molecular diagrams. A first impression about the effect of those booklets can be seen in Tables 16.2 - 16.4. These results show that the students who received remediation through DDRP booklets performed significantly better on the Rotation Test than those who did not receive the remediation. From this it could be concluded that DDRP booklets are effective in teaching the task of visualising rotation. A comparison of each of the treatment mean score with the control gives the results as shown in Tables 16.5 - 16.7.

17.3 EFFECTS OF NUMBER OF DIAGRAMS

The second question was to find out the relationship between the number of diagrams used for each of the methods and the effectiveness of learning.

With reference to Table 16.2, it may be concluded that:

For 13 year olds the groups which used 3D showed no significant difference compared to the groups which were exposed to 6 and 9 diagrams, and the 9D groups were not significantly different from the 6D groups. Planned orthogonal comparison Table 16.9 indicates that for 15 year olds, students remediated with 6 or 9 diagrams were significantly better than the 3D groups. However, there were no significant differences between 6D and 9D groups.

With 17 year olds the use of 9D was significantly better than the use of 6D, and both were significantly better than the use of 3D.

Thus, increasing the number of diagrams results in greater effectiveness with 17 year olds, and to a lesser extent with 15 year olds, but seems to have little effect on 13 year olds.

The contrasts shown in Table 16.5 reveal the following:

For the 3D method with the 13 year olds there was a significant difference between the experimental and the control group using 18 degree of colouring. With the 6D method significant differences are found only when using 9 degree of colouring, while with 9D significant differences are observed using 0 and 6 degrees of colouring.

Table 16.5 shows that for the 15 year olds, the 3D show no significant difference between most of the degrees of colouring with the exception of 9 vs control.

In the 6D method all except 0 vs control gave significant differences. For 9D all gave significant differences.

The contrast shown in Table 16.9 reveals the following:

For 17 year olds, with the 3D method, there were significant differences with 0, 3 and 9 vs control. The rest gave none for the 6D method all gave significant differences with the exception of 3 vs control.

Finally for 9D method all except 0 and 3 vs control gave significant differences.

17.4 EFFECTS OF DEGREES OF COLOURING

The third question was on the extent to which the use of colour improves learning.

In Tables 16.3 and 16.4 there were no significant main effects ($p > 0.05$) attributable to the degrees of colouring. This may lead to the conclusions that for 13 and 15 year old students, the degrees of colouring seem not to be important and therefore using colours in such remediation programme will have no effect. However, Table 16.5 shows a significant effect ($p < 0.01$) due to the use of different degrees of colouring for 17 year old students.

This lead to the conclusion that for 17 year old students, the degrees of colouring is a significant factor for learning rotation in molecular diagram, but is not significant for either 13 or 15 year olds.

The graph shown in Figure 16.1 shows the result of the Tukey's Test carried out to compare the mean scores of successive pairs of experimental groups, where a continuous line joins pairs of means which were found to be significantly different from each other ($p < 0.01$), and a dashed line joins pairs of means which were not significantly different from each other. In addition Table 16.8 gives the same comparison in a tabular form.

From the graph:

There is a statistically maximum mean for 3D at 3 degree of colouring, while for 6D, the maximum mean is at 6 degree of colouring, and for 9D the maximum is at 9 degree of colouring. These results suggest that for the 9D method the most effective programme was that which used 9 degree of colouring, while for 6D method, the most effective programme was with 6 degree of colouring. However, for the 3D method, the most effective programmes were those using 0, 3 or 6 degree of colouring. For these three degrees of colouring, the Tukey Test shows no significant difference between the mean scores, which suggests that any of them could be used equally effectively.

17.5 EFFECTS OF AGE

The fourth question sought to find out whether performance improved with increase in the age of the groups of students studied. The results shown in Table 16.10 indicate that there is no significant improvement in performance with increasing age for the groups tested ($p > 0.05$). This is probably due to the fact that students were able to work at their own pace in this experiment with no externally applied time constraints. This appears to benefit the younger students in comparison to the older students, so that the marked age effect observed in earlier experiments is less in evidence here.

17.6 EFFECTS OF NUMBER OF DIAGRAMS AND DEGREES OF COLOURING ON THE AGE OF THE STUDENTS

The last question was on the overall effects of number of diagrams and degrees of colouring when compared with the age of the students studied.

Tables 16.2 - 16.4 and Table 16.9 show that for 15 and 17 year olds there was a significant improvement in performance with increasing number of diagrams in the self instructional remedial programme. However, there was no significant difference shown by the 13 year olds for this effect. On the other hand 13 and 15 year old students did not show a significant difference in performance which depended on degrees of colouring, while the 17 year olds showed a marked relationship between the performance depending on the degree of colouring.

17.7 JUSTIFICATION OF FINDINGS

(a) Diagram and Age

(i) For the 13 year olds there was no significant difference on the three methods (3D, 6D and 9D) studied, one reason for this observation could be that the 13 year olds have limited memory capacity for processing information greater than 3 diagrams.

(ii) For the 15 year olds, there was significant difference between the use of 6D or 9D, and 3D, but none between 6D and 9D. This suggests that the capacity of 15 year olds to process information could reach a maximum at around six diagrams.

(iii) However, for the 17 year olds, there was significant difference between 9D and 6D, suggesting that with maturation, memory capacity for processing chains of information increases.

(b) Colour and Age

In this case, only 17 year olds benefitted from the use of colour (compare with CSRP, Section 13.2). Otherwise these findings are in line with those found for the CSRP, and the possible explanations put forward earlier (see Section 13.2) could also apply here.

17.8 CONCLUSIONS

On the strength of the data collected and analyses carried out, it could be concluded that:

1. The use of diagram/diagram rotation programme (DDRP) is an effective method for teaching rotation in molecular diagrams for all the age ranges studied.

2. a) There was no significant difference in the effectiveness of learning amongst 13 year olds as the number of diagrams is increased from 3 through 6 to 9. However, significant differences were observed within the 15 and 17 year olds respectively.

   b) Further, there was no significant difference between the effectiveness of 6 and 9 diagrams on learning by the 15 year olds. However, a significant difference was observed between 9 diagram and 6 diagram for the 17 year olds.

3. a) There was no significant differences related to the degree of colouration on the performance of 13 and 15 year olds, but significant differences were observed for the 17 year olds.

   b) For 17 year olds, the mean score is maximum for the 3D method when 3 degrees of colouring are used, for the 6D method with 6 degrees of colouring and for the 9D method with 9 degrees of colouring (see Figure 16.1).

4. There is no significant difference in the performance of the students in the different age groups.

CHAPTER 18

OVERALL CONCLUSIONS AND SUGGESTIONS FOR FURTHER STUDIES

18.1 AN OVERVIEW

In this last chapter, the aims, methods, results, and final conclusions are treated briefly. The chapter ends with suggestions for further research into the area of study.

18.2 INTRODUCTION

This study started with the purpose of diagnosing and remediating students' difficulties in understanding spatial relationships in molecular diagrams.

Four different experiments were administered to identify the areas of difficulties on which remedial programmes were designed, and tried out.

A number of findings from these have been itemised and discussed extensively in the body of this thesis. On the strength of these results and findings, the following conclusions could be made.

18.3 FINAL CONCLUSIONS

1. For all the methods investigated the remediation has been shown to be effective for all the age groups.
2. Before remediation, performance on the tests improves with age up to around 15 years old then remains approximately constant. After remediation there is a marked improvement with age for all the age range studied.

3. In the experiment where the effect of the number of diagrams was investigated, it seems that in general increasing the number of diagrams up to a certain point results in increased learning, but increasing beyond this point does not result in any further improvement. There is a marked age relation in this effect, so that the point at which increasing the number of diagrams fails to result in further improvement is dependent upon the age group being studied.

4. In the experiments where use of colour was studied the general pattern that emerged showed that there is an optimum value for the number of diagrams which are shown in colour. There was generally a range of values around the optimum which were approximately as effective as each other, but use of full colour or black and white were less effective. The optimum value was generally around 50% of the diagrams in colour. Again there was a strong age related effect. Younger students did not derive much benefit from the use of colour, but older students benefitted to a greater extent.

18.4 IMPLICATIONS FOR TEACHING AND LEARNING OF CHEMICAL CONCEPTS WHICH REQUIRE SPATIAL RELATIONSHIPS.

The conclusions made above could be used by a teacher faced with the problem of teaching spatial relationship concepts to chemistry students. In the first instance, the teacher must admit that the problem exists. He can use the conclusions as hints to reduce the difficulties which the students are likely to encounter.

In this regard, the teacher can:

(i) use the complete exposure rather than incremental exposure for the transparencies experiment since it is much easier.

(ii) use the DDRP programme since it is the cheapest of the methods studied and could be at the reach of the teacher, but taking into account the maximum number of diagrams suitable for each age group. The other methods are equally useful if the facilities to procure them are handy. In fact they are highly recommended for both developed and developing countries.

(iii) teach the concept of spatial relationships at an earlier age since all the age groups studied show marked improvement in learning.

(iv) classify his students into slow and fast learners and use any of the different programmes suggested to teach them accordingly.

(v) make use of a minimum number of multi-coloured diagrams for teaching since it involves more effort to produce them.

18.5 SUGGESTIONS FOR FUTURE RESEARCH

1. Part of the work done for this thesis showed that the use of overhead transparencies as a method for teaching visualisation of rotation in molecular diagram is effective. Future investigations following up from here could be undertaken to investigate the application of this method to teach the visualisation or reflection or inversions of molecular diagrams.

2. Further research may also be undertaken to extend the applications of the motion diagrams (Diagram Diagram programme) to teach the visualisation of reflection or inversion of molecular diagrams.

3. Further research may be also undertaken by investigating the effect of using coloured slides in video tape instructional programme. This can be done by recording the remedial programmes from coloured slides representing same steps of systematic representation of rotation or reflection.

4. Further research may also be undertaken by comparing the use of coloured and monochrome slides when using Lap-dissolve, rather than conventional slide projection.

5. The "Complete exposure" technique using overhead projection transparencies, could be adopted for use with slides. This would give simpler and more easily administered remediation programme. Further research would be needed to evaluate its effectiveness.

6. A further research may be undertaken to investigate the effects of using different angle increments between successive diagrams in the programme booklets. For instance, the experiment could be repeated using 5^{o} or 15^{o} rotation between diagrams to compare the effectiveness with the 10^{o} shifts used in this study.

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APPENDICES

APPENDIX 1	DESCRIPTION OF THE PROGRAMME USED TO DRAW THE MOLECULAR DIAGRAMS
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APPENDIX 3	MOLECULAR ROTATION PROGRAMME BOOKLET
APPENDIX 4	THE DIAGRAM PERCEPTION TEST
APPENDIX 5	THE CUES-TEST
APPENDIX 6	COPIES OF OVERHEAD TRANSPARENCIES USED IN TRANSPARENCY INSTRUCTIONAL PROGRAMME
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APPENDIX 1

DESCRIPTION OF THE PROGRAM USED TO DRAW THE MOLECULAR DIAGRAMS

APPENDIX 1

DRAWING THE MOLECULAR STRUCTURES

A convenient and easily reproducible method for drawing three-dimensional 'ball-and-rod' representation of molecules is provided by the computer 'Program HX 88' (Scower, 1965; Adamson and Cole, 1969; Lee, 1970).

The main data required for drawing each molecular structure are: the angle between the co-ordinate axes, the viewpoint co-ordinates, and, for each atom the radius of the sphere representing the atoms and the names of all the other atoms connected to it. All co-ordinates are given in A^{o} and an appropriate scale factor is selected. An example of the complete data set for drawing the Sulphur VI Fluoride (SF 6) molecule is given in Table 1.

TABLE 1 Data Profile for Drawing the Sulphur VI Fluoride (SF 6) Molecule at a Calculated Initial Viewpoint.

Angle	90	90	90	
Scale	1.0			
Sizes	S 0.3	F 0.3		
Atom	X/A	Z/A	Y/A	
S	0.0000	0.0000	0.0000	F_1 F_2 F_3 F_4 F_5 F_6
F_1	0.5000	0.0000	0.0000	S
F_2	- 0.5000	0.0000	0.0000	S
F_3	0.0000	0.5000	0.0000	S
F_4	0.0000	- 0.5000	0.0000	S
F_5	0.0000	0.0000	0.5000	S
F_6	0.0000	0.0000	- 0.5000	S
View	2	34	15	

APPENDIX 1 (cont'd)

Rotated structures were produced by subjecting the initial co-ordinates to the following transformation equations.

Rotation about X - axis

$$Y' = Yo \cos \theta + Zo \sin \theta$$

$$Z' = Zo \cos \theta - Yo \sin \theta$$

θ angle of rotation

Rotation about Y - axis

$$X' = Xo \cos \theta + Zo \sin \theta$$

$$Z' = Zo \cos \theta - Xo \sin \theta$$

Rotation about Z - axis

$$X' = Xo \cos \theta + Yo \sin \theta$$

$$Y' = Yo \cos \theta - Xo \sin \theta$$

Using the set of data in Table 1 as the initial viewpoint of the Sulphur VI Fluoride molecule, a new set of data (Table 2) is worked out. This data profile represents the molecule when rotated by 10^{o} around the X axis (Figure 2). Each molecule was drawn in this way to obtain rotated diagrams from 0 through 90^{o} on all axes.

TABLE 2 Data Profile for Drawing the Sulphur VI Fluoride Molecule at 10° X-Axis Rotation(a)

Angle	90	90	90	
Scale	1.0			
Sizes	S 0.3	F 0.3		
Atom	X/A	Z/A(b)	Y/A	
S	0.0000	0.0000	0.0000	F_1 F_2 F_3 F_4 F_5 F_6
F_1	0.5000	0.0000	0.0000	S
F_2	- 0.5000	0.0000	0.0000	S
F_3	0.0000	0.4924	- 0.0868	S
F_4	0.0000	- 0.4924	0.0868	S
F_5	0.0000	0.0868	0.4924	S
F_6	0.0000	- 0.0868	- 0.4924	S
View	2	34	15	

(a) Parameters were derived from those of the initial viewpoint represented in Table 1.

(b) Conventionally this axis is Y but it is Z to the computer.

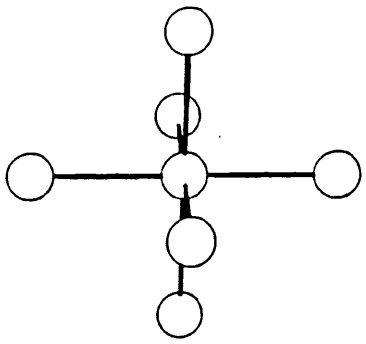


FIGURE 1 Digital Plotter Output Based on the Data Profile in Table 1.

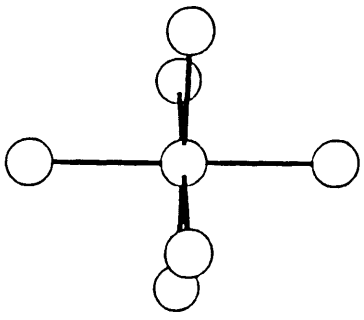


FIGURE 2 Digital Plotter Output Based on the Data Profile in Table 2.

APPENDIX 2

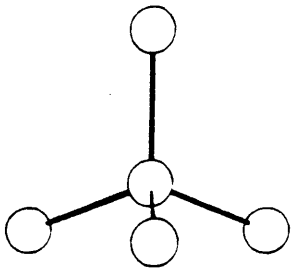
MOLECULAR ROTATION TEST

A - ENGLISH

B - ARABIC

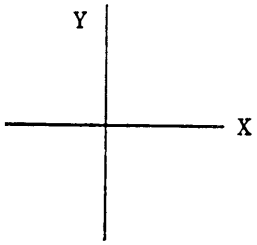
APPENDIX 2A

MOLECULAR ROTATION TEST

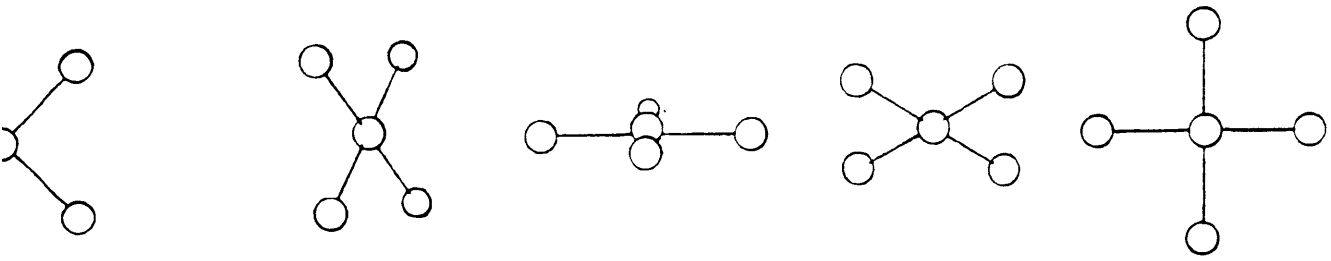


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NORWICH, ENGLAND

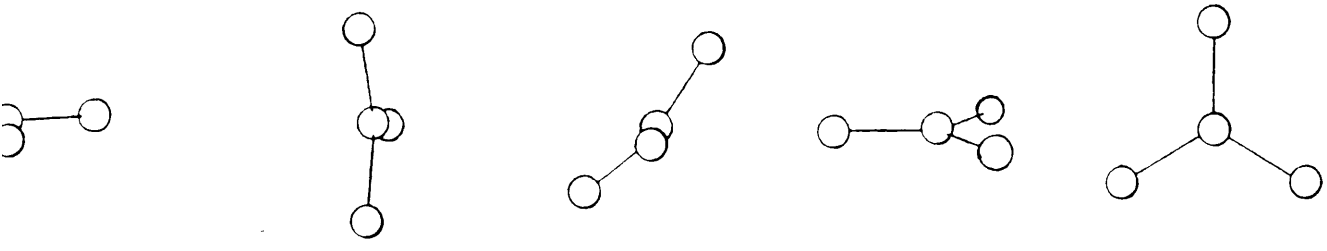


Note: You need to refer to the axes in this diagram on the left hand side while answering the questions. The X- and Y-axes are drawn in the plane of the paper. You must imagine the Z-axis as being perpendicular to them, coming out of the plane of the paper.



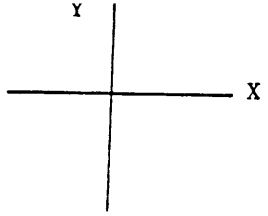
1 2 3 4 5

If the structure in diagram 1 were rotated about the X-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

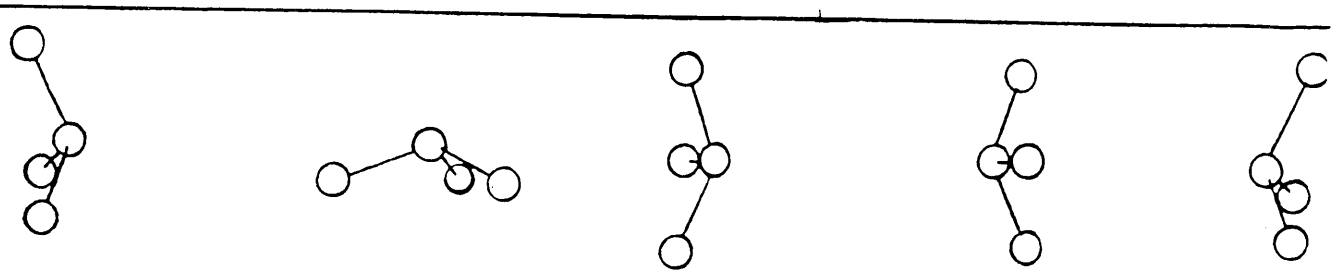


1 2 3 4 5

If the structure in diagram 1 were rotated about the X-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?



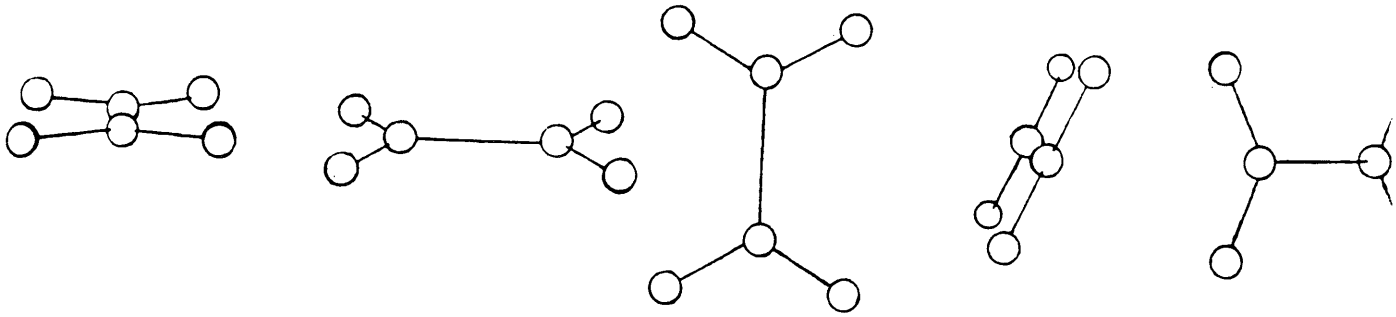
Note: You need to refer to the axes in this diagram on the l
hand side while answering the questions. The X- and Y
axes are drawn in the plane of the paper. You must ima
the Z-axis as being perpendicular to them, coming out
plane of the paper.



1 2 3 4 5

If the structure in diagram 1 were rotated about the Y-axis, which o
the diagrams 2-5 could represent the structure as seen after rotatio

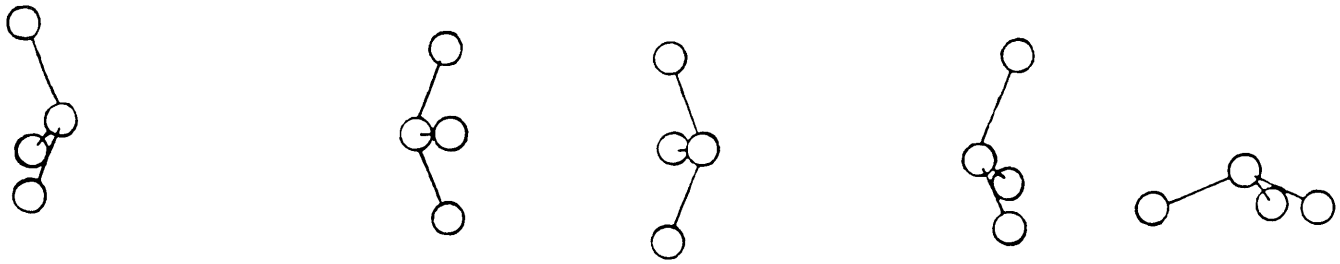
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1 2 3 4 5

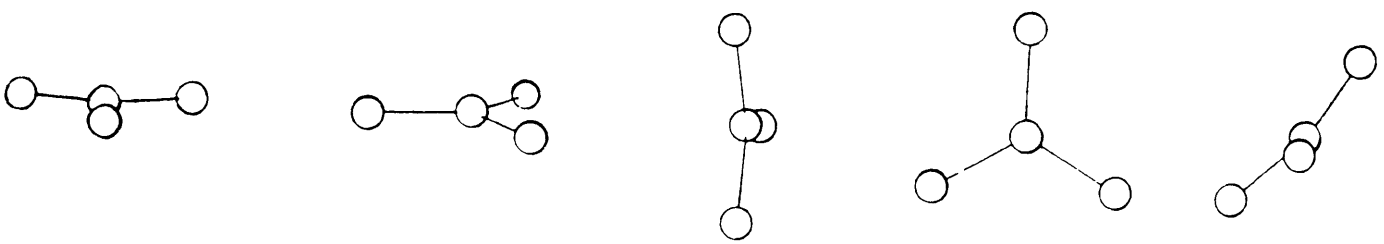
If the structure in diagram 1 were rotated about the X-axis, which of
the diagrams 2-5 could represent the structure as seen after rotation

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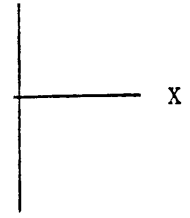
1 2 3 4 5

If the structure in diagram 1 were rotated about the X-axis, which of
the diagrams 2-5 could represent the structure as seen after rotation?

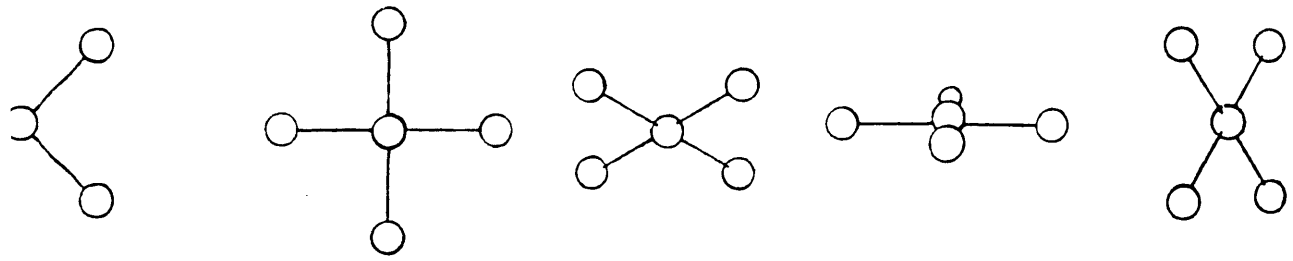


1 2 3 4 5

If the structure in diagram 1 were rotated about the Y-axis, which o
the diagrams 2-5 could represent the structure as seen after rotatio

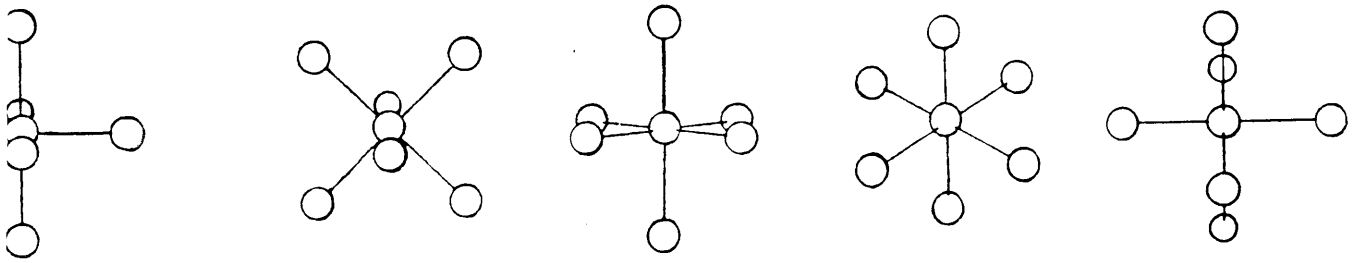


Note: You need to refer to the axes in this diagram on the left hand side while answering the questions. The X- and Y- axes are drawn in the plane of the paper. You must imagine the Z-axis as being perpendicular to them, coming out of the plane of the paper.



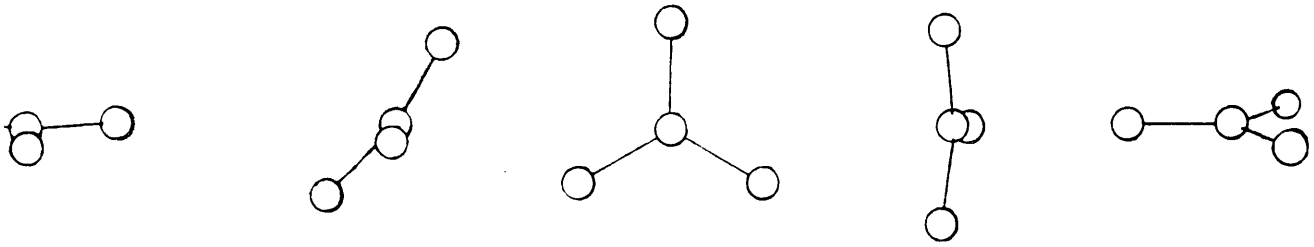
1 2 3 4 5

If the structure in diagram 1 were rotated about the Y-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?



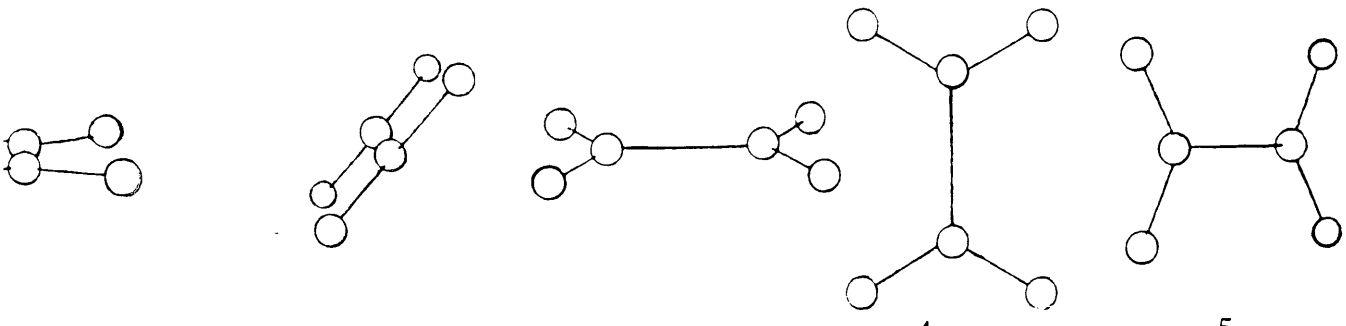
1 2 3 4 5

If the structure in diagram 1 were rotated about the Z-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?



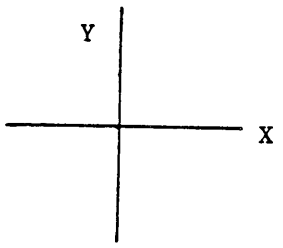
1 2 3 4 5

If the structure in diagram 1 were rotated about the Z-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

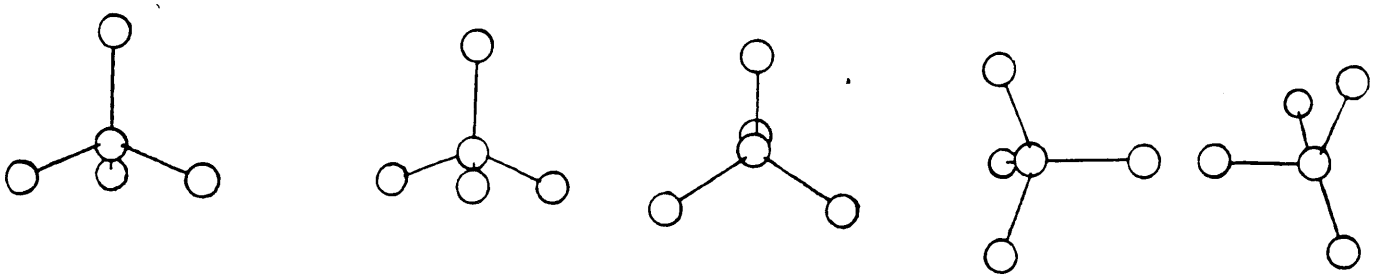


1 2 3 4 5

If the structure in diagram 1 were rotated about the Z-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?



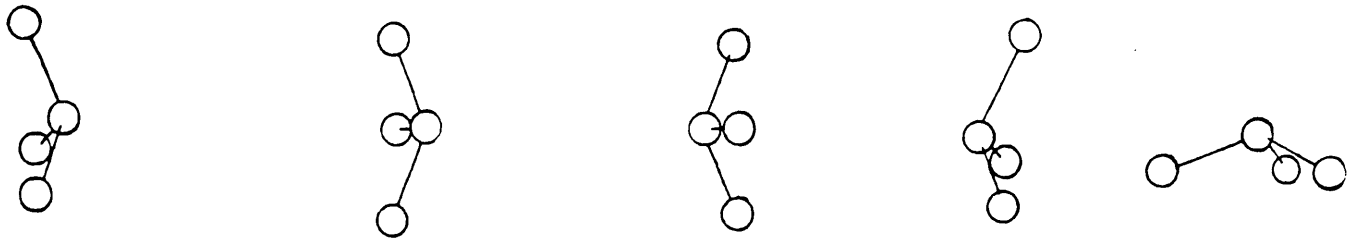
Note: You need to refer to the axes in this diagram on the le hand side while answering the questions. The X- and Y- axes are drawn in the plane of the paper. You must ima the Z-azis as being perpendicular to them, coming out o the plane of the paper.



1 2 3 4 5

If the structure in diagram 1 were rotated about the X-axis, which the diagrams 2-5 could represent the structure as seen after rotatic

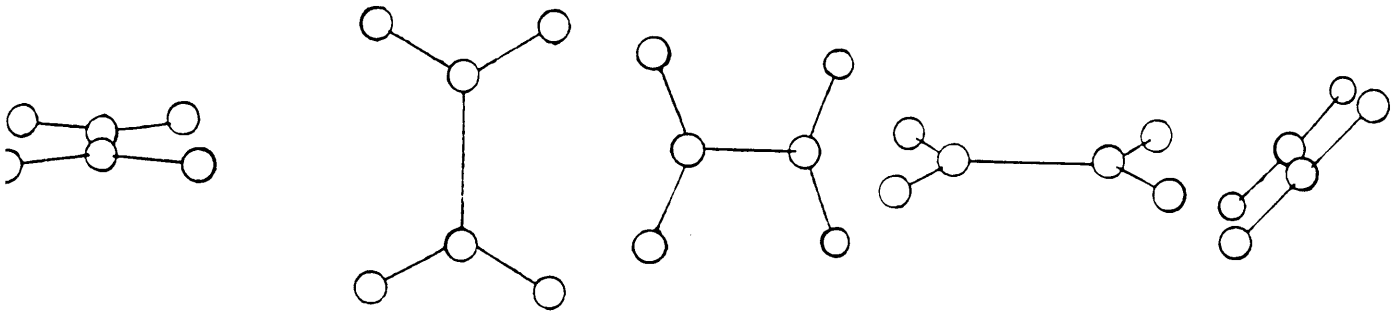
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1 2 3 4 5

If the structure in diagram 1 were rotated about the Z-axis, which c the diagrams 2-5 could represent the structure as seen after rotatic

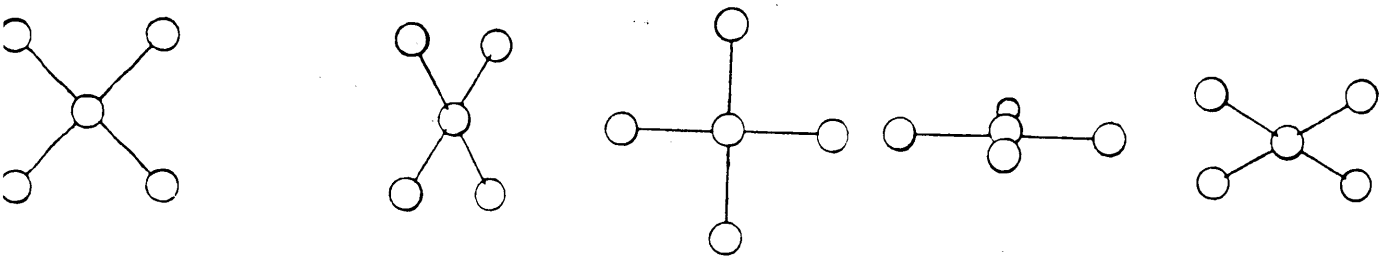
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1 2 3 4 5

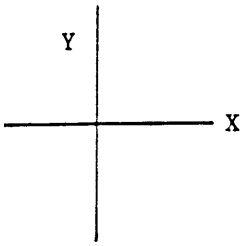
If the structure in diagram 1 were rotated about the Y-axis, which c the diagrams 2-5 could represent the structure as seen after rotatic

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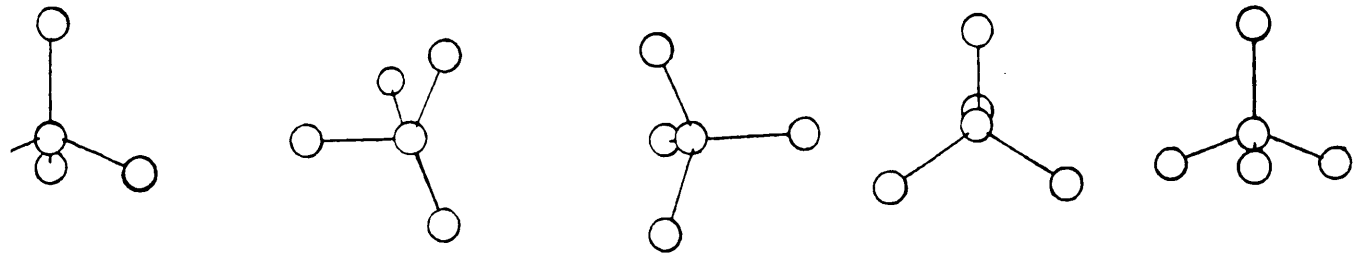


1 2 3 4 5

If the structure in diagram 1 were rotated about the Z-axis, which

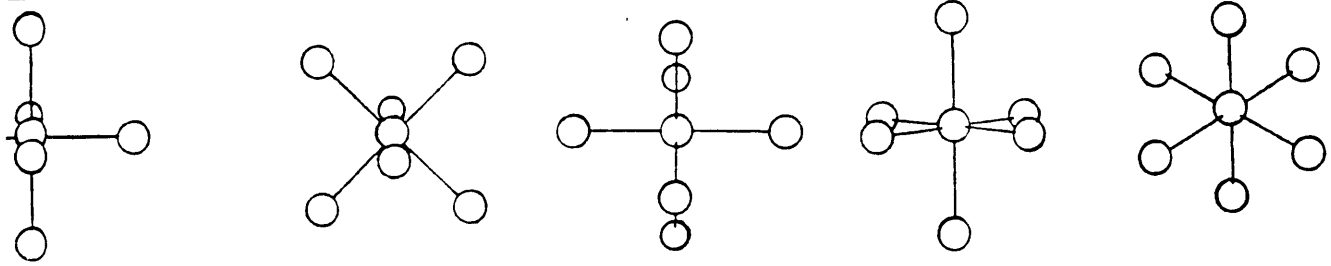


Note: You need to refer to the axes in this diagram on the left hand side while answering the questions. The X- and Y- axes are drawn in the plane of the paper. You must imagine the Z- axis as being perpendicular to them, coming out of the plane of the paper.



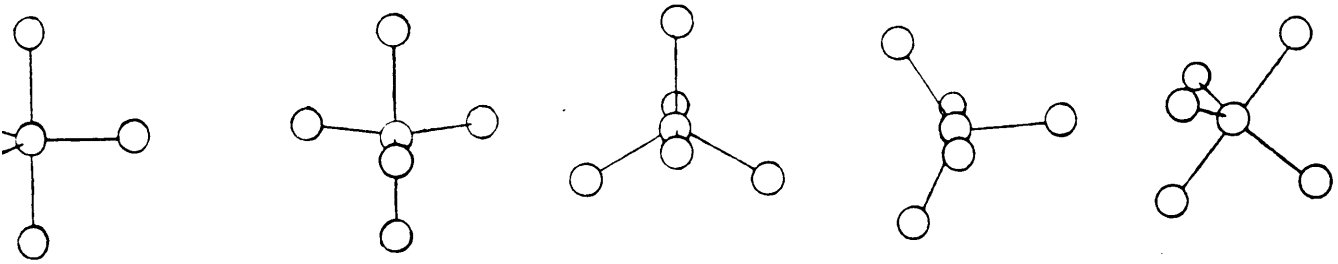
1 2 3 4 5

If the structure in diagram 1 were rotated about the Y-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?



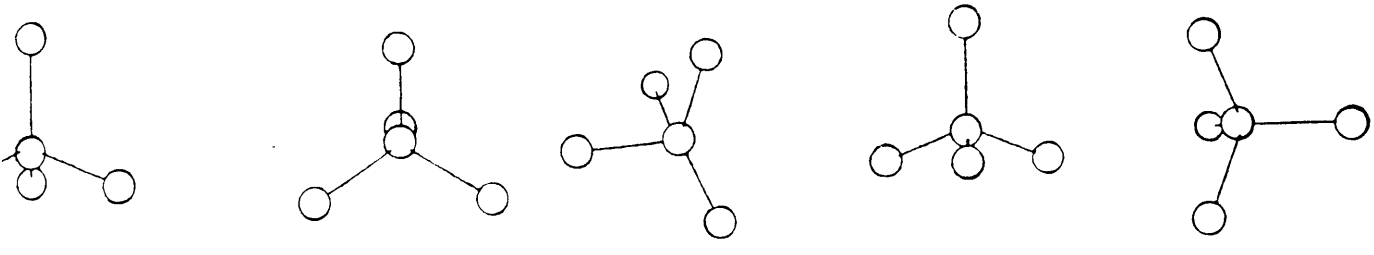
1 2 3 4 5

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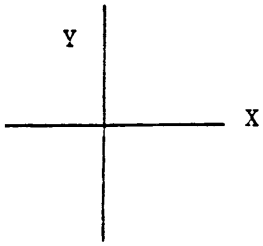
1 2 3 4 5

If the structure in diagram 1 were rotated about the X-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

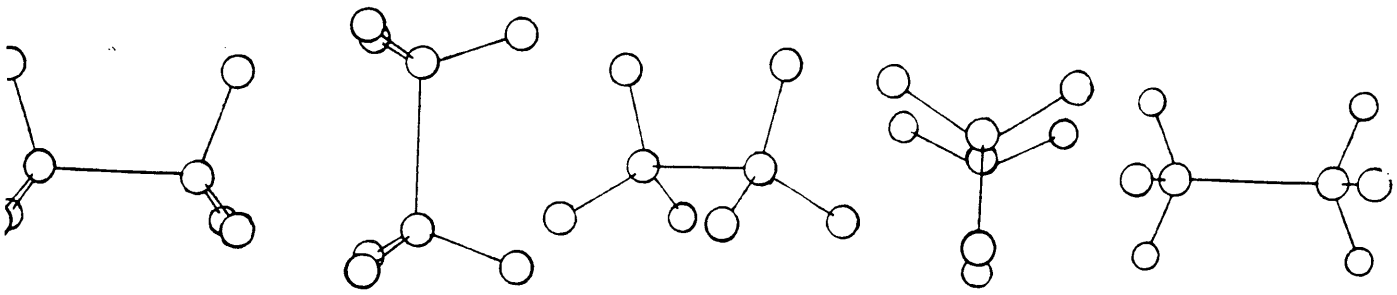


1 2 3 4 5

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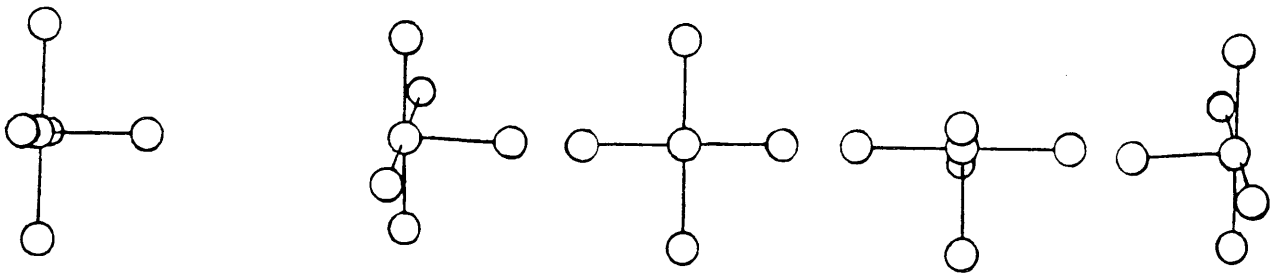


Note: You need to refer to the axes in this diagram on the left han side while answering the questions. The X- and Y- axes are drawn in the plane of the paper. You must imagine the Z- axi as being perpendicular to them, coming out of the plane of th paper.



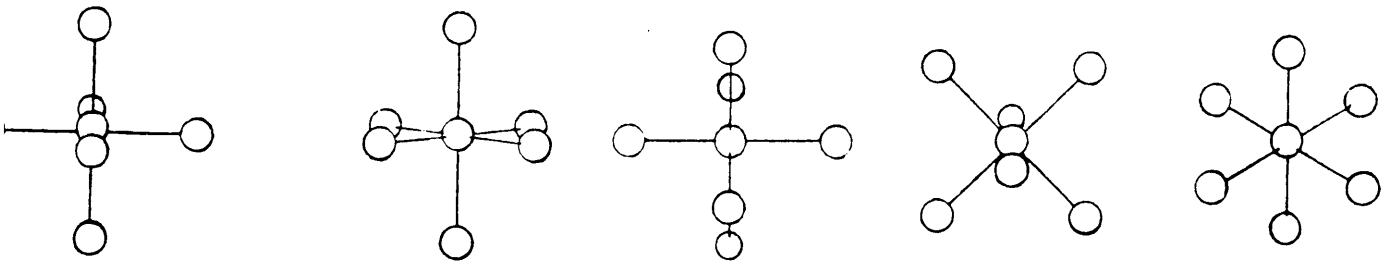
1 2 3 4 5

If the structure in diagram 1 were rotated about the X-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?



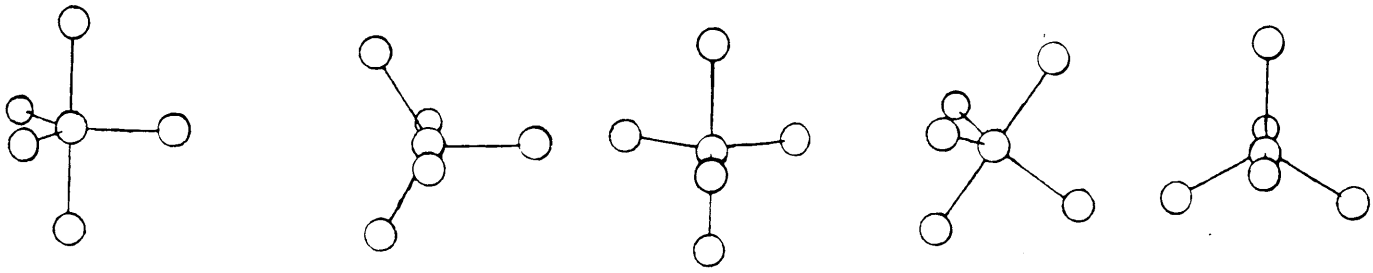
1 2 3 4 5

If the structure in diagram 1 were rotated about the X-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?



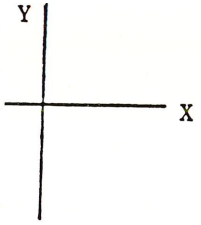
1 2 3 4 5

If the structure in diagram 1 were rotated about the Y-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

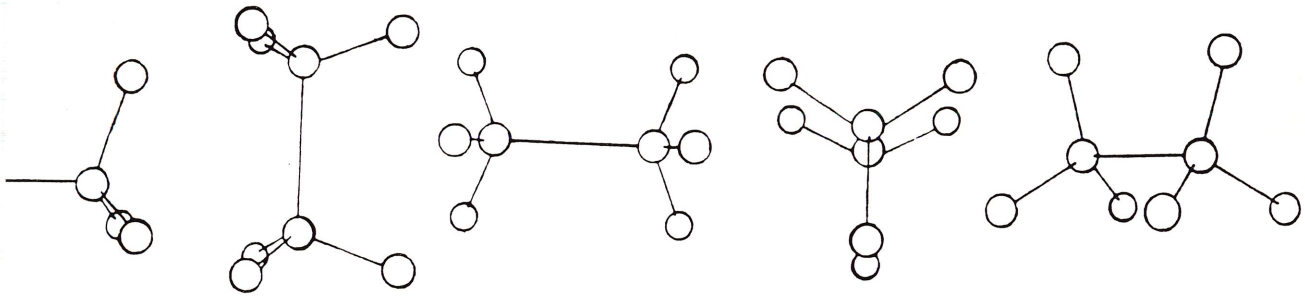


1 2 3 4 5

If the structure in diagram 1 were rotated about the Y-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

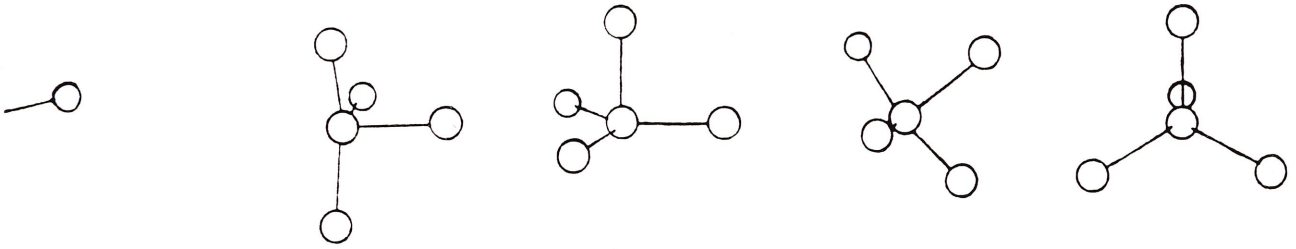


Note: You need to refer to the axes in this diagram on the left hand side while answering the questions. The X- and Y-axes are drawn in the plane of the paper. You must imagine the Z- axis as being perpendicular to them, coming out of the plane of the paper.



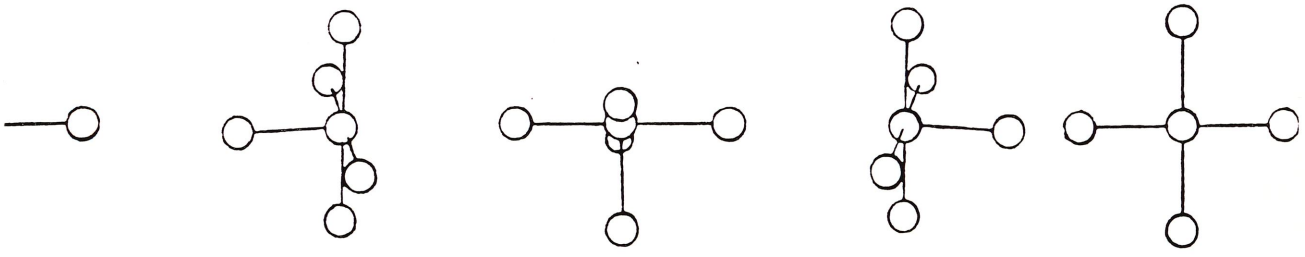
1 2 3 4 5

If the structure in diagram 1 were rotated about the Z-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?



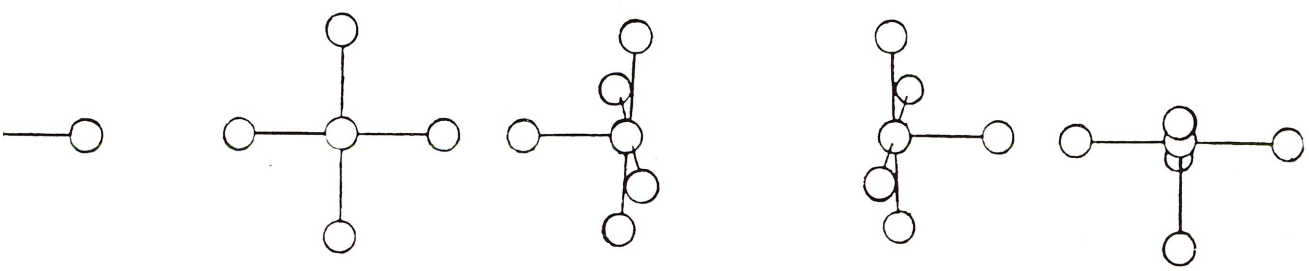
2 3 4 5

If the structure in diagram 1 were rotated about the X-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?



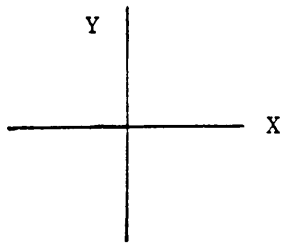
2 3 4 5

If the structure in diagram 1 were rotated about the Z-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

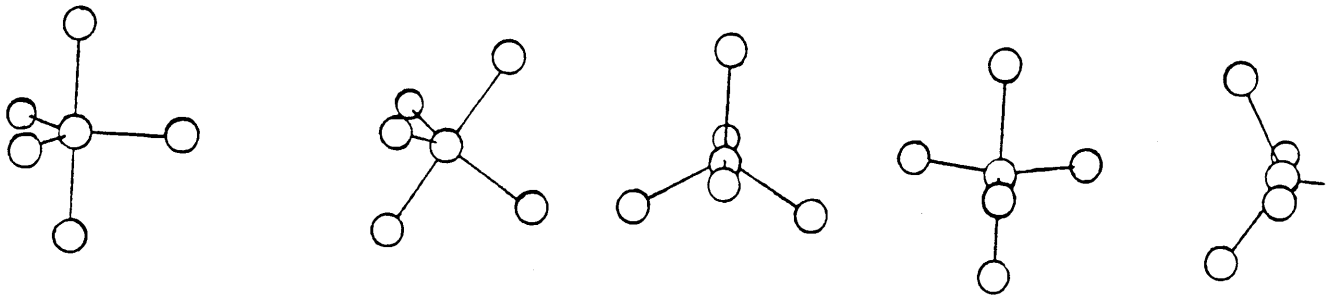


2 3 4 5

If the structure in diagram 1 were rotated about the Y-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?



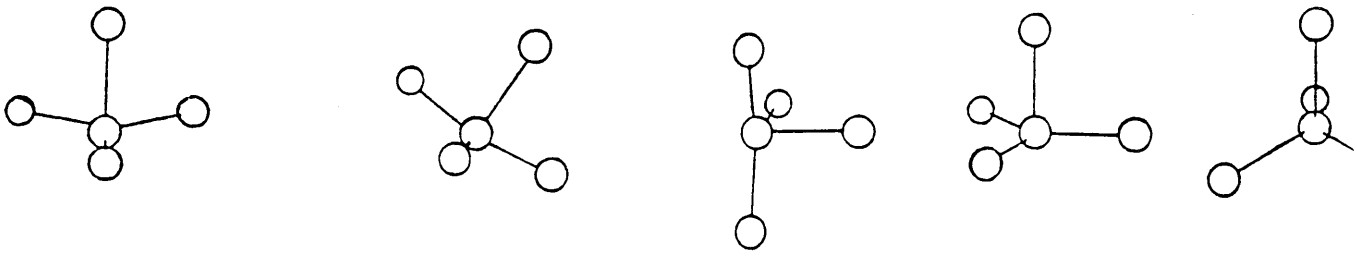
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hand side while answering the questions. The X- and Y
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1 2 3 4 5

If the structure in diagram 1 were rotated about the Z-axis, which
the diagrams 2-5 could represent the structure as seen after rotat

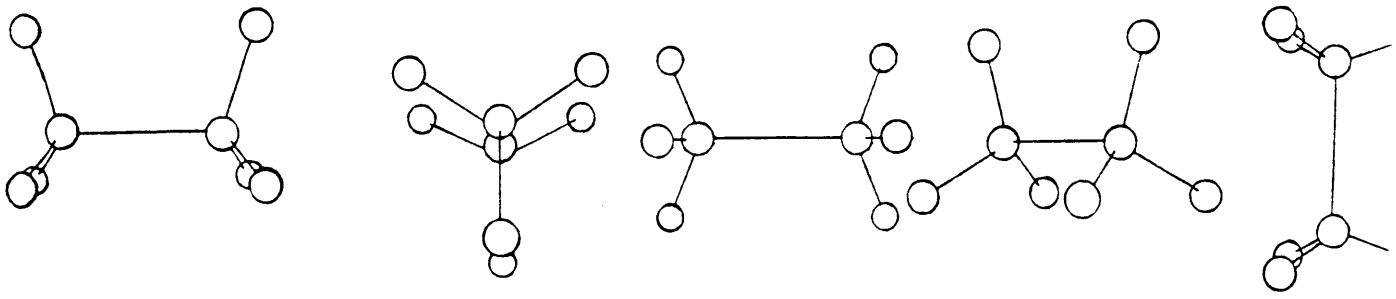
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1 2 3 4 5

If the structure in diagram 1 were rotated about the Z-axis, which
the diagrams 2-5 could represent the structure as seen after rotat

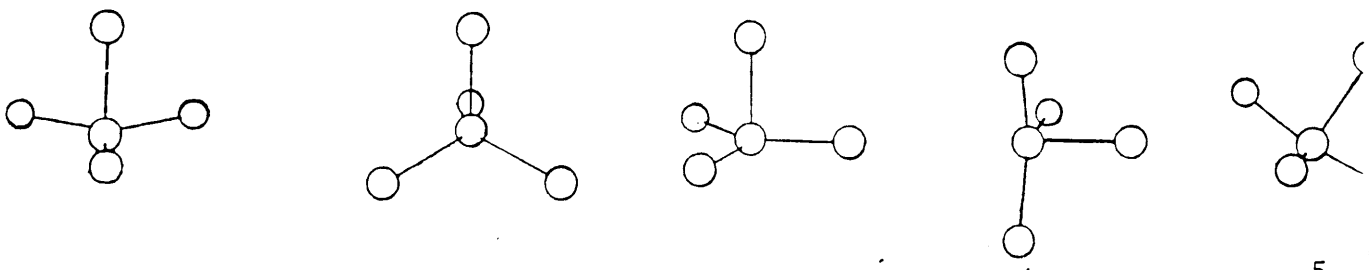
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1 2 3 4 5

If the structure in diagram 1 were rotated about the Y-axis, which
the diagrams 2-5 could represent the structure as seen after rotat

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1 2 3 4 5

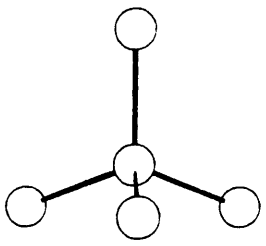
If the structure in diagram 1 were rotated about the Y-axis, whicl
the diagrams 2-5 could represent the structure as seen after rotat

MOLECULAR ROTATION TEST KEY

Item No.	Correct Answer
1	4
2	5
3	5
4	3
5	3
6	2
7	5
8	2
9	2
10	2
11	3
12	5
13	4
14	3
15	5
16	3
17	4
18	5
19	5
20	2
21	2
22	3
23	2
24	5
25	3
26	2
27	2
28	2
29	4
30	3

APPENDIX 2B

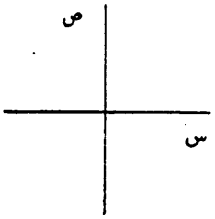
اختبار الدوران الجزيئي

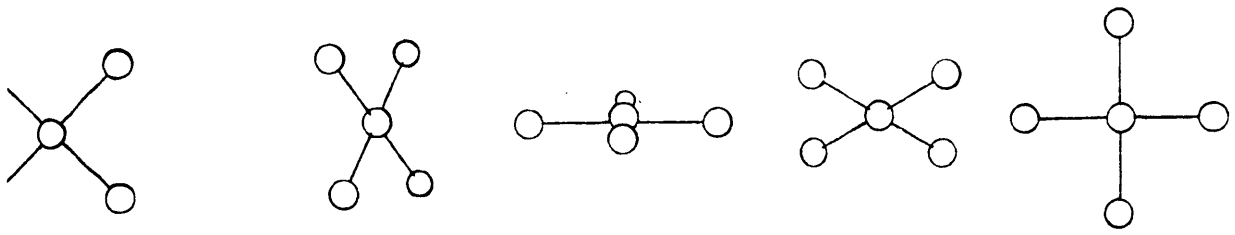


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نورج ـ انجلترا

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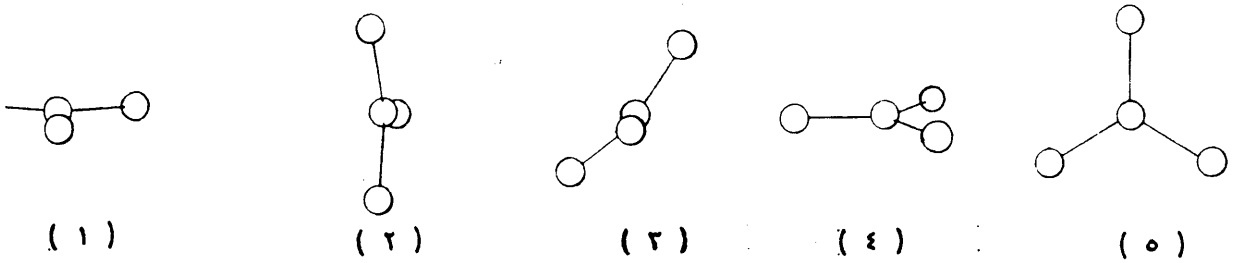
ملاحظة: انك سوف تحتاج للرجوع الى الشكل المرسوم على يسار هذه الملاحظة عند الاجابة على الاسئلة الواردة في هذا الاختبار ان محورى السينات (س) ،والصادات (ص) مرسومان في مستوى الورقة و عليك تصور ان محور العينات (ع) على أنه المحور العمودى على محورى السينات والصادات ، والخارج من مستوى الورقة .





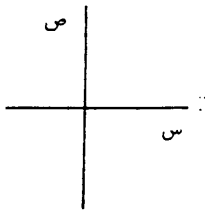
(١) (٢) (٣) (٤) (٥)

عند دروان البناء الجزيئي المبين في شكل (١) حول محور السينات (س)، اى من الاشكال (٢ ـ ٥) يمثل البناء الجزيئي بعد دورانه .

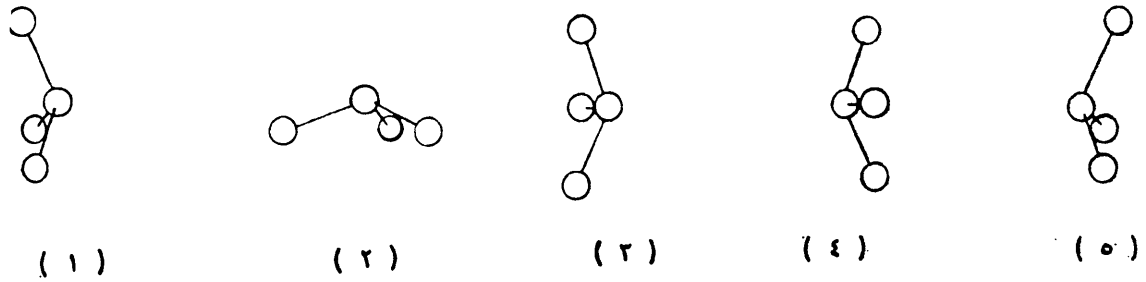


(١) (٢) (٣) (٤) (٥)

عند دروان البناء الجزيئي المبين في شكل (١) حول محور السينات (س)، اى من الاشكال (٢ ـ ٥) يمثل البناء الجزيئي بعد دورانه .

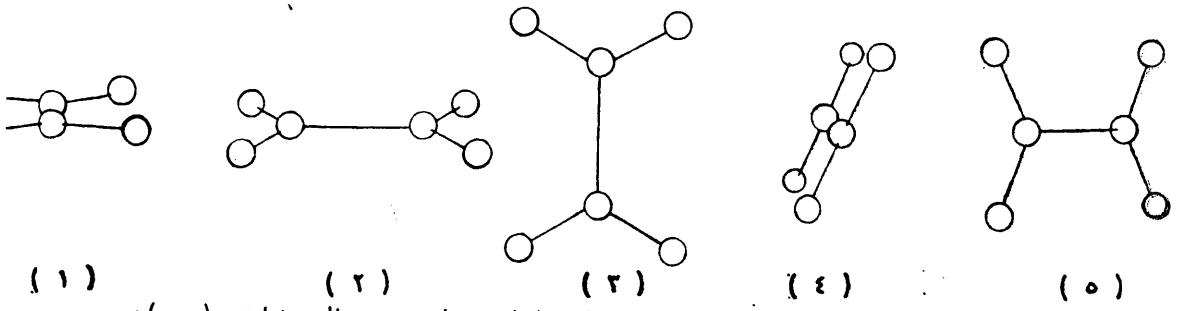


ملاحظة: انك سوف تحتاج للرجوع الى الشكل المرسوم على يسار هذه الملاحظة عند الاجابة على الاسئلة الواردة في هذا الاختبار ان محورى السينات (س) ، والصادات (ص) مرسومان في مستوى الورقة و عليك تصور ان محور العينات (ع) على أنه المحور العمودى على محورى السينات والصادات ، والخارج من مستوى الورقة .



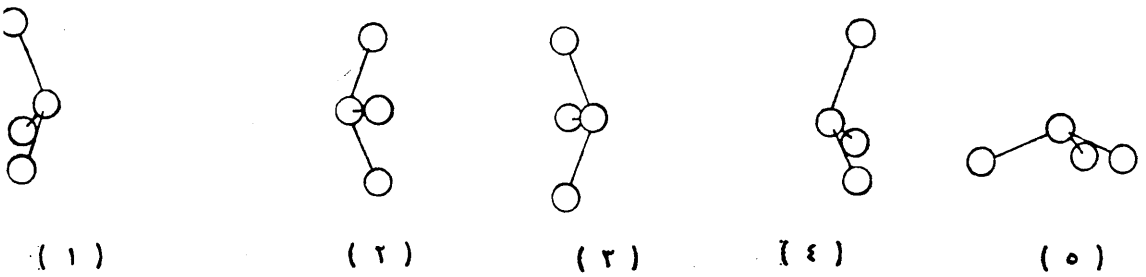
(١) (٢) (٣) (٤) (٥)

عند دوران البناء الجزيئي المبين في شكل (١) حول محور الصادات (ص) ، أى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .



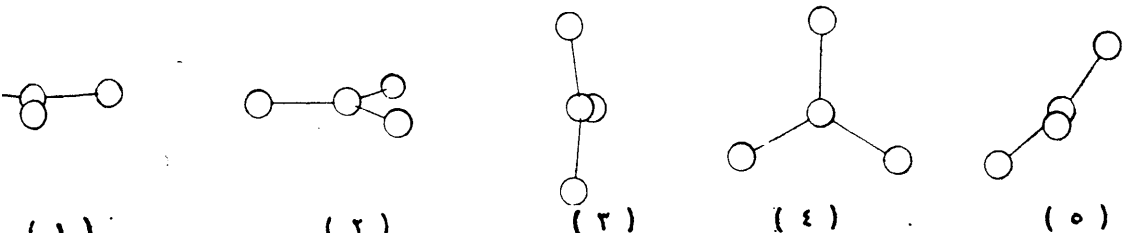
(١) (٢) (٣) (٤) (٥)

عند دوران البناء الجزيئي المبين في شكل (١) حول محور السينات (س) ، اى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .



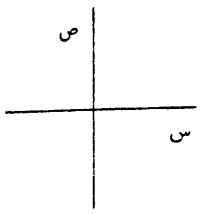
(١) (٢) (٣) (٤) (٥)

عند دوران البناء الجزيئي المبين في شكل (١) حول محور السينات (س) ، اى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .

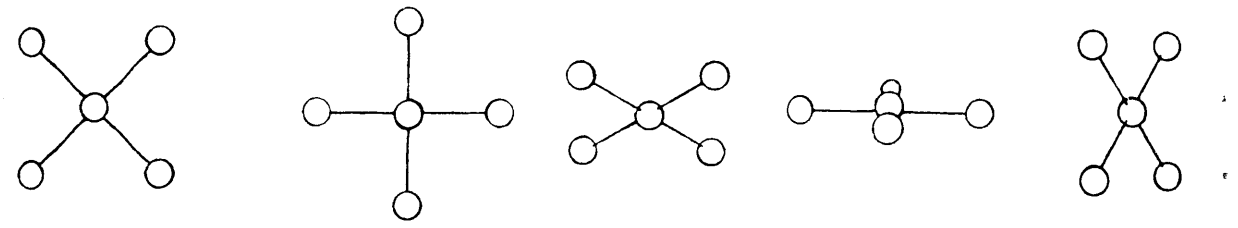


(١) (٢) (٣) (٤) (٥)

عند دوران البناء الجزيئي المبين في شكل (١) حول محور الصادات (ص) ، أى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .

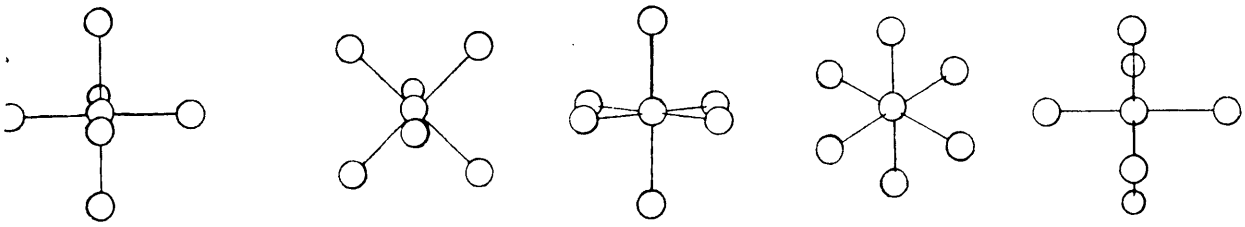


ملاحظة: انك سوف تحتاج للرجوع الى الشكل المرسوم على يسار هذه الملاحظة عند الاجابة على الاسئلة الواردة في هذا الاختبار ان محورى السينات (س) ، والصادات (ص) مرسومان في مستوى الورقة و عليك تصور ان محور العينات (ع) على أنه المحور العمودى على محورى السينات والصادات ، والخارج من مستوى الورقة .



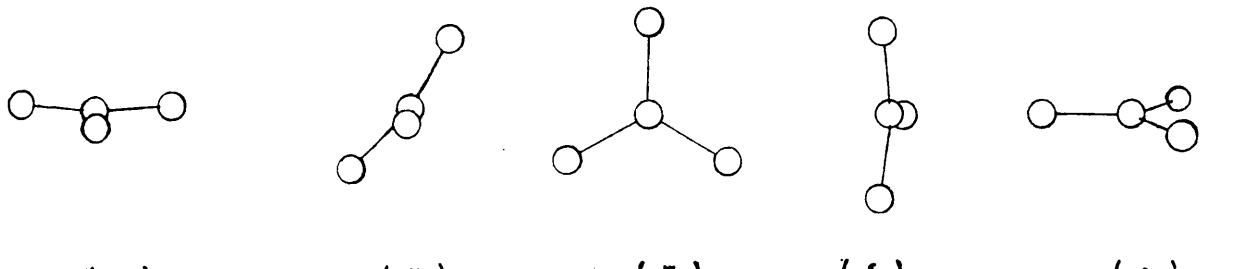
(١) (٢) (٣) (٤) (٥)

عند دوران البناء الجزيئي المبين في شكل (١) حول محور الصادات (ص) ، أى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .



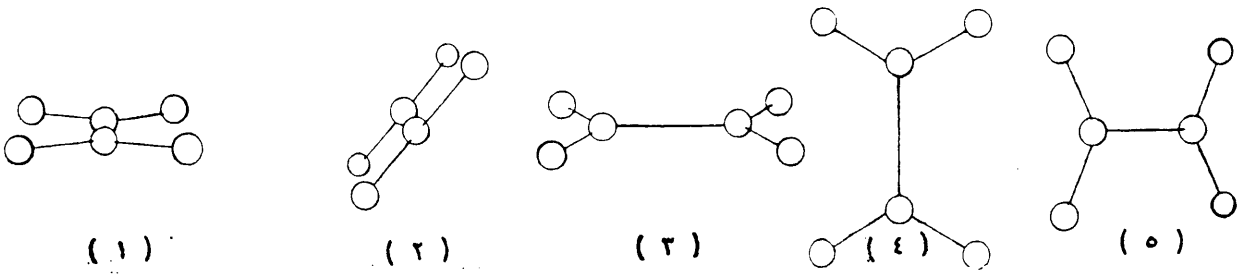
(١) (٢) (٣) (٤) (٥)

عند دوران البناء الجزيئي المبين في شكل (١) حول محور العينات (ع) ، اى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .



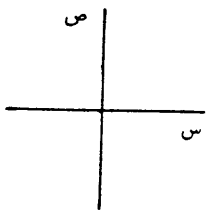
(١) (٢) (٣) (٤) (٥)

عند دوران البناء الجزيئي المبين في شكل (١) حول محور العينات (ع) ، اى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .

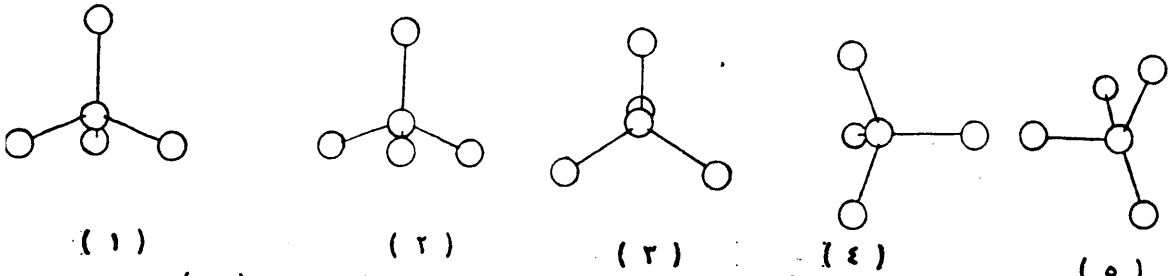


(١) (٢) (٣) (٤) (٥)

عند دوران البناء الجزيئي المبين في شكل (١) حول محور العينات (ع) ، اى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .

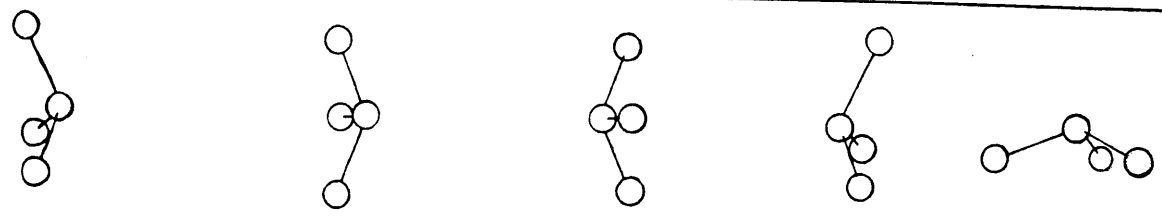


ملاحظة: انك سوف تحتاج للرجوع الى الشكل المرسوم على يسار هذه الملاحظة عند الاجابة على الاسئلة الواردة في هذا الاختبار ان محورى السينات (س) ، والصادات (ص) مرسومان في مستوى الورقة و عليك تصور ان محور العينات (ع) على أنه المحور العمودى على محورى السينات والصادات ، والخارج من مستوى الورقة .



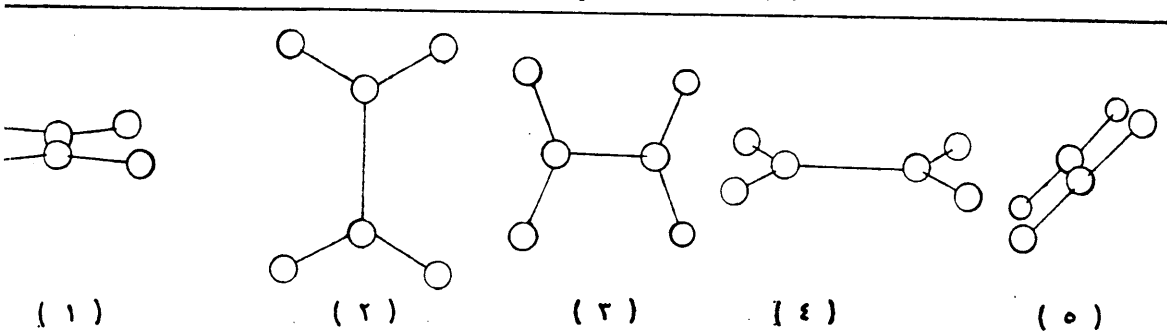
(١) (٢) (٣) (٤) (٥)

عند دوران البناء الجزيئي المبين في شكل (١) حول محور السينات (س)، اى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .



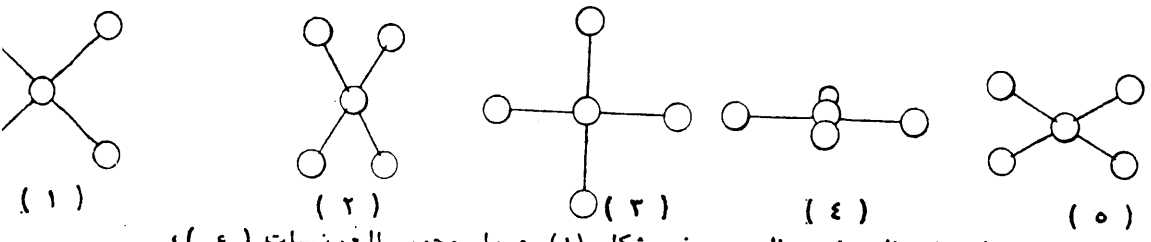
(١) (٢) (٣) (٤) (٥)

عند دوران البناء الجزيئي المبين في شكل (١) حول محور العينات (ع)، اى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .



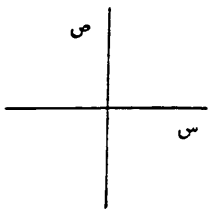
(١) (٢) (٣) (٤) (٥)

عند دوران البناء الجزيئي المبين في شكل (١) حول محور الصادات (ص) ، أى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .



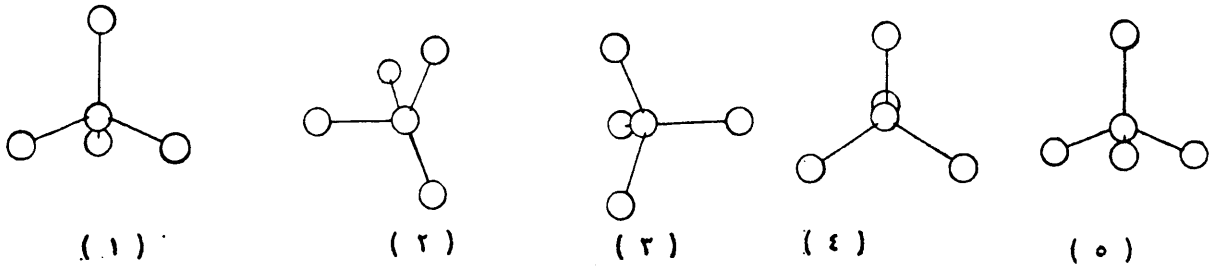
(١) (٢) (٣) (٤) (٥)

عند دوران البناء الجزيئي المبين في شكل (١) حول محور العينات (ع)، اى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .



ملاحظة: انك سوف تحتاج للرجوع الى الشكل المرسوم على يسار هذه الملاحظة عند الاجابة على الاسئلة الواردة في هذا الاختبار ان محورى السينات (س) ، والصادات (ص) مرسومان في مستوى الورقة و عليك تصور ان محور العينات (ع) على أنه المحور العمودى على محورى السينات والصادات ، والخارج من مستوى الورقة .

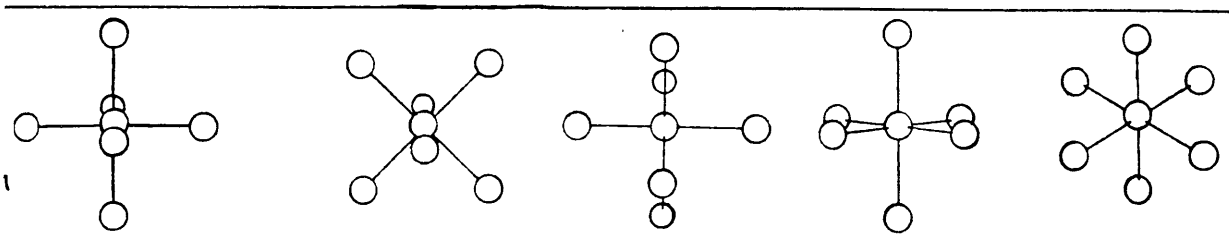
٥



(١) (٢) (٣) (٤) (٥)

عند دوران البناء الجزيئي المبين في شكل (١) حول محور الصادات (ص) ، أى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .

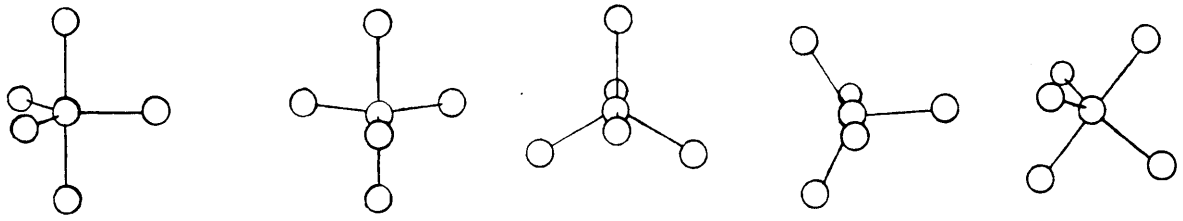
٦



(١) (٢) (٣) (٤) (٥)

عند دوران البناء الجزيئي المبين في شكل (١) حول محور السينات (س) ، اى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .

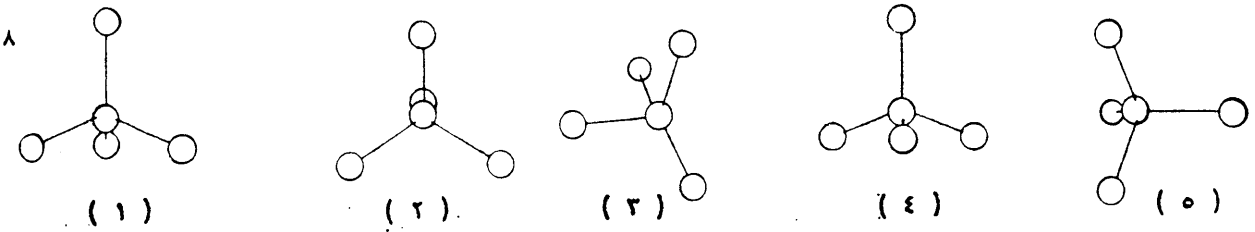
٧



(١) (٢) (٣) (٤) (٥)

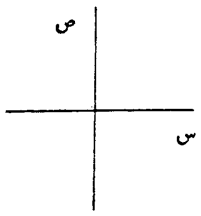
عند دوران البناء الجزيئي المبين في شكل (١) حول محور السينات (س) ، اى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .

٨

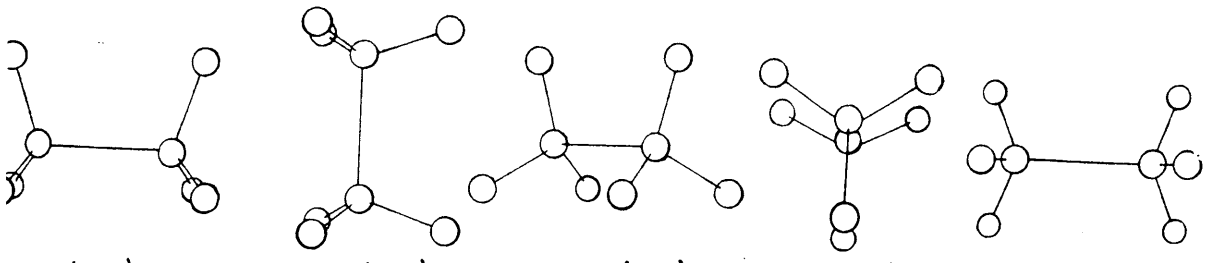


(١) (٢) (٣) (٤) (٥)

عند دوران البناء الجزيئي المبين في شكل (١) حول محور العينات (ع) ، اى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .

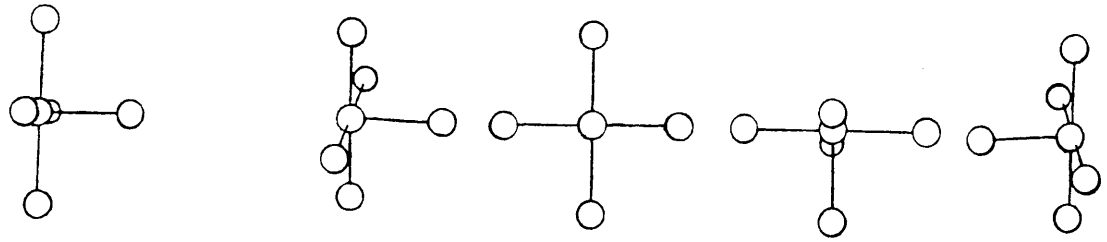


ملاحظة: انك سوف تحتاج للرجوع الى الشكل المرسوم على يسار هذه الملاحظة عند الاجابة على الاسئلة الواردة في هذا الاختبار ان محورى السينات (س) ،والصادات (ص) مرسومان في مستوى الورقة و عليك تصور ان محور العينات (ع) على أنه المحور العمودى على محورى السينات والصادات ، والخارج من مستوى الورقة .



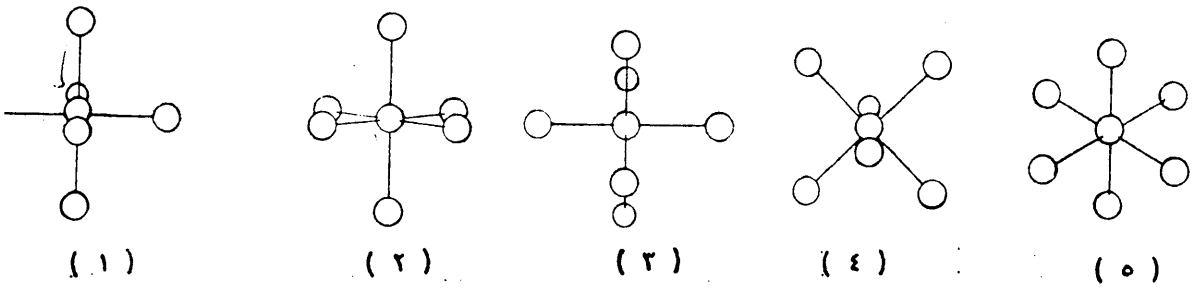
(١) (٢) (٣) (٤) (٥)

عند دوران البناء الجزيئي المبين في شكل (١) حول محور السينات (س)، اى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .



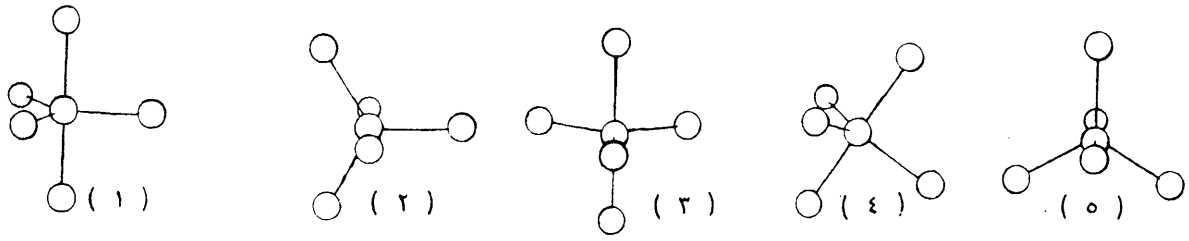
(١) (٢) (٣) (٤) (٥)

عند دوران البناء الجزيئي المبين في شكل (١) حول محور السينات (س)، اى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .



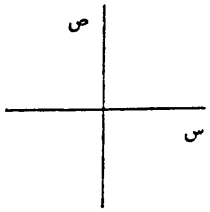
(١) (٢) (٣) (٤) (٥)

عند دوران البناء الجزيئي المبين في شكل (١) حول محور الصادات (ص) ، أى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .

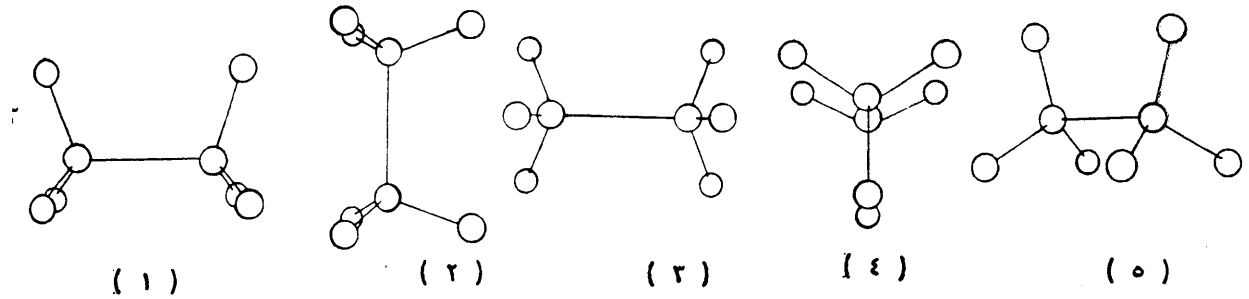


(١) (٢) (٣) (٤) (٥)

عند دوران البناء الجزيئي المبين في شكل (١) حول محور الصادات (ص) ، أى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .



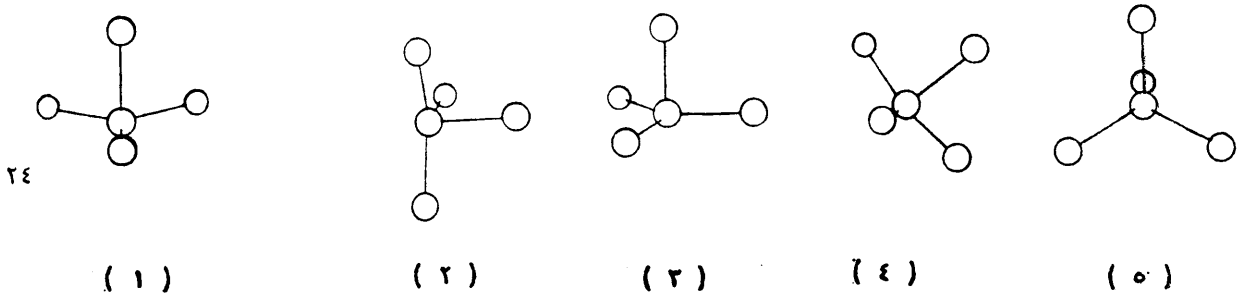
ملاحظة: انك سوف تحتاج للرجوع الى الشكل المرسوم على يسار هذه الملاحظة عند الاجابة على الاسئلة الواردة في هذا الاختبار ان محوري السينات (س) ، والصادات (ص) مرسومان في مستوى الورقة و عليك تصور ان محور العينات (ع) على أنه المحور العمودي على محوري السينات والصادات ، والخارج من مستوى الورقة .



(١) (٢) (٣) (٤) (٥)

عند دوران البناء الجزيئي المبين في شكل (١) حول محور العينات (ع)، اى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .

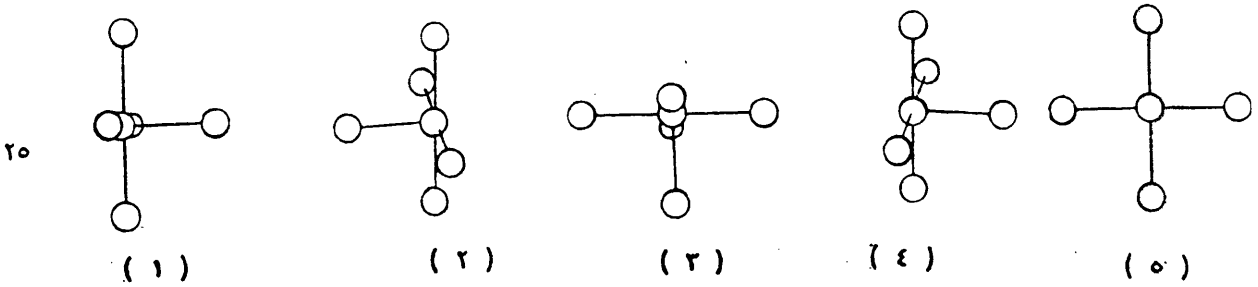
٢٤



(١) (٢) (٣) (٤) (٥)

عند دوران البناء الجزيئي المبين في شكل (١) حول محور السينات (س)، اى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .

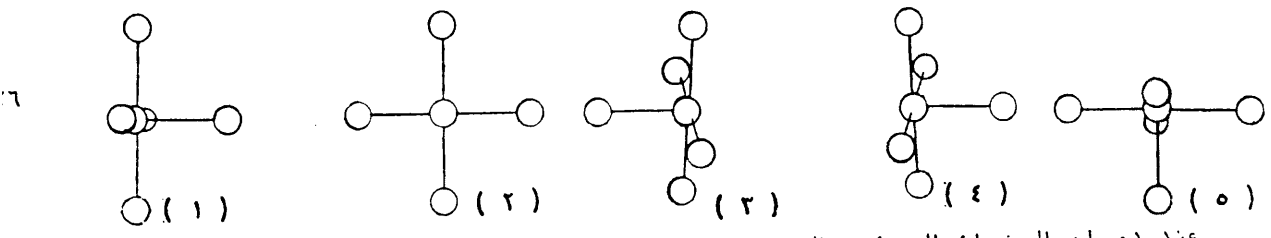
٢٥



(١) (٢) (٣) (٤) (٥)

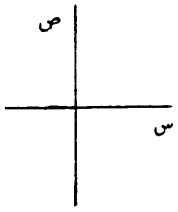
عند دوران البناء الجزيئي المبين في شكل (١) حول محور العينات (ع)، اى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .

٢٦

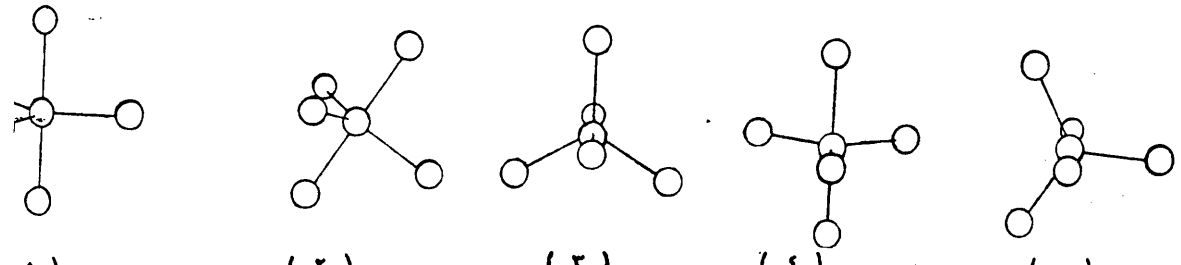


(١) (٢) (٣) (٤) (٥)

عند دوران البناء الجزيئي المبين في شكل (١) حول محور الصادات (ص) ، أى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .

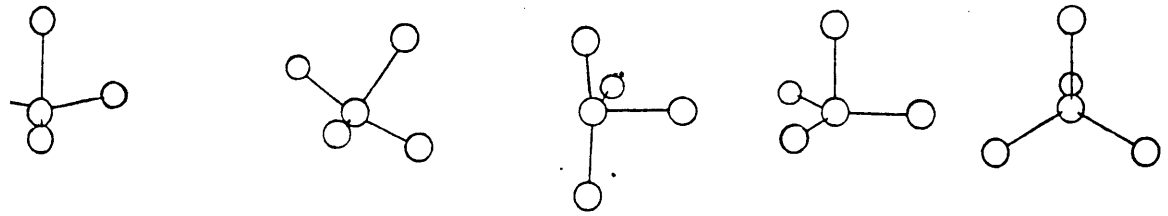


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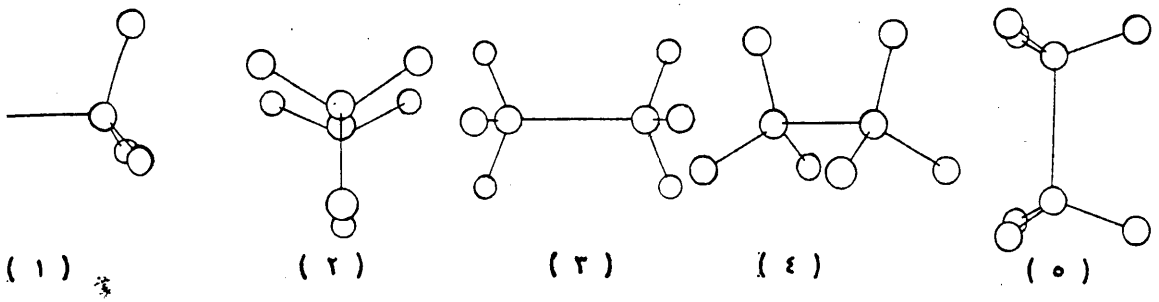
(١) (٢) (٣) (٤) (٥)

عند دوران البناء الجزيئي المبين في شكل (١) حول محور العينات (ع)، اى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .



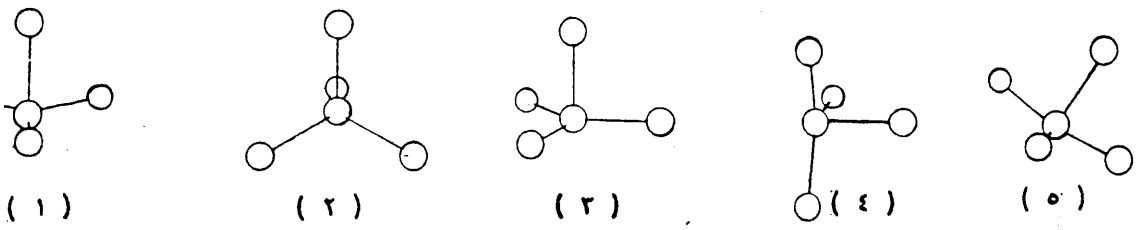
(١) (٢) (٣) (٤) (٥)

عند دوران البناء الجزيئي المبين في شكل (١) حول محور العينات (ع)، اى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .



(١) (٢) (٣) (٤) (٥)

عند دوران البناء الجزيئي المبين في شكل (١) حول محور الصادات (ص) ، أى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .



(١) (٢) (٣) (٤) (٥)

عند دوران البناء الجزيئي المبين في شكل (١) حول محور الصادات (ص) ، أى من الاشكال (٢ – ٥) يمثل البناء الجزيئي بعد دورانه .

APPENDIX 3

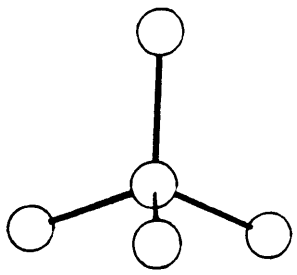
MOLECULAR ROTATION PROGRAMME BOOKLET

A - ENGLISH

B - ARABIC

APPENDIX 3A

MOLECULAR ROTATION PROGRAMME



UNIVERSITY OF EAST ANGLIA

NORWICH, ENGLAND

INTRODUCTION

The aim of this course is to give you some training in improving your ability to visualise rotation of diagrams of molecular structures. Each rotation is about one of three mutually perpendicular axes namely X, Y and Z

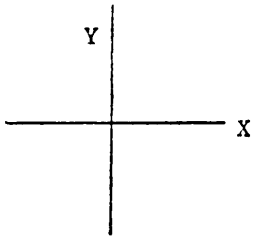
WHAT TO DO

The diagram on the screen represents various stages in the rotation of a structure about the X, Y or Z axis. You will be required to answer questions about some of these diagrams.

The questions are in the booklet and you should write your answer on a separate piece of paper. After attempting each question you will be shown the correct answer on the screen.

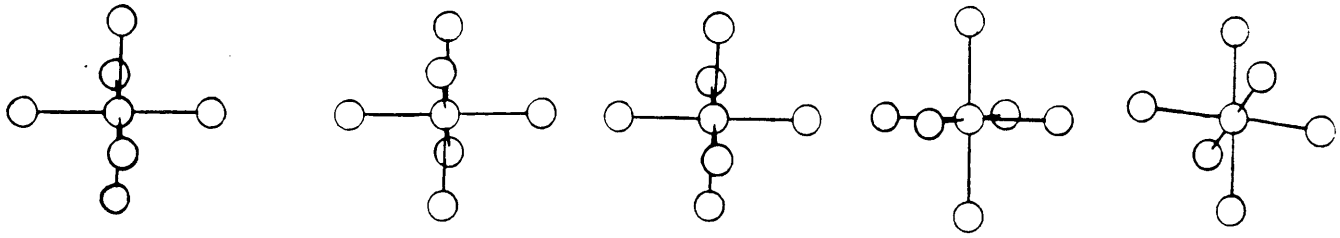
DO NOT MARK IN THIS BOOKLET

Section – X



Note: You need to refer to the axes in this diagram on the le hand side while answering the questions. The X- and Y- axes are drawn in the plane of the paper. You must ima the Z- axis as being perpendicular to them, coming out the plane of the paper.

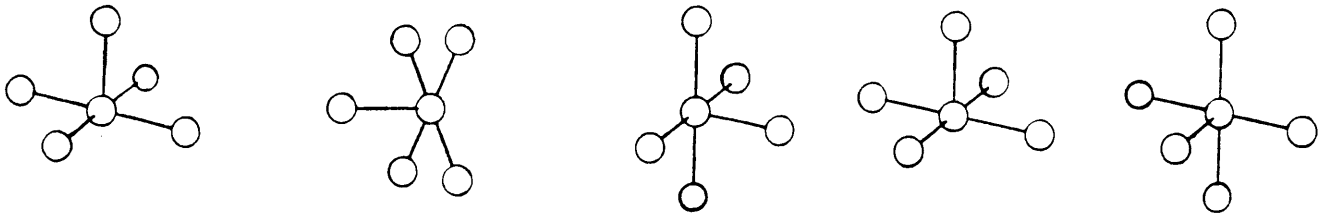
1



1 2 3 4 5

If the structure in diagram 1 were rotated about the X-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

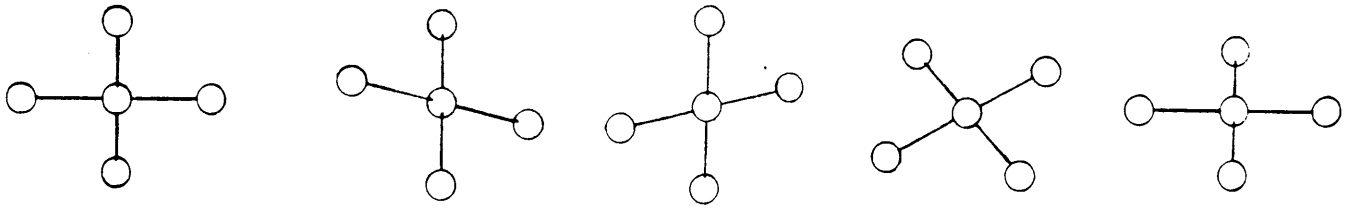
2



1 2 3 4 5

If the structure in diagram 1 were rotated about the X-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

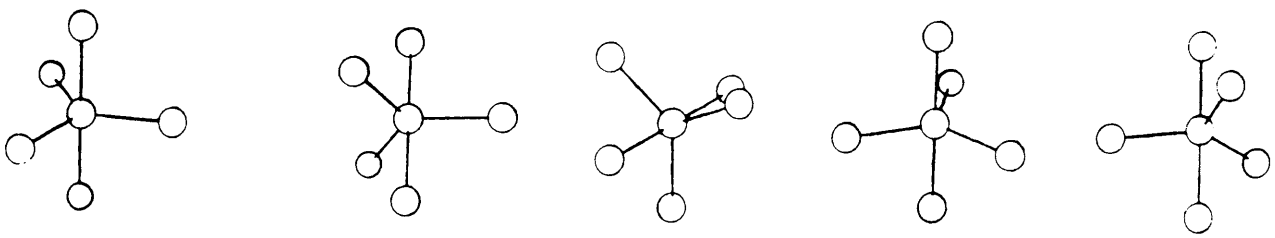
3.



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4.

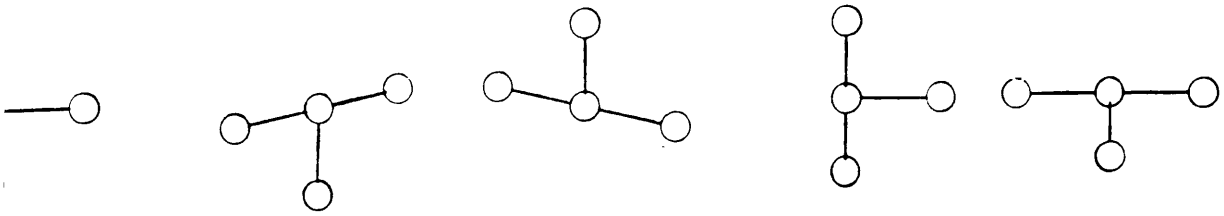


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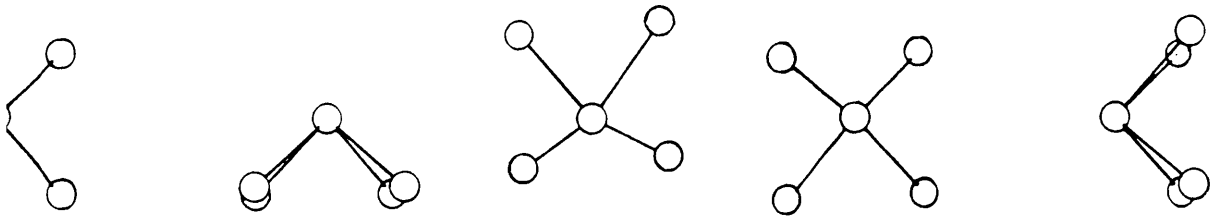
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X



2 3 4 5

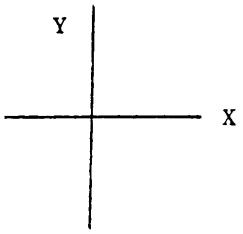
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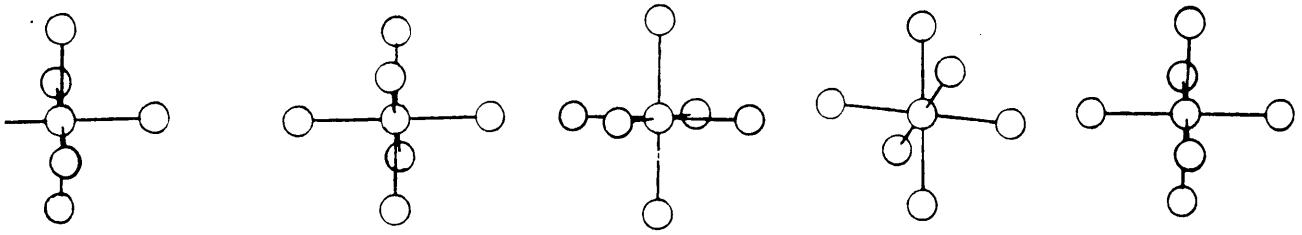
2 3 4 5

If the structure in diagram 1 were rotated about the X-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

Section – Y

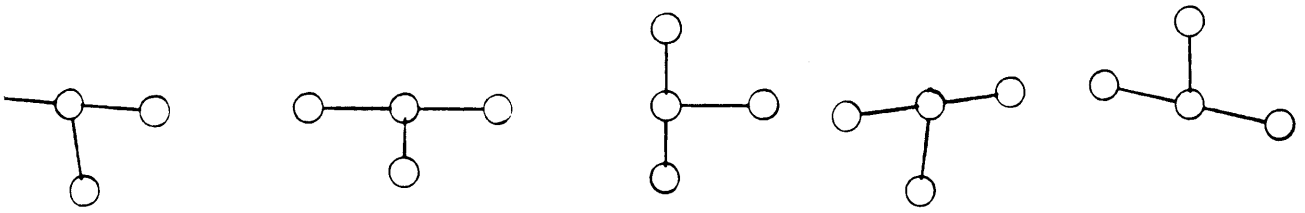


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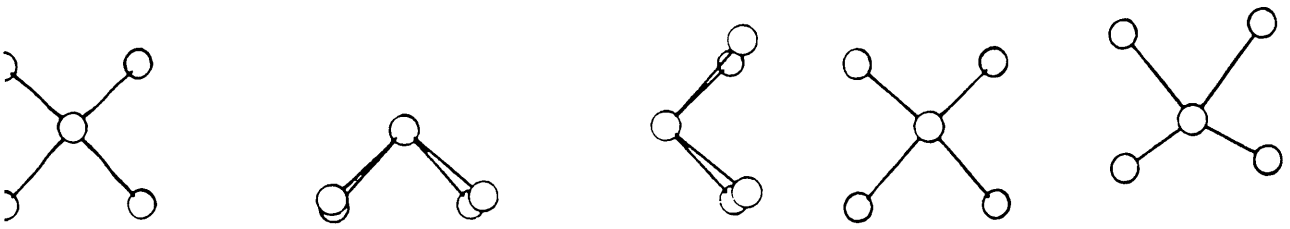
1 2 3 4 5

If the structure in diagram 1 were rotated about the Y- axis, which of the diagrams 2-5 could represent the structure as seen after rotation?



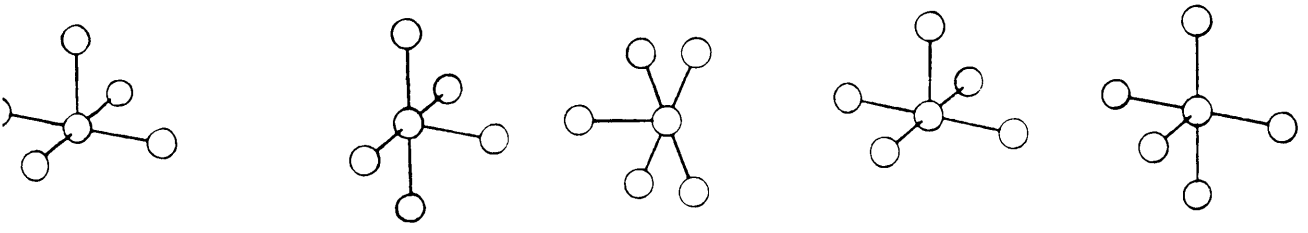
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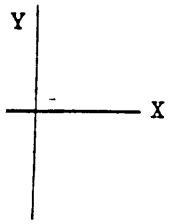
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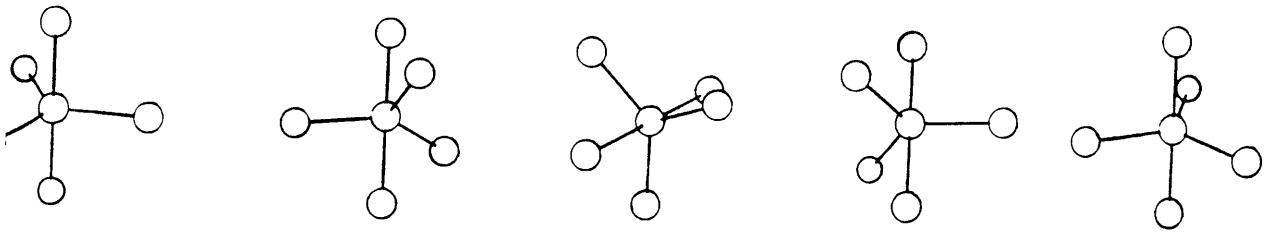


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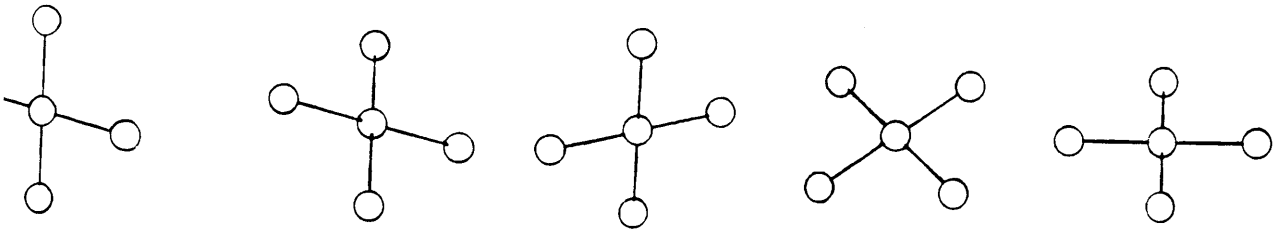


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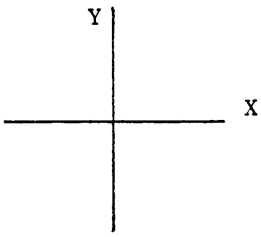
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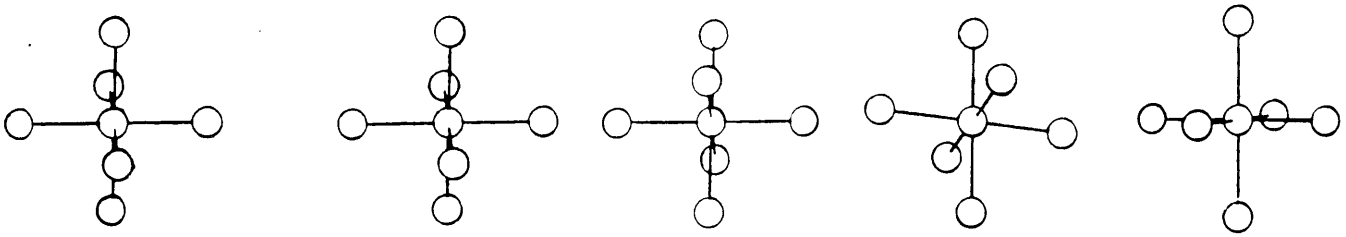


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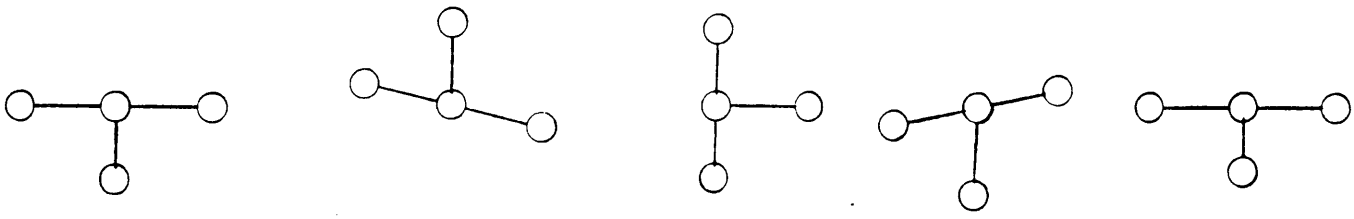


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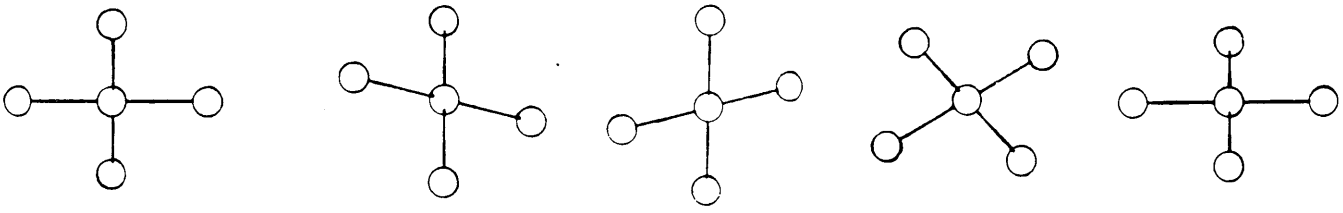
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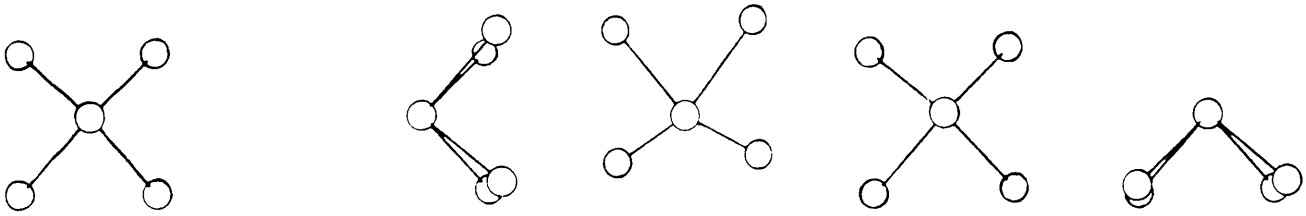
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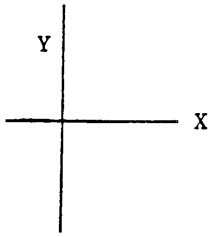
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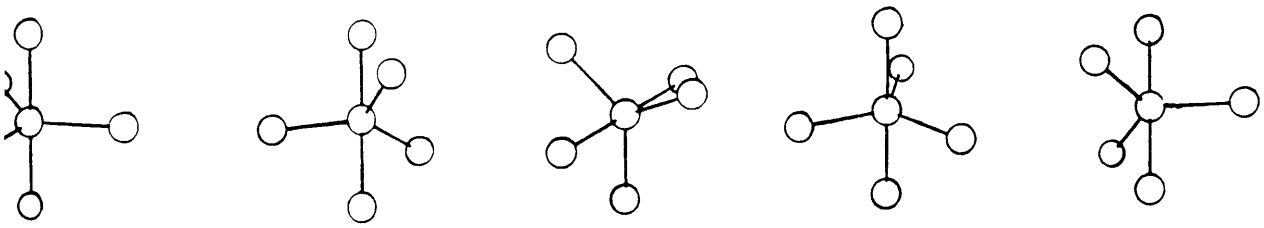


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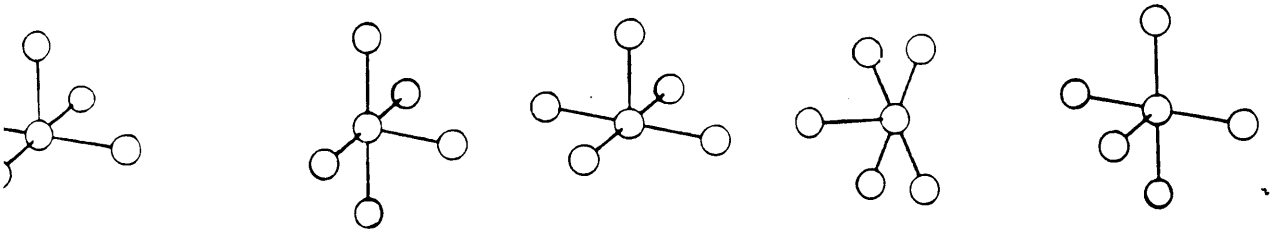


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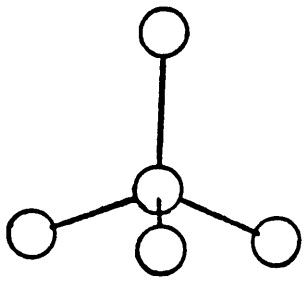


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APPENDIX 3B

برنامج الدوران الجزيئ



جامعة ايست انجليا
نورج ـ انجلترا

١٩٨٣ م

مقدمـــــــة :

ان الهدف من هذا الكتيب هو تدريبك لغرض المساعدة على تحسيـــــــــن مقدرتك على تصور دوران الاشكال التى تبين التراكيب الجزيئيـــــة حـــــول محور واحد من المحاور الفراغية الثلاث س ، ص ، ع المتعاهدة علـــــــى بعضها البعض .

ماهو المطلوب منك عملـــــــــة :

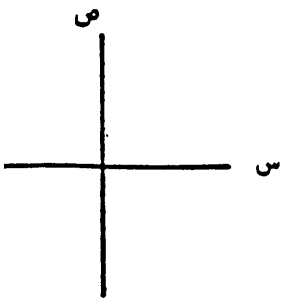
ان الشكل الموجود على الشاشة يمثـل مراحـل متعددة لـدوران تركيـــب جزيئـي واحد حول المحور س ،ص ،ع ، المطلوب منك اجابة لبعض الاسئلـــــة المتعلقة بهذه الاشكال و الـواردة في هذا الكتيب .

المطلوب منك هوكتابة اجابتك على هـذه الأسئلة في ورقـــــــــــة منفصلة وبعد محاولتك على كل سؤال سـوف ترى الاجابة الصحيحـــــــــــة على الشاشـــــــــــــة .

تنبيـــــة :

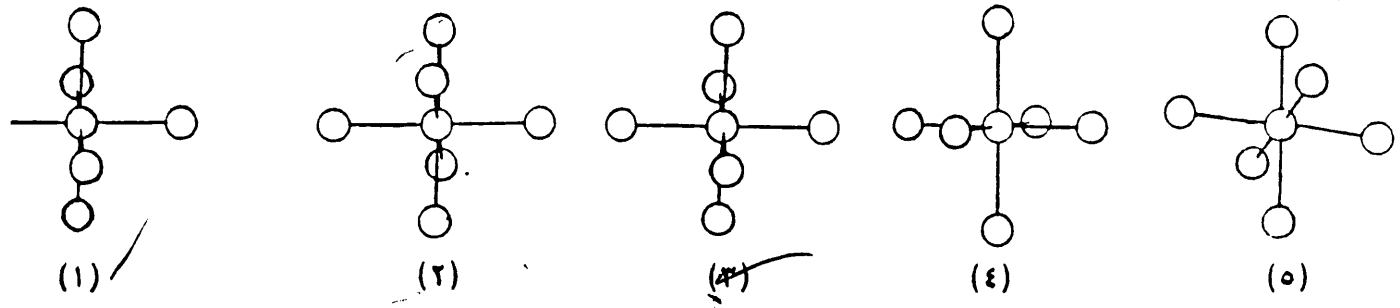
لا تكتب او تعلم على هذا الكتيـب

قسم ـ س



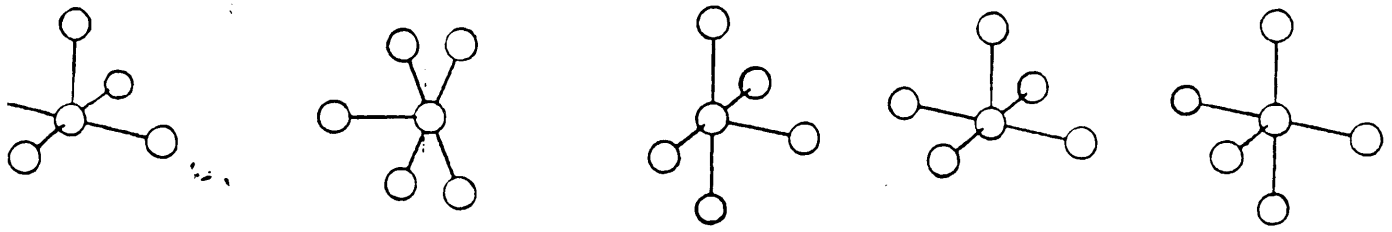
ملاحظـــــة :

سوف تحتاج للرجوع الى الشكل المرسوم على يسار هذه الملاحظـــــة عند الاجابة على الأسئلة الواردة في هذا الكتيب ان محورى السينات (س) ، والصادات (ص) مرسومان في مستوى الورقة وعليك ان تتصور ان محور العينات (ع) على أنه المحور العمـــودى على محورى السينات والصادات والخارج من مستوى الورقة .



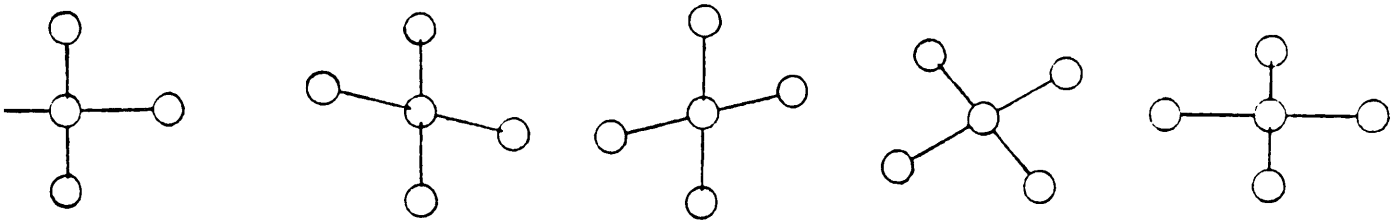
(١) (٢) (٣) (٤) (٥)

عند دوران التركيب المبين في شكل (١) حول محور السينات (س) ، اى مـــــن الأشكـــال (٢ ـ ٥) يمثل التركيب بعد عملية الـدوران .



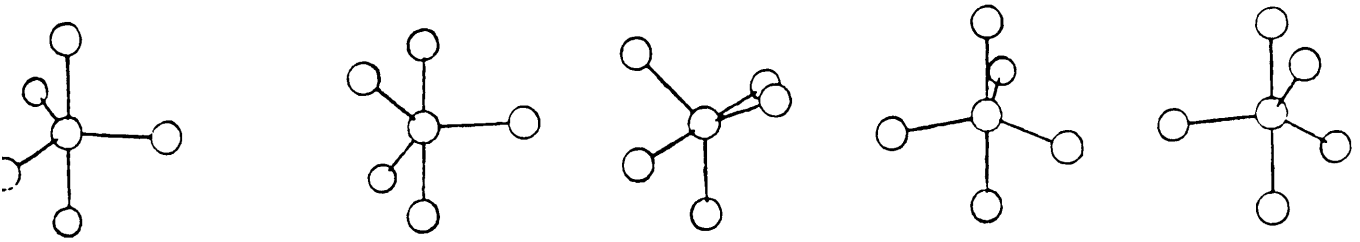
(١) (٢) (٣) (٤) (٥)

عنـد دوران التركيب المبين في شكل (١) حـول محور السينات (س) ، اى مـــــن الأشكال (٢ ـ ٥) يمثل التركيب بعد عملية الـدوران .



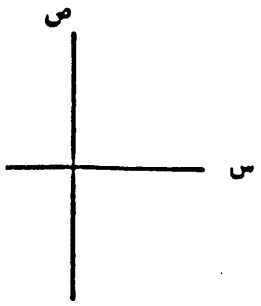
(١) (٢) (٣) (٤) (٥)

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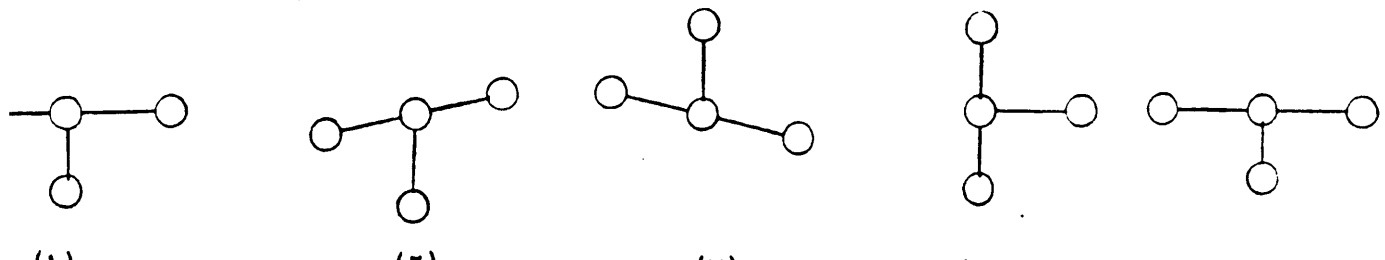
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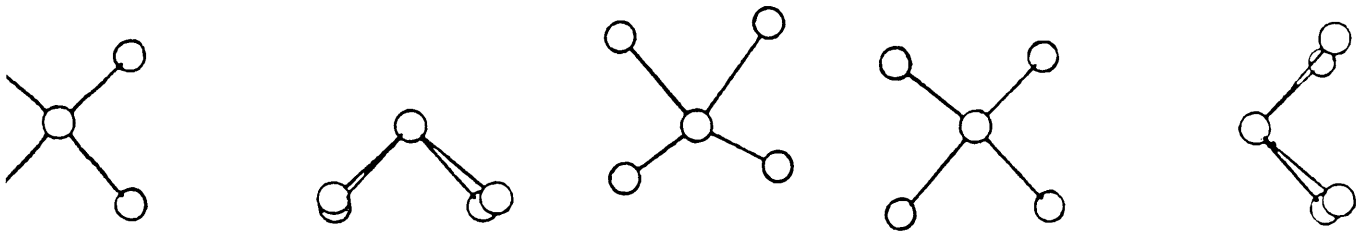
ملاحظـــــة :

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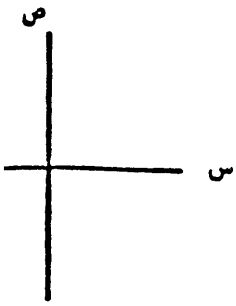
عند دوران التركيب المبين في شكل (١) حول محور السينات (س) ، اى مـــــــن الأشكـــال (٢ – ٥) يمثل التركيب بعد عملية الـــدوران .



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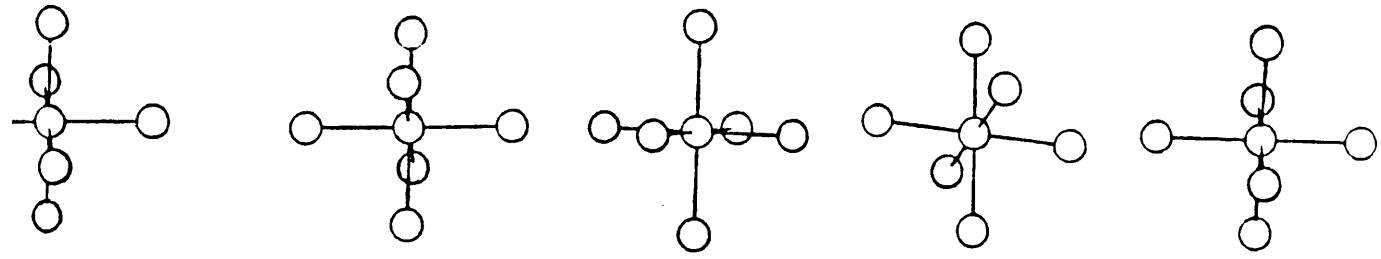
عنـــد دوران التركيب المبين في شكل (١) حـــول محور السينات (س) ، اى مـــــن الأشكال (٢ – ٥) يمثل التركيب بعد عملية الـــدوران .

قسم ـ ص



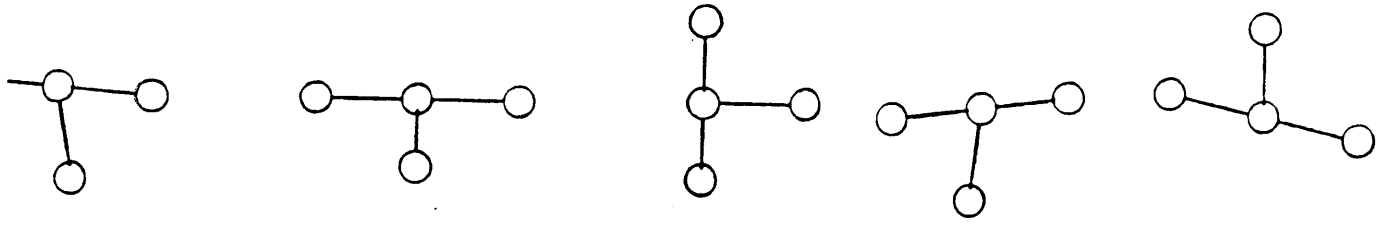
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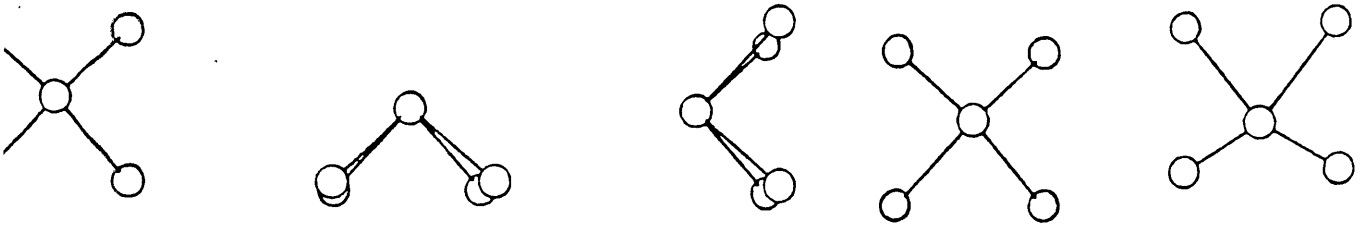
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عند دوران التركيب المبين في شكل (١) حـول محور الصـادات (ص) ، اى مـــن الأشكال (٢ ـ ٥) يمثل التركيب بعد عملية الـدوران .



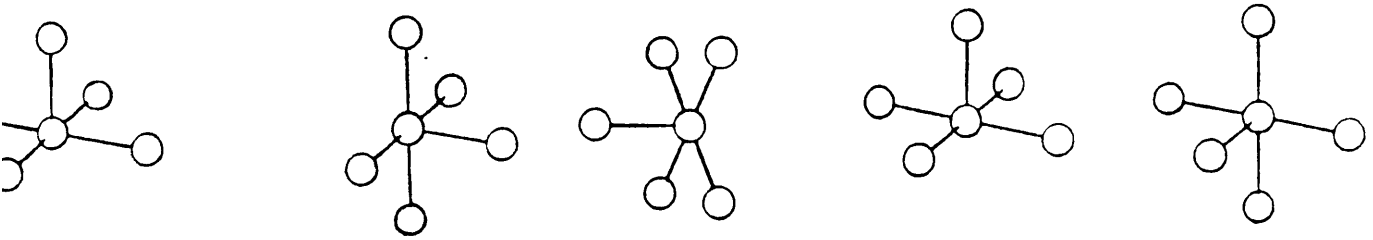
(١) (٢) (٣) (٤) (٥)

عند دوران التركيب المبين في شكل (١) حـول محور الصـادات (ص) ، اى مـــن الأشكال (٢ ـ ٥) يمثل التركيب بعد عملية الـدوران .



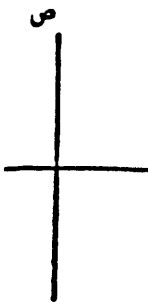
(١) (٢) (٣) (٤) (٥)

عند دوران التركيب المبين في شكل (١) حـول محور الصـادات (ص) ، اى مـــن الأشكال (٢ ـ ٥) يمثل التركيب بعد عملية الـدوران .



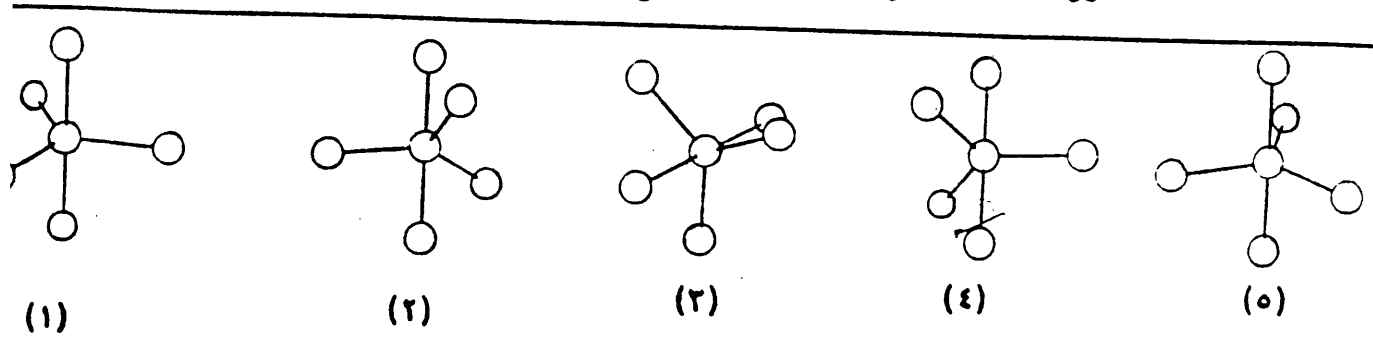
(١) (٢) (٣) (٤) (٥)

عند دوران التركيب المبين في شكل (١) حـول محور الصـادات (ص) ، اى مـــن الأشكال (٢ ـ ٥) يمثل التركيب بعد عملية الـدوران .



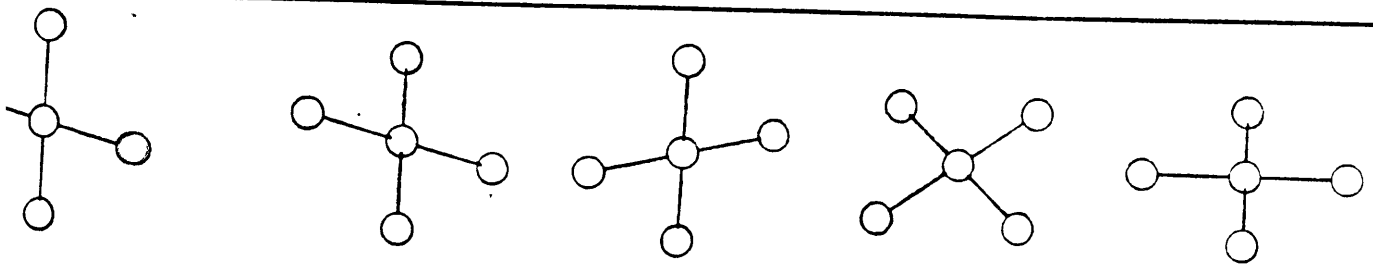
ملاحظـــــة :

سوف تحتاج للرجوع الى الشكل المرسوم على يسار هذه الملاحظـــــة عند الاجابة على الأسئلة الواردة في هذا الكتيب ان محورى السينات (س) ، والصادات (ص) مرسومان في مستوى الورقة وعليك ان تتصوران محور العينات (ع) على أنه المحور العمـــودى على محورى السينات والصادات والخارج من مستوى الورقة .



(١) (٢) (٣) (٤) (٥)

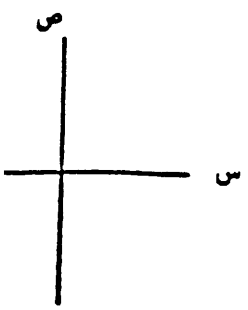
عند دوران التركيب المبين في شكل (١) حـول محور الصادات (ص) ، اى مـــــن الأشكال (٢ ـ ٥) يمثل التركيب بعد عملية الـدوران .



(١) (٢) (٣) (٤) (٥)

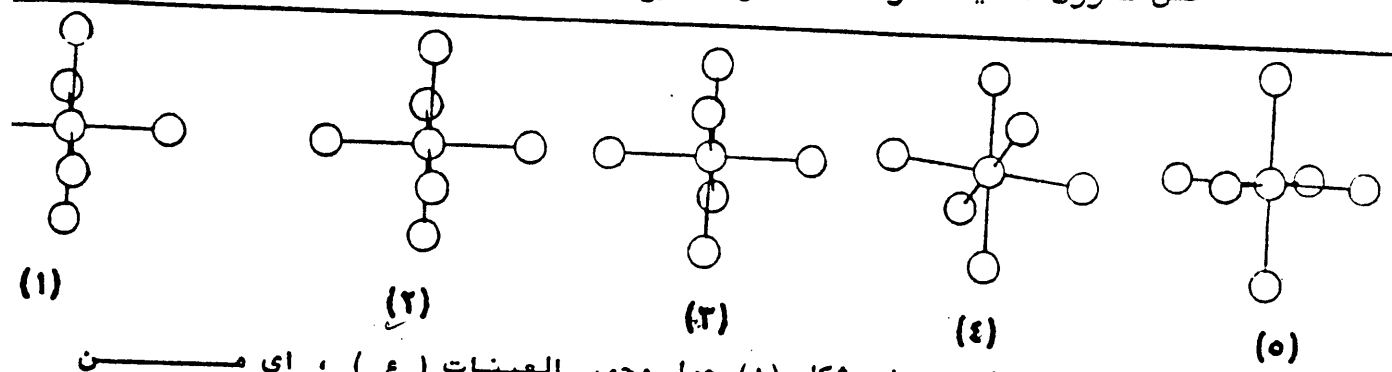
عند دوران التركيب المبين في شكل (١) حـول محور الصادات (ص) ، اى مـــــن الأشكال (٢ ـ ٥) يمثل التركيب بعد عملية الـدوران .

قسم – ع

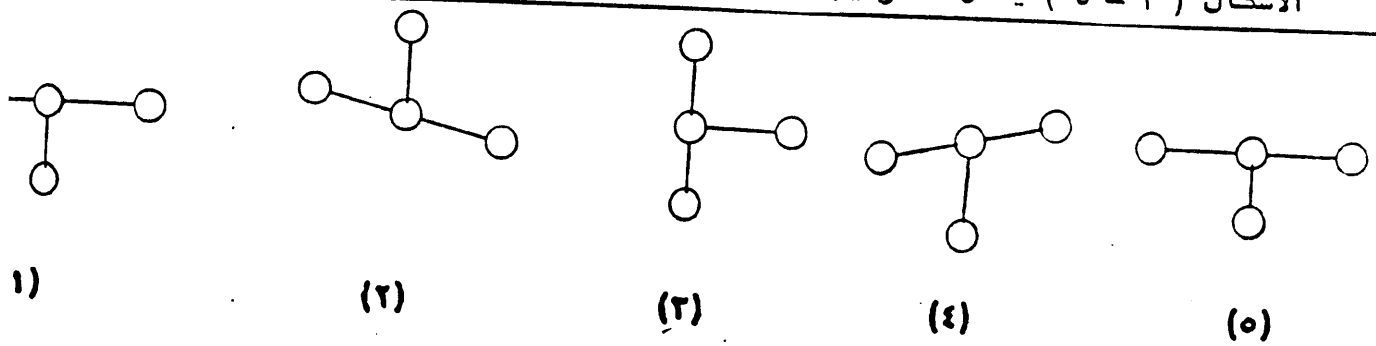


ملاحظـــــة :

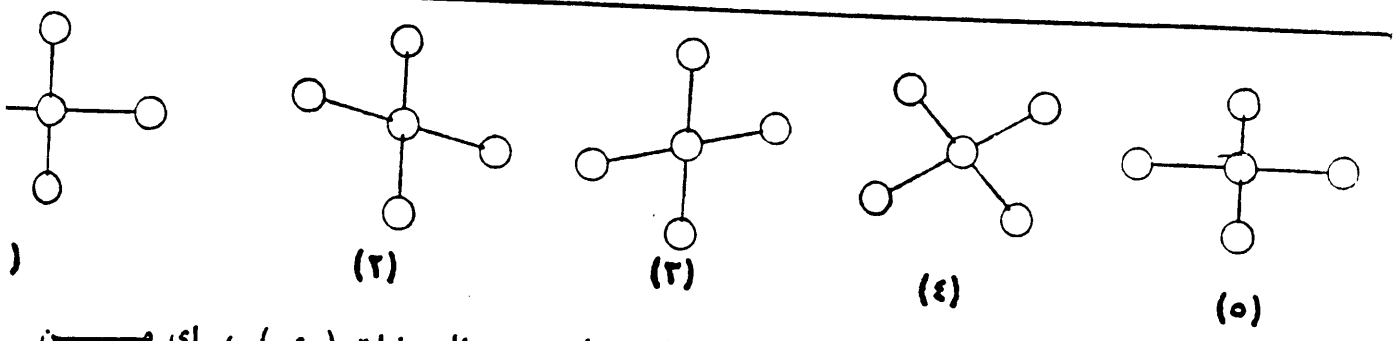
سوف تحتاج للرجوع الى الشكل المرسوم على يسار هذه الملاحظـــــة عند الاجابة على الأسئلة الواردة في هذا الكتيب ان محورى السينات (س) ، والصادات (ص) مرسومان في مستوى الورقة وعليك ان تتصوران محور العينات (ع) على أنه المحور العمـــودى على محورى السينات والصادات والخارج من مستوى الورقة .



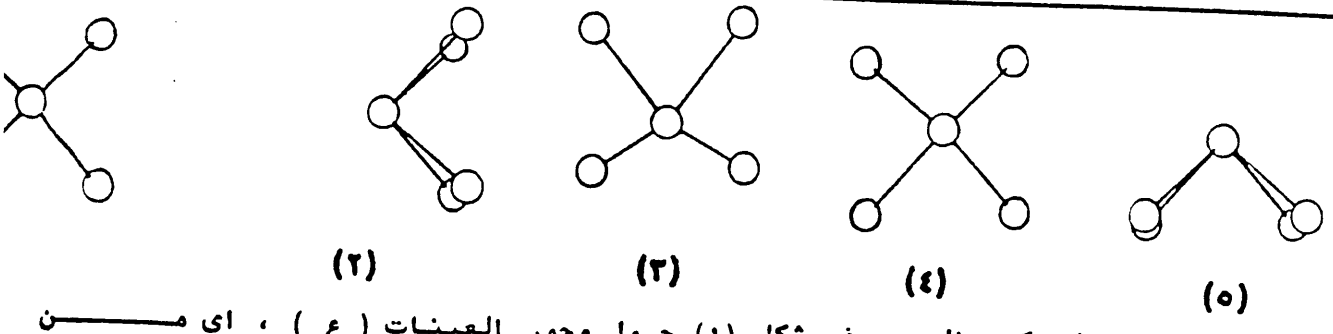
عند دوران التركيب المبين في شكل (١) حول محور العينات (ع) ، اى مـــــن الأشكال (٢ – ٥) يمثل التركيب بعد عملية الدوران .



عند دوران التركيب المبين في شكل (١) حول محور العينات (ع) ، اى مـــــن الأشكال (٢ – ٥) يمثل التركيب بعد عملية الدوران .

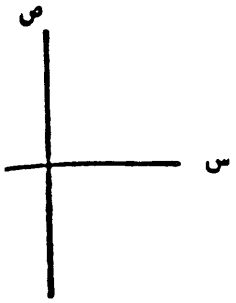


عند دوران التركيب المبين في شكل (١) حول محور العينات (ع) ، اى مـــــن الأشكال (٢ – ٥) يمثل التركيب بعد عملية الدوران .



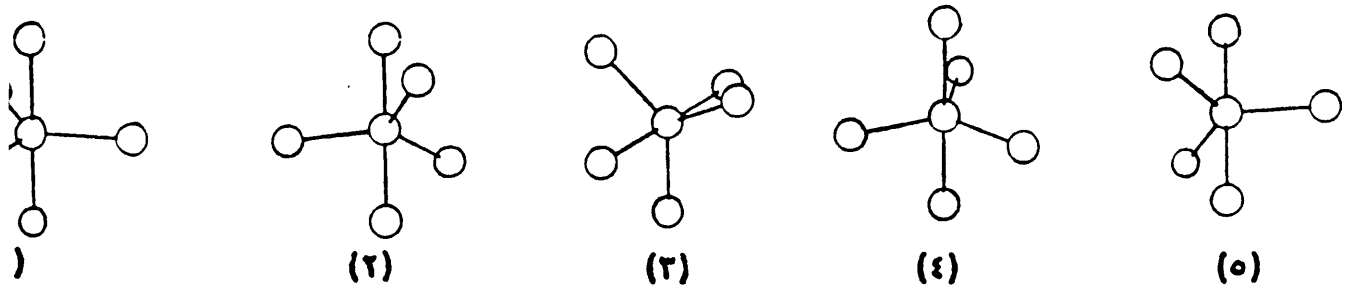
عند دوران التركيب المبين في شكل (١) حول محور العينات (ع) ، اى مـــــن

يمثل التركيب بعد عملية الدوران .

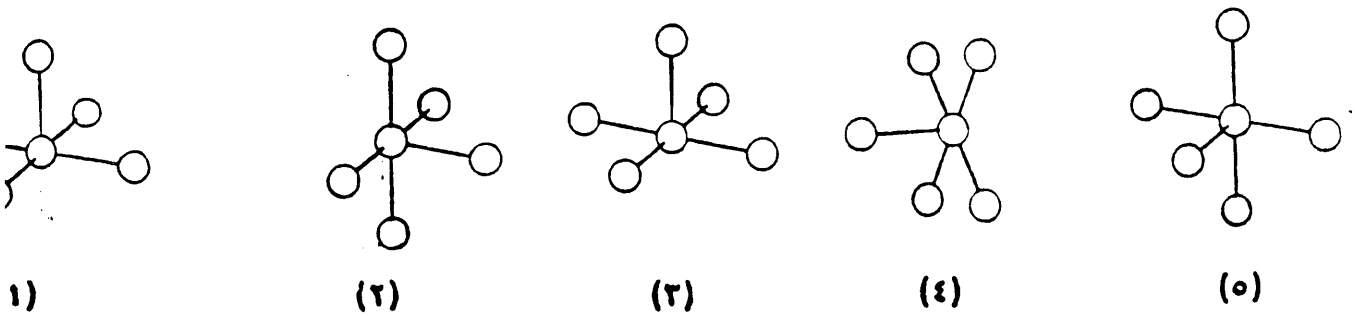


ملاحظـــــة :

سوف تحتاج للرجوع الى الشكل المرسوم على يسار هذه الملاحظـــــة عند الاجابة على الأسئلة الواردة في هذا الكتيب ان محورى السينات (س) ، والصادات (ص) مرسومان في مستوى الورقة وعليك ان تتصوران محور العينات (ع) على أنه المحور العمـــودى على محورى السينات والصادات والخارج من مستوى الورقة .



عند دوران التركيب المبين في شكل (١) جول محور العينات (ع) ، اى مـــــن الأشكال (٢ – ٥) يمثل التركيب بعد عملية الدوران .



عند دوران التركيب المبين في شكل (١) حول محور العينات (ع) ، اى مـــــن الأشكال (٢ – ٥) يمثل التركيب بعد عملية الدوران .

APPENDIX 4

THE DIAGRAM PERCEPTION TEST

(FRAMEWORKS TEST)

A - ENGLISH

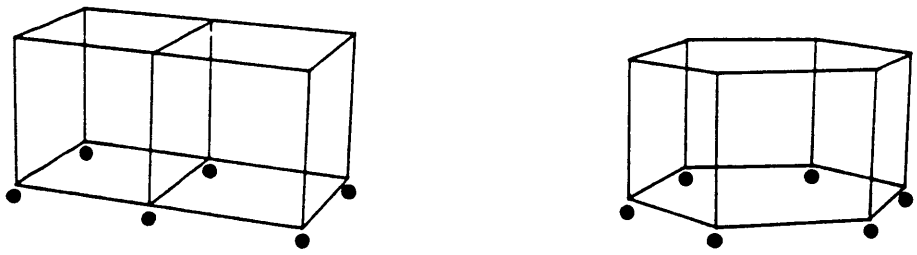
B - ARABIC

APPENDIX 4A

DIAGRAM PERCEPTION TEST

PLEASE DO NOT OPEN YOUR BOOKLET UNTIL YOU ARE TOLD TO DO SO.

This booklet contains diagrams of frameworks. There are two kinds, as shown below.



The frameworks in this booklet are shown sitting on a flat horizontal surface like a table. The dots in the diagrams show which parts of the framework are on the flat surface.

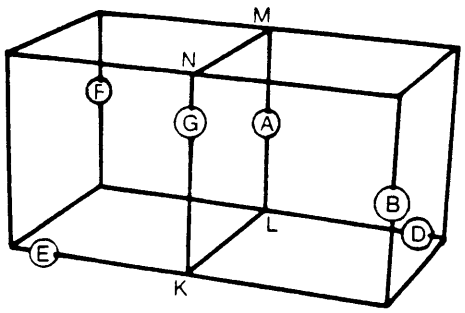
Before you start the test you will see an example of each framework.

The diagrams in this booklet show balls attached to the frameworks. Questions are asked about each diagram. Please mark the answers on the answer sheet provided.

These booklets may have to be used again. PLEASE DO NOT DRAW UPON THEM, OR MARK THEM IN ANY WAY.

THERE IS NO TIME LIMIT FOR THIS TEST.

1



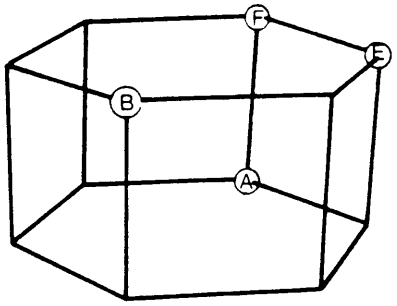
1.1 Which ball, F or G, is higher on the framework?

1.2 Which ball, E or F, is nearer to the vertical plane KLMN?

1.3 Which ball, B or D, is nearer to the vertical plane KLMN?

1.4 Which ball, B or G, is at the same height on the framework as ball A?

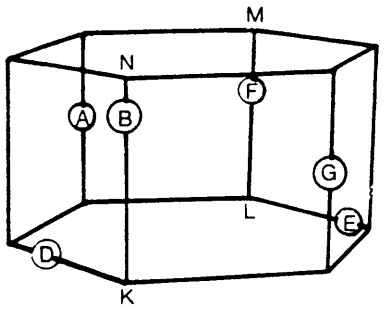
2



2.1 Which ball, F or A, is nearer to ball B?

2.2 Which ball, E or A, is further from ball B?

3



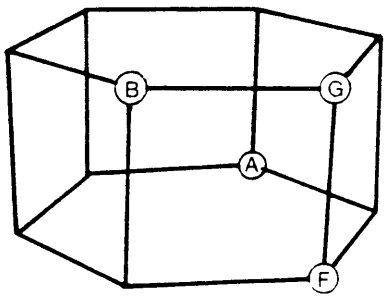
3.1 Which ball, A or D, is nearer to the vertical plane KLMN?

3.2 Which ball, B or F, is higher on the framework?

3,3 Which ball, B or G, is at the same height on the framework as ball A?

3.4 Which ball, E or G, is nearer to the vertical plane KLMN?

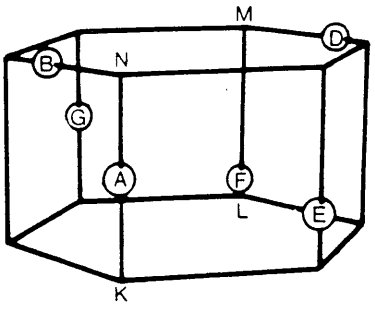
4



4.1 Which ball, F or A, is further from ball B?

4.2 Which ball, G or A, is nearer to ball B?

5



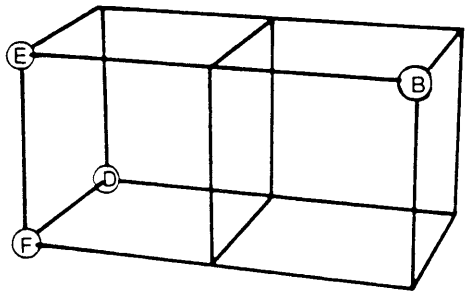
5.1 Which ball, D or E, is nearer to the vertical plane KLMN?

5.2 Which ball, F or G, is at the same height on the framework as ball A?

5.3 Which ball, B or G, is nearer to the vertical plane KLMN?

5.4 Which ball, E or F, is higher on the framework?

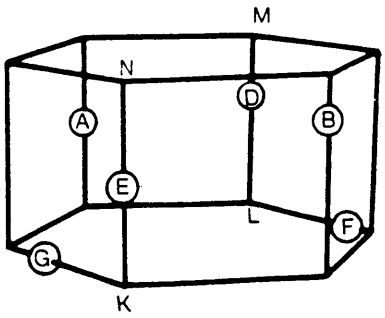
6



6.1 Which ball, D or F, is further from ball B?

6.2 Which ball, D or E, is nearer to ball B?

7



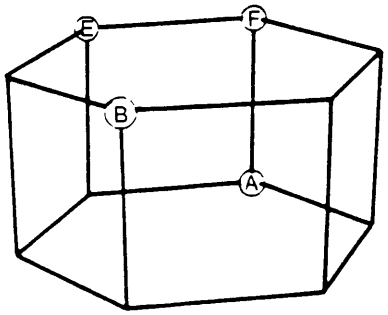
7.1 Which ball, B or D, is higher on the framework?

7.2 Which ball, B or F, is nearer to the vertical plane KLMN?

7.3 Which ball, A or G, is nearer to the vertical plane KLMN?

7.4 Which ball, B or E, is at the same height on the framework as ball A?

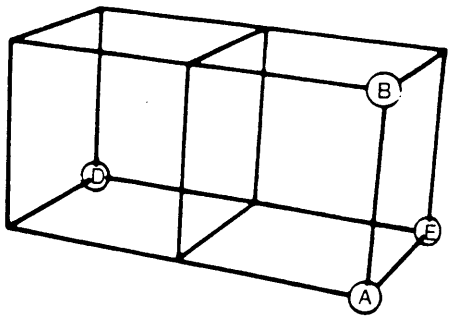
8



8.1 Which ball, F or B, is nearer to ball A?

8.2 Which ball, E or B, is further from ball A?

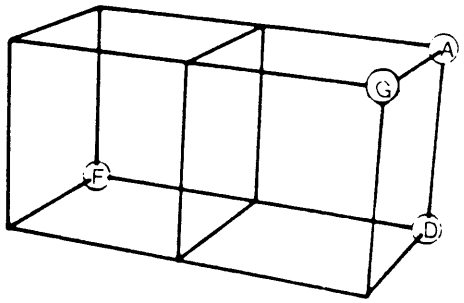
9



9.1 Which ball, A or E, is nearer to ball D?

9.2 Which ball, B or E, is further from ball D?

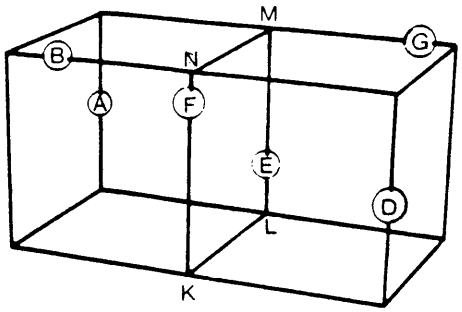
10



10.1 Which ball, D or G, is nearer to ball F?

10.2 Which ball, G or A, is further from ball F?

11



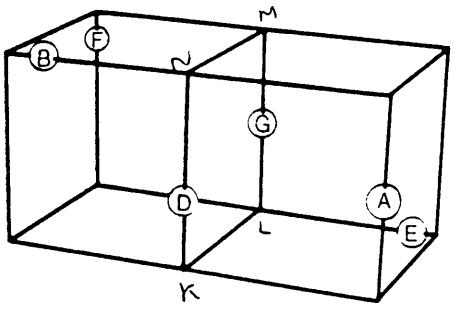
11.1 Which ball, D or E is higher on the framework?

11.2 Which ball, D or F, is at the same height on the framework as ball A?

11.3 Which ball, D or G, is nearer to the vertical plane KLMN?

11.4 Which ball, A or B, is nearer to the vertical plane KLMN?

12



12.1 Which ball, B or F, is higher on the framework?

12.2 Which ball, A or E, is nearer to the vertical plane KLMN?

12.3 Which ball, B or F, is nearer to the vertical plane KLMN?

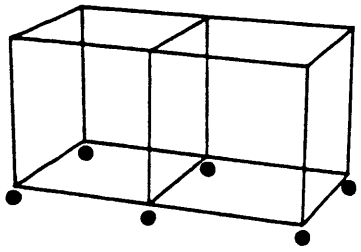
12.4 Which ball, D or G, is at the same height on the framework as ball A?

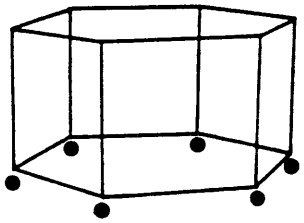
APPENDIX 4B

اختبار فى ادراك الأشكـــــــــــال

الرجاء ابقاء كتيب الاختبار مغلقا حتى يطلب منك فتحـــــــــــه .

يحتوى كتيب الاختبار هذا على أشكال مجسمات ، ويوجد نوعان منها كما هو مبين أد





يجب اعتبار جميع المجسمات الواردة في هذا الاختبار مرتكزة على سطح أفقي مستوى كـ الطاولة مثلا . وتبين النقاط الكبيرة السوداء أجزاء المجسمات المرتكزة على ذلك الس المستوى .

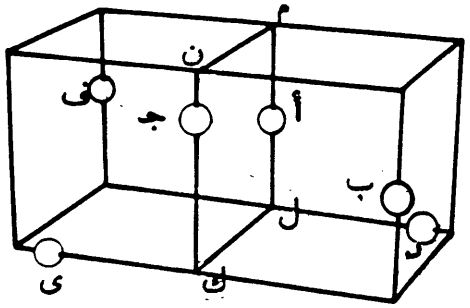
قبل البدء بالاجابة على أسئلة الاختبار ستشاهد نموذجا لكل نوع من هذه المجسما تظهر الرسومات فى هذا الكتيب كرات ملصقة بالمجسمات ، وتدور الأسئلة حول شكـ كل مجســـــــم .

الرجاء الاشارة الى الأجوبة الصحيحة على ورقة الاجابة المرفقـــــــة .

قد تستعمل كتيبات الاختبار هذا مرة أخرى ، لذا نرجو عدم الكتابة أو الرسم عليهـ تحت أى ظـــــرف.

الوقت غير محدود لهذا الاختبـــــــار

١



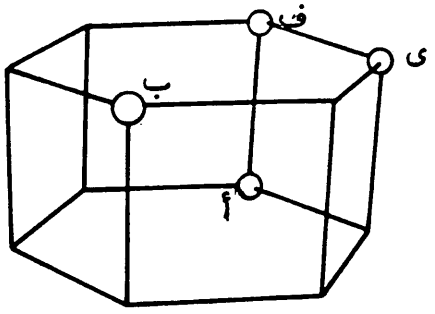
١٠١ في المجسم أعلاه أى الكرتين أعلى (ف) أم (جـ) ؟

٢٠١ أى الكرتين (ى) أم (ف) أقرب الى السطح المعمود ى ك ل م ن ؟

٣٠١ أى الكرتين (ب) أم (د) أقرب الى السطح المعمود ى ك ل م ن ؟

٤٠١ أى الكرتين (ب) أم (جـ) تقع على نفس ارتفاع الكرة (أ) في المجسم ؟

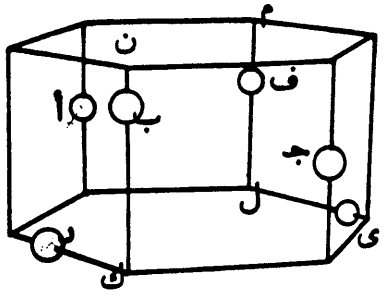
٢



١٠٢ أى الكرتين (ف) أم (أ) أقرب الى الكرة (ب) ؟

٢٠٢ أى الكرتين (ى) أم (أ) أكثر بعدا عن الكرة (ب) ؟

٣



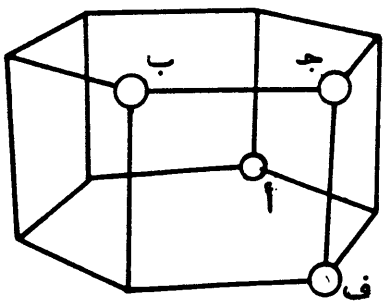
١٠٣ أى الكرتين (أ) أم (د) أقرب الى السطح العمودى ك ل م ن ؟

٢٠٣ أى الكرتين (ب) أم (ف) أكثر ارتفاعا على المجســـم ؟

٣٠٣ أى الكرتين (ب) أم (جـ) تقع على نفس ارتفاع الكرة (أ) في المجسم ؟

٤٠٣ أى الكرتين (ى) أم (جـ) أقرب الى السطح العمودى ك ل م ن ؟

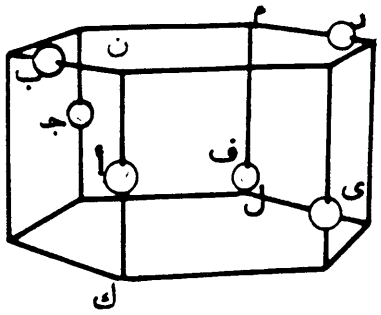
٤



١٠٤ أى الكرتين (ف) أم (أ) أكثر بعدا عن الكرة (ب) ؟

٢٠٤ أى الكرتين (جـ) أم (أ) أقرب الى الكرة (ب) ؟

٥



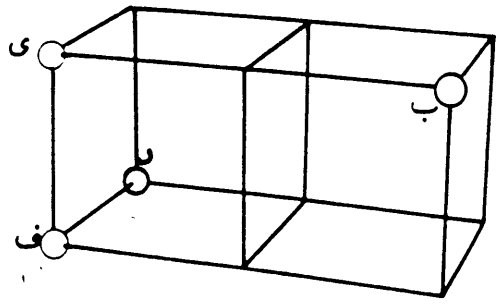
١٠٥ أى الكرتين (د) أم (ى) أقرب الى السطح العمودى ك ل م ن ؟

٢٠٥ أى الكرتين (ف) أم (جـ) تقع على نفس ارتفاع الكرة (أ) في المجسم ؟

٣٠٥ أى الكرتين (ب) أم (جـ) أقرب الى السطح العمودى ك ل م ن ؟

٤٠٥ أى الكرتين (ى) أم (ف) أكثر ارتفاعا على المجسم ؟

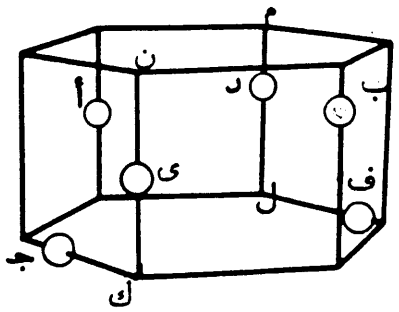
٦



١٠٦ أى الكرتين (د) أم (ف) أكثر بعدا عن الكرة (ب) ؟

٢٠٦ أى الكرتين (د) أم (ى) أقرب الى الكرة (ب) ؟

٧



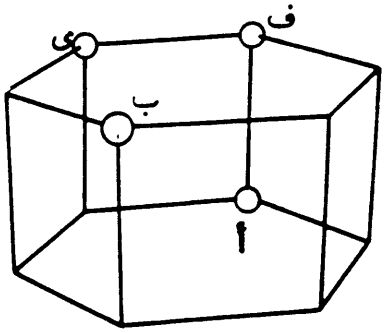
١٠٧ أى الكرتين (ب) أم (د) أكثر ارتفاعا على المجســـــم ؟

٢٠٧ أى الكرتين (ب) أم (ف) أقرب الى السطح العمودى ك ل م ن ؟

٣٠٧ أى الكرتين (أ) أم (جـ) أقرب الى السطح العمودى ك ل م ن ؟

٤٠٧ أى الكرتين (ب) أم (ى) تقع على نفس ارتفاع الكرة (أ) في المجسم ؟

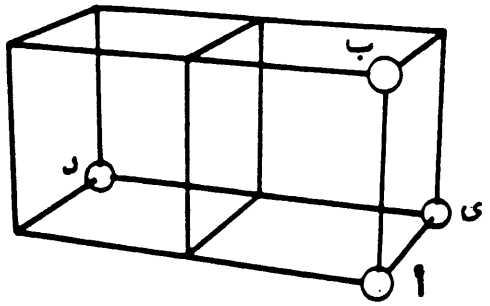
٨



١٠٨ أى الكرتين (ف) أم (ب) أقرب الى الكرة (أ) ؟

٢٠٨ أى الكرتين (ى) أم (ب) أكثر بعدا عن الكرة (أ) ؟

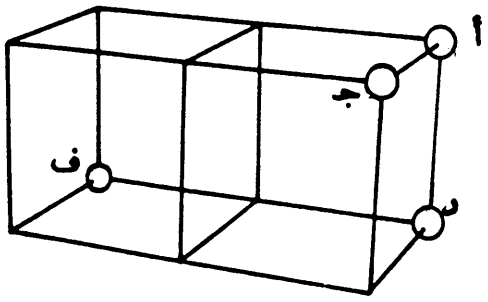
٩



١٠٩ أى الكرتين (أ) أم (ى) أقرب الى الكرة (د) ؟

٢٠٩ أى الكرتين (ب) أم (ى) أكثر بعدا عن الكرة (د) ؟

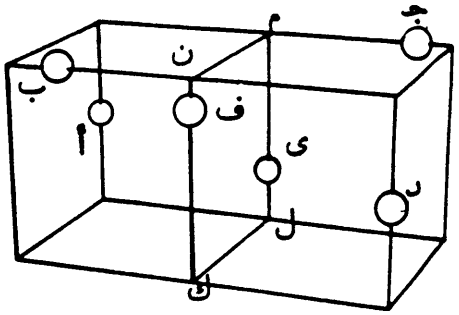
١٠



١٠١٠ أى الكرتين (د) أم (جـ) أقرب الى الكرة (ف) ؟

٢٠١٠ أى الكرتين (جـ) أم (أ) أكثر بعدا عن الكرة (ف) ؟

١١



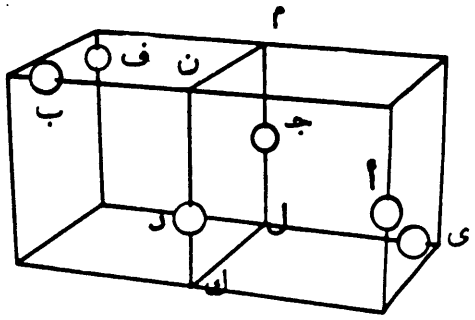
١٠١١ أى الكرتين (د) أم (ى) أكثر ارتفاعا على المجســـم ؟

٢٠١١ أى الكرتين (د) أم (ف) تقع على نفس ارتفاع الكرة (أ) في المجسم ؟

٣٠١١ أى الكرتين (د) أم (جـ) أقرب الى السطح العمودى ك ل م ن ؟

٤٠١١ أى الكرتين (أ) أم (ب) أقرب الى السطح العمودى ك ل م ن ؟

١٢



١٠١٢ أى الكرتين (ب) أم (ف) أكثر ارتفاعا على المجســـــم ؟

٢٠١٢ أى الكرتين (أ) أم (ى) أقرب الى السطح العمودى ك ل م ن ؟

٣٠١٢ أى الكرتين (ب) أم (ف) أقرب الى السطح العمودى ك ل م ن ؟

٤٠١٢ أى الكرتين (د) أم (جـ) تقع على نفس ارتفاع الكرة (أ) في المجسم ؟

APPENDIX 5

THE CUES TEST

A - ENGLISH

B - ARABIC

APPENDIX 5A

UNIVERSITY OF EAST ANGLIA

CUES-TEST

1983

INSTRUCTIONS

Use the ANSWER SHEET provided to answer each of the questions.

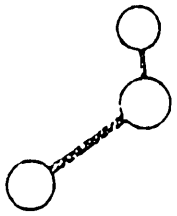
DO NOT MARK OR WRITE ON THIS BOOKLET.

When answering the questions, view the models from the CORRECT VIEWPOINT. The models are in the CORRECT VIEWPOINT when they are placed in the VIEWING STAND. If you are in doubt, speak to the supervisor.

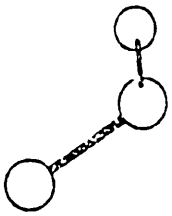
DO NOT TWIST OR BEND THE MODELS OUT OF SHAPE.

Place model number 200 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT, and then answer the following question:-

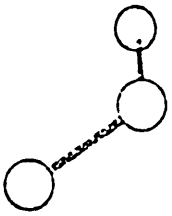
1. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



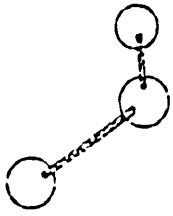
A



B



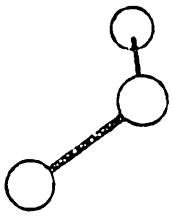
C



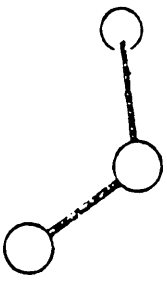
D

Place model number 200 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT, and then answer the following question:-

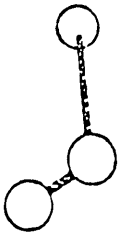
2. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A



B



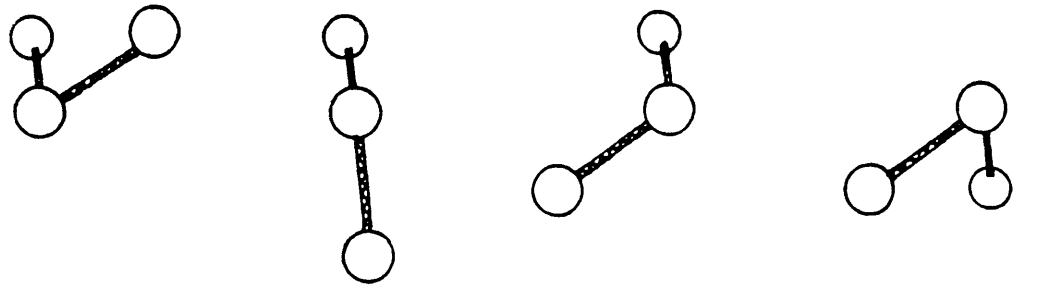
C



D

Place model number 200 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT, and then answer the following question:-

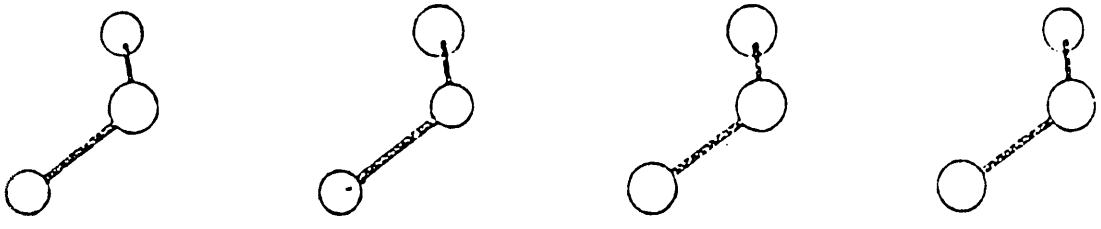
3. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 200 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT, and then answer the following question:-

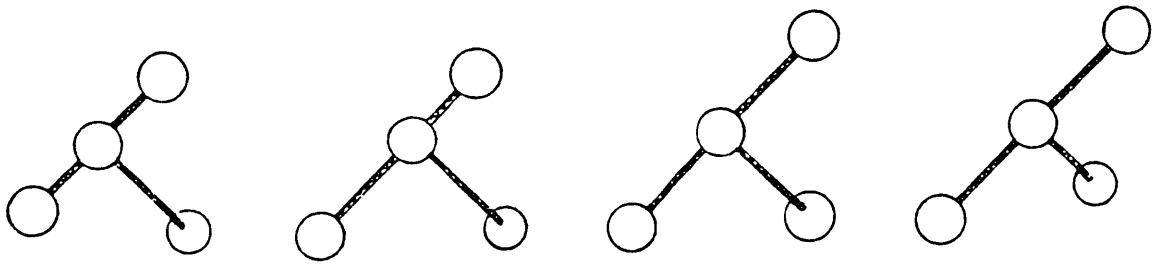
4. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 61 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT, and then answer the following question:-

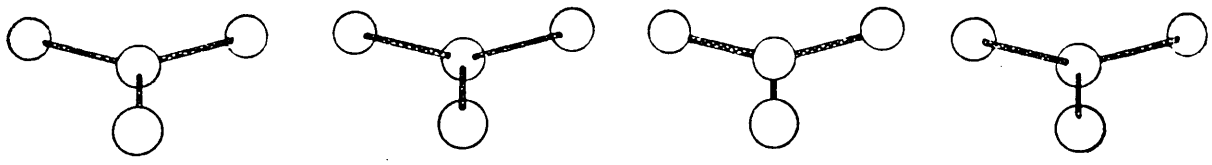
5. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 62 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT, and then answer the following question:-

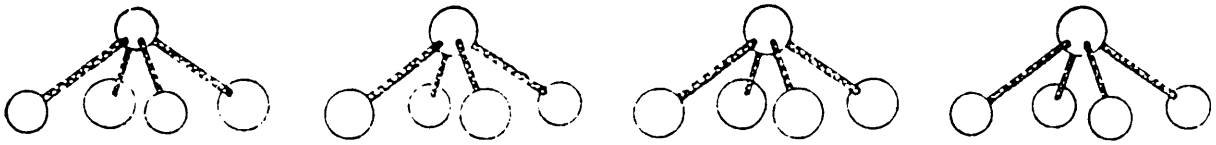
6. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 64 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT and then answer the following question:-

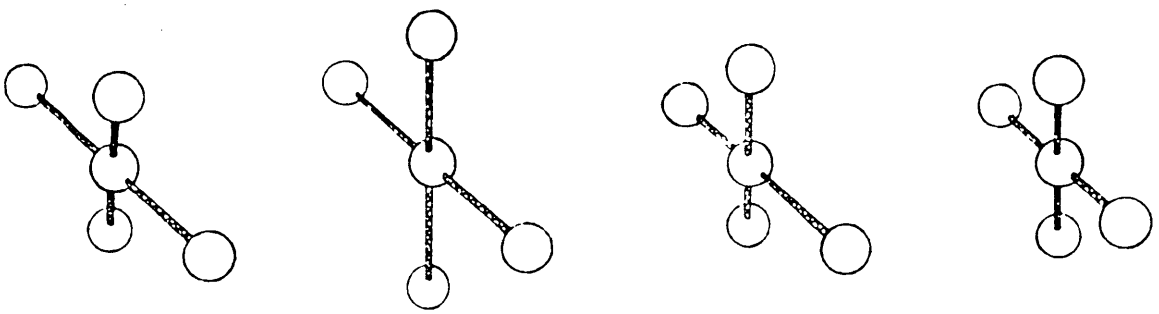
7. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 65 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT, and then answer the following question:-

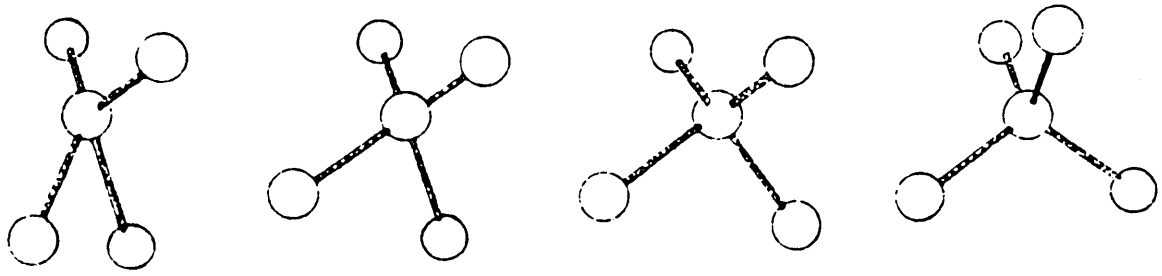
8. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 66 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT and then answer the following question:-

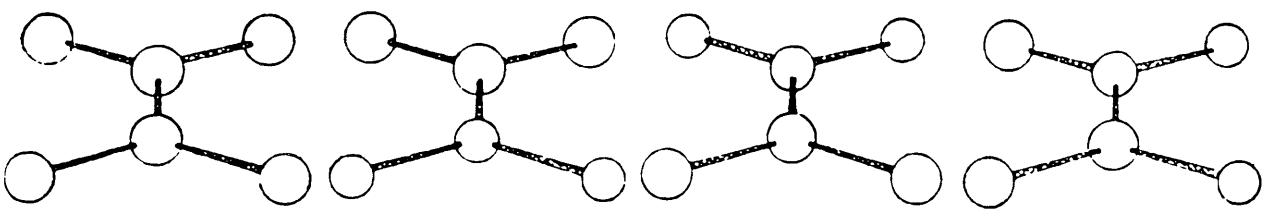
9. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 68 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT and then answer the following question:-

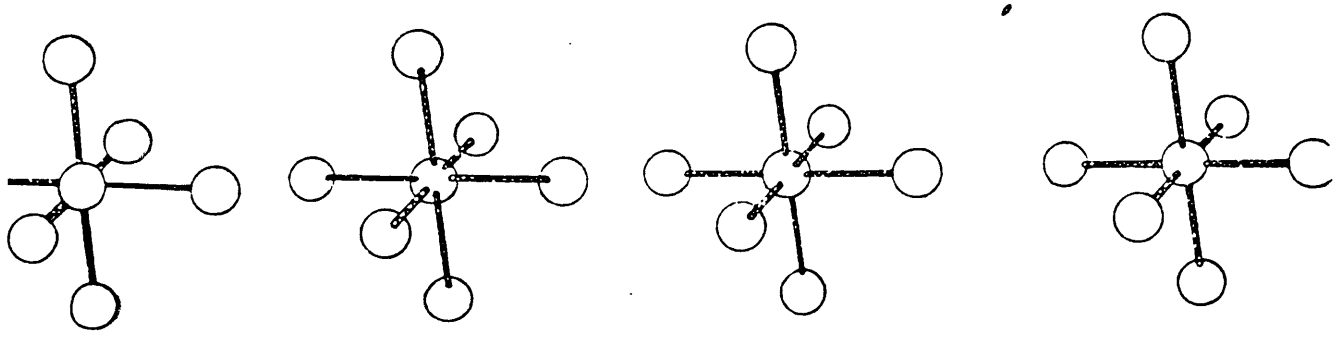
10. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 69 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT, and then answer the following question:-

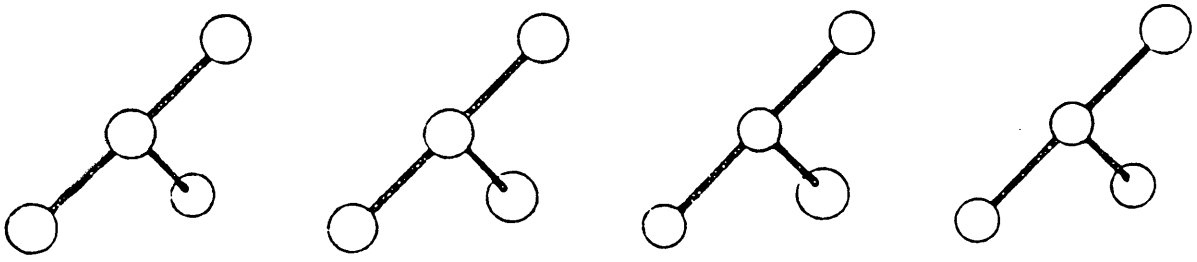
11. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 61 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT and then answer the following question:-

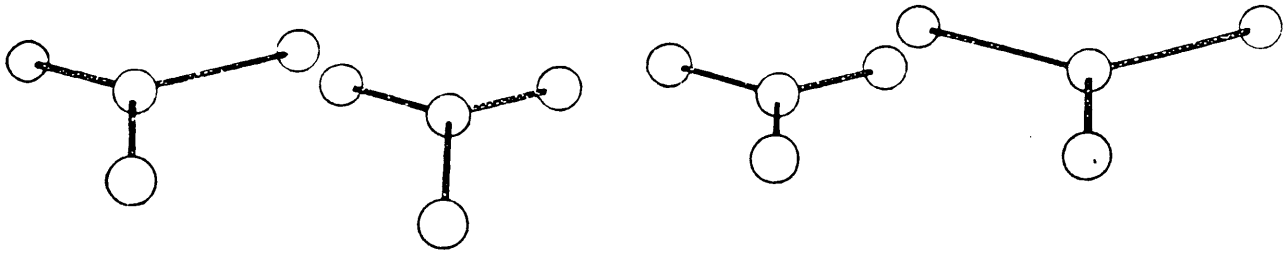
12. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 62 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT, and then answer the following question:-

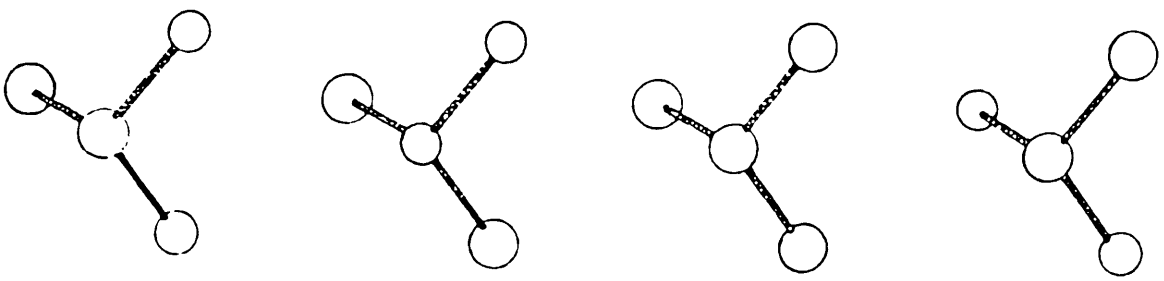
13. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 63 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT and then answer the following question:-

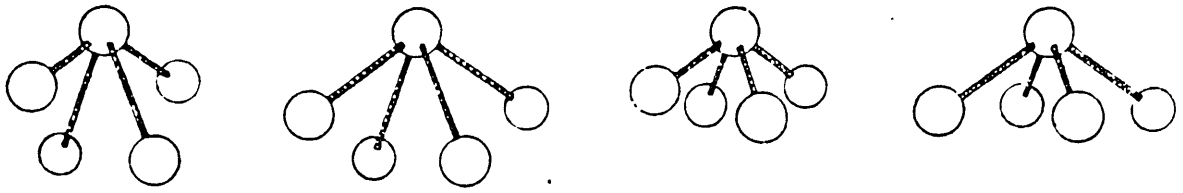
14. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 64 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT, and then answer the following question:-

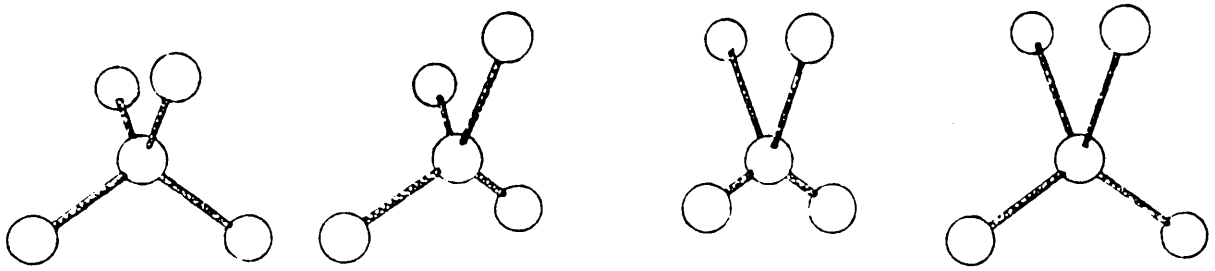
15 . Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 66 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT, and then answer the following question:-

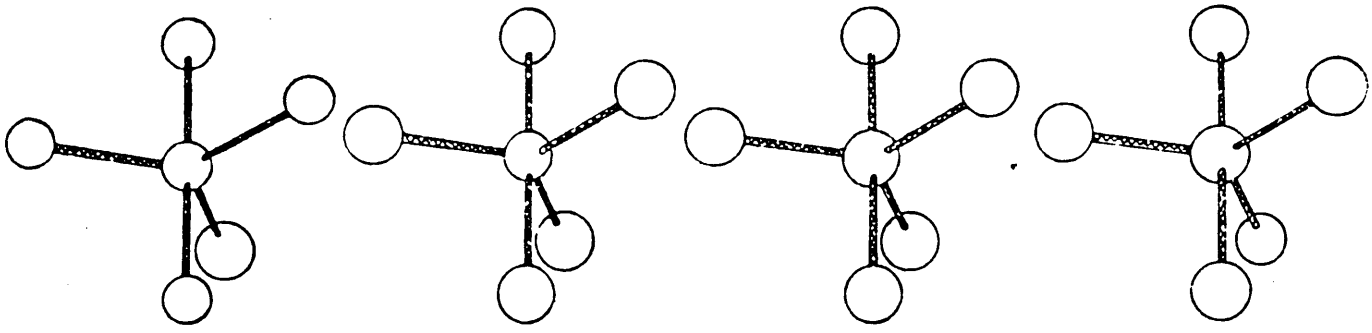
16 . Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 67 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT and then answer the following question:-

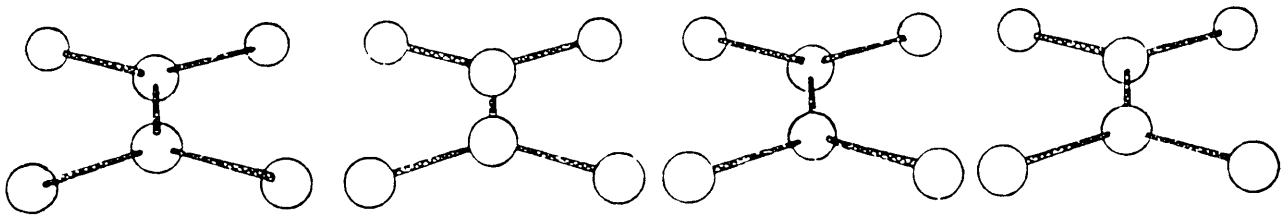
17. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 68 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT, and then answer the following question:-

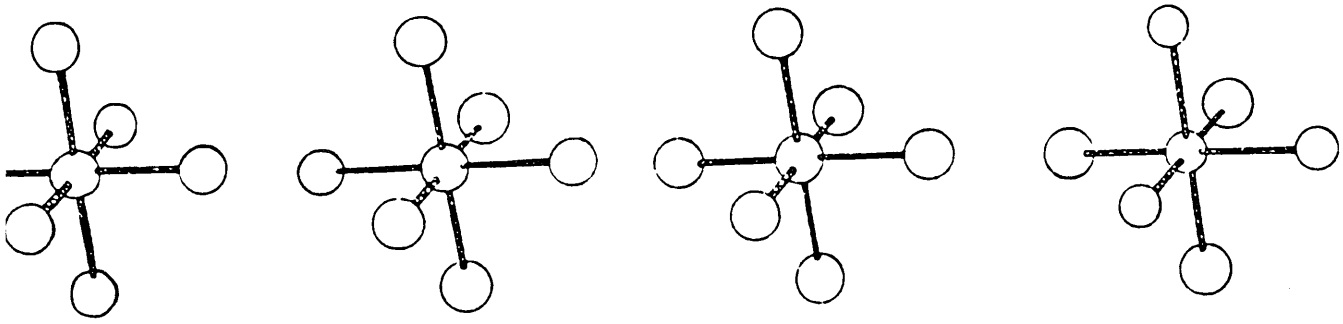
18. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 69 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT and then answer the following question:-

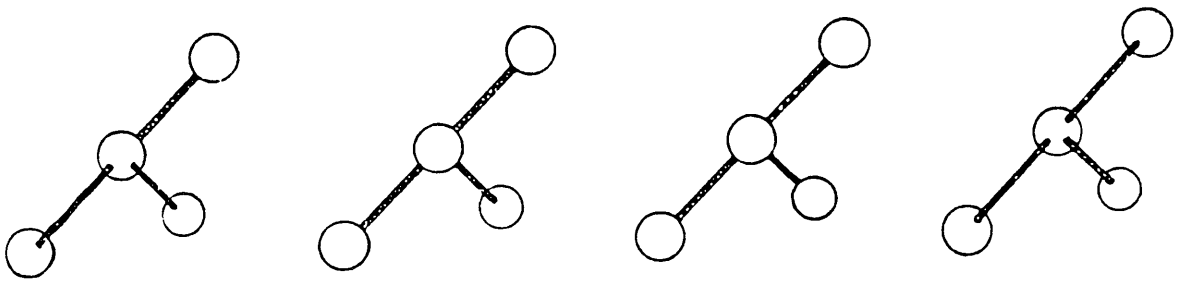
19. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 61 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT, and then answer the following question:-

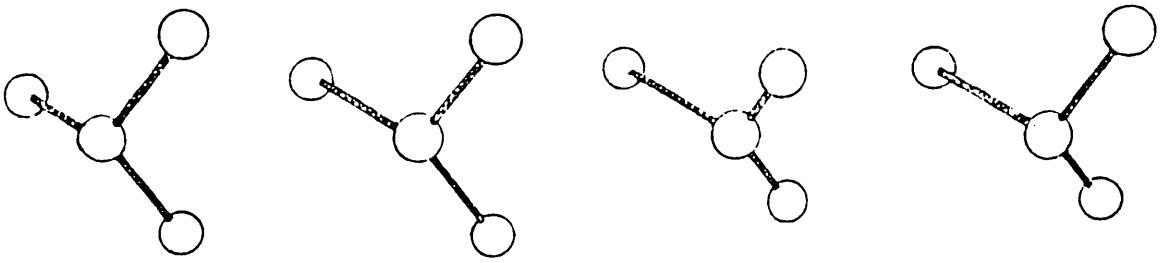
20. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 63 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT, and then answer the following question:-

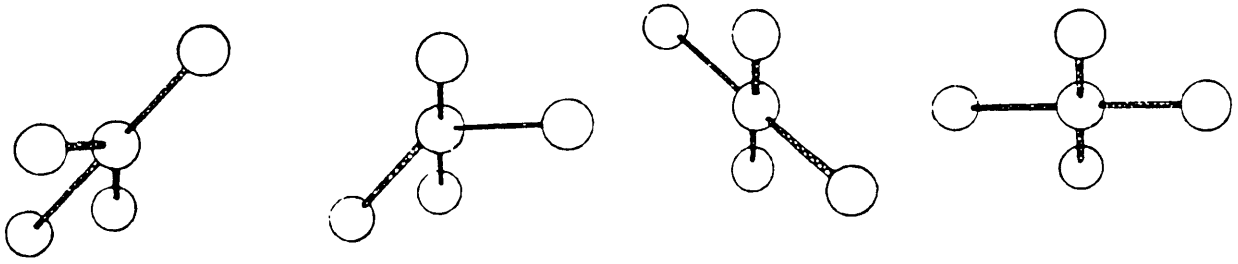
21. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 65 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT and then answer the following question:-

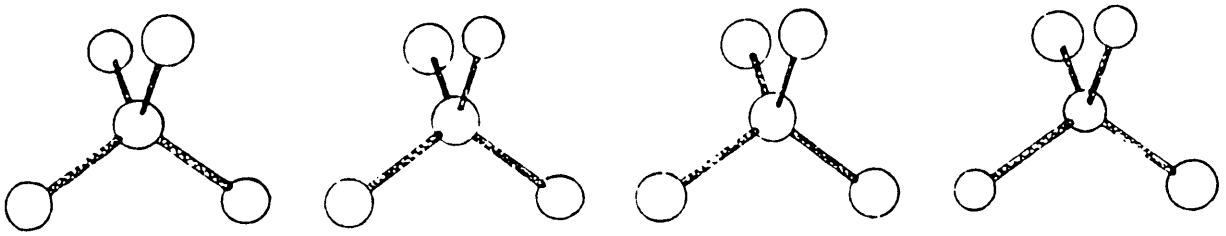
22. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 66 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT and then answer the following question:-

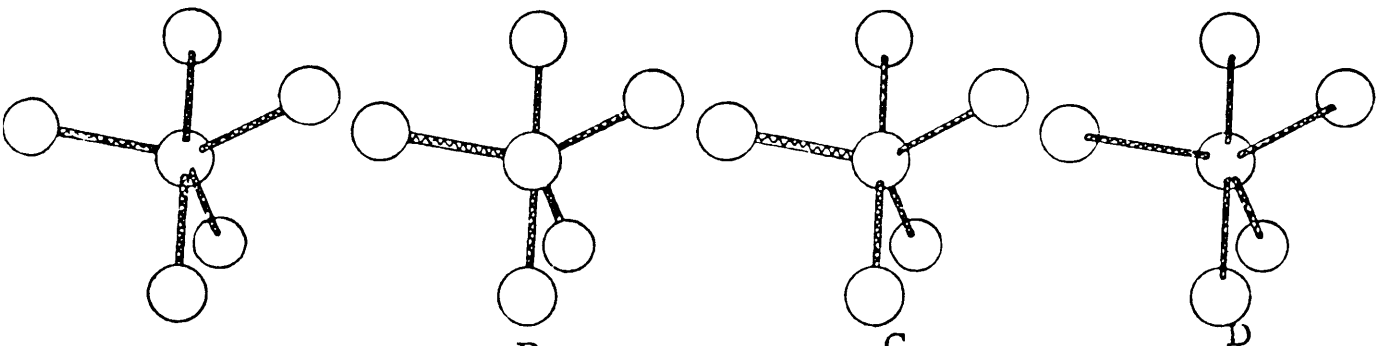
23. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 67 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT, and then answer the following question:-

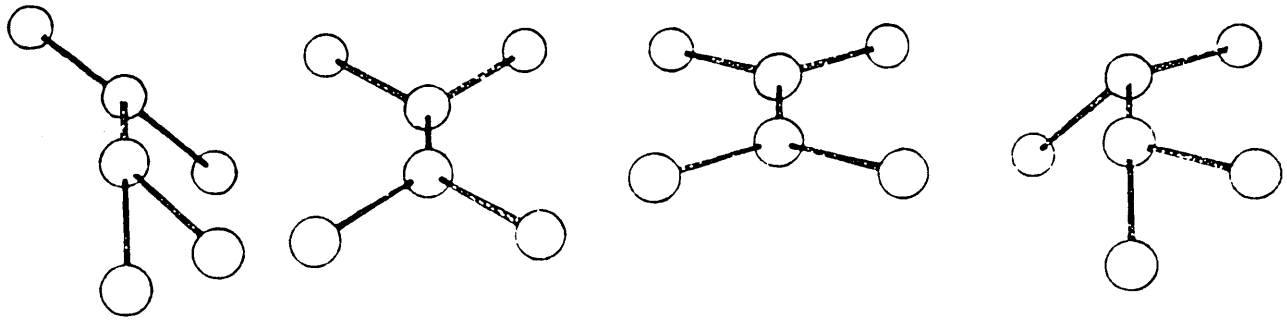
24. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 68 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT and then answer the following question:-

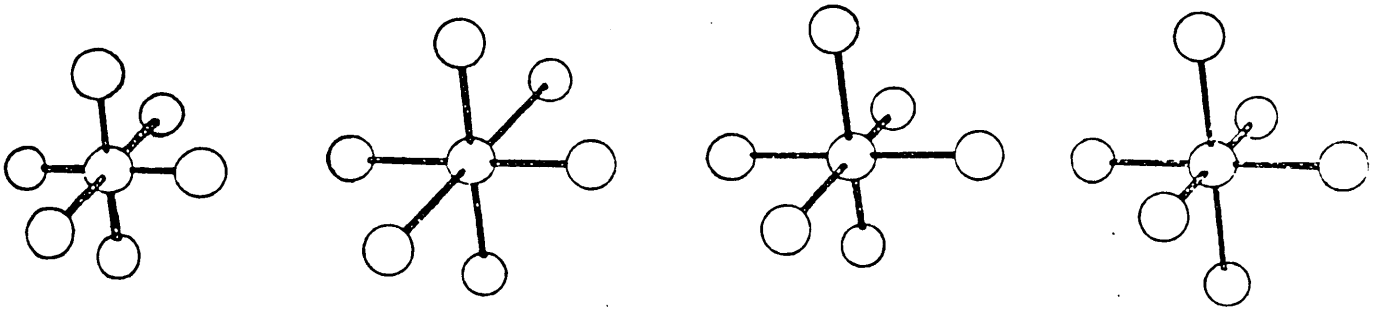
25. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 69 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT and then answer the following question:-

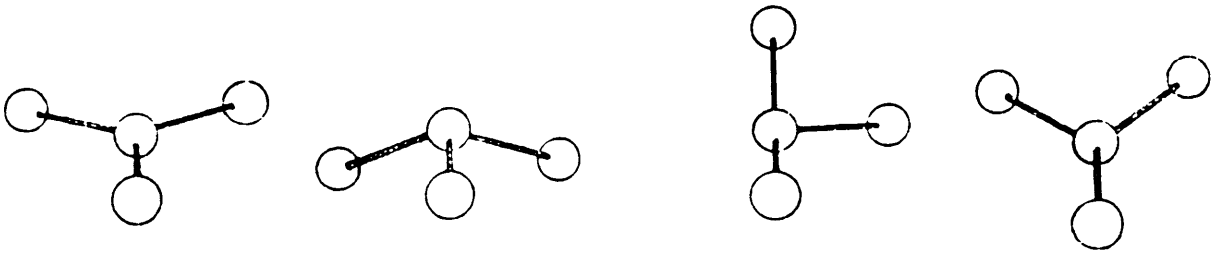
26. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 62 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT and then answer the following question:-

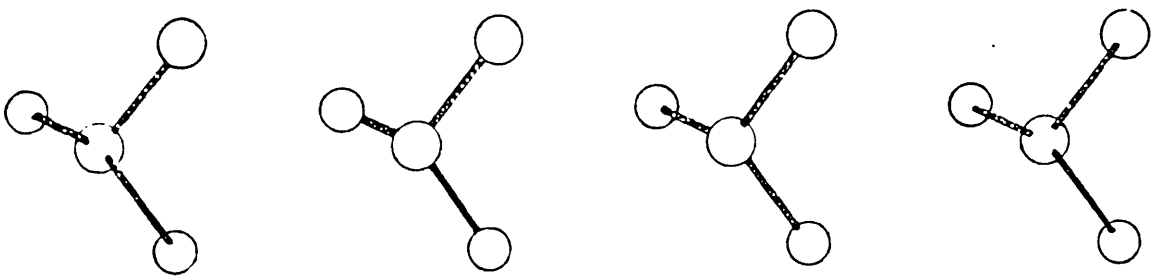
27 . Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 63 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT, and then answer the following question:-

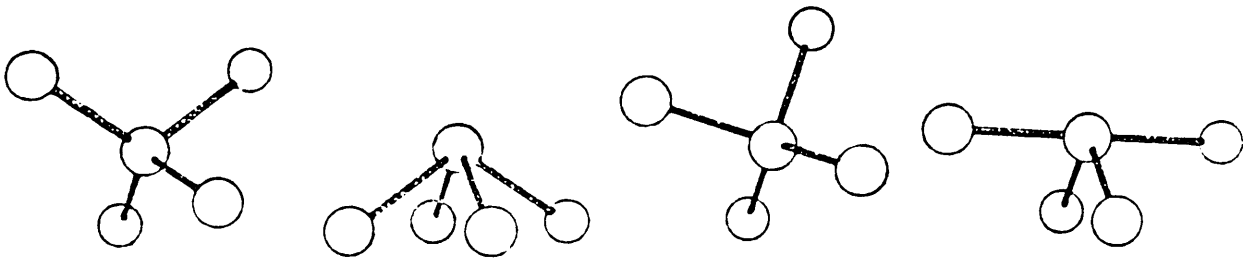
28 . Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 64 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT and then answer the following question:-

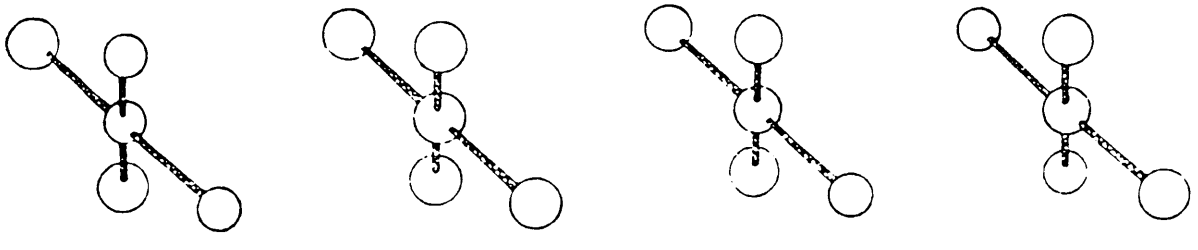
29. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 65 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT and then answer the following question:-

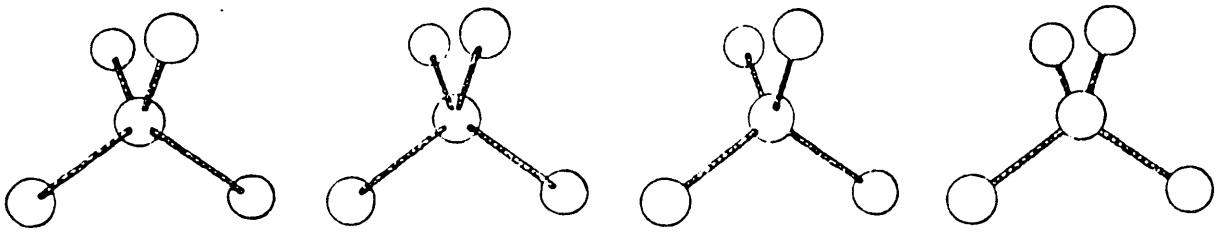
30. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 66 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT, and then answer the following question:-

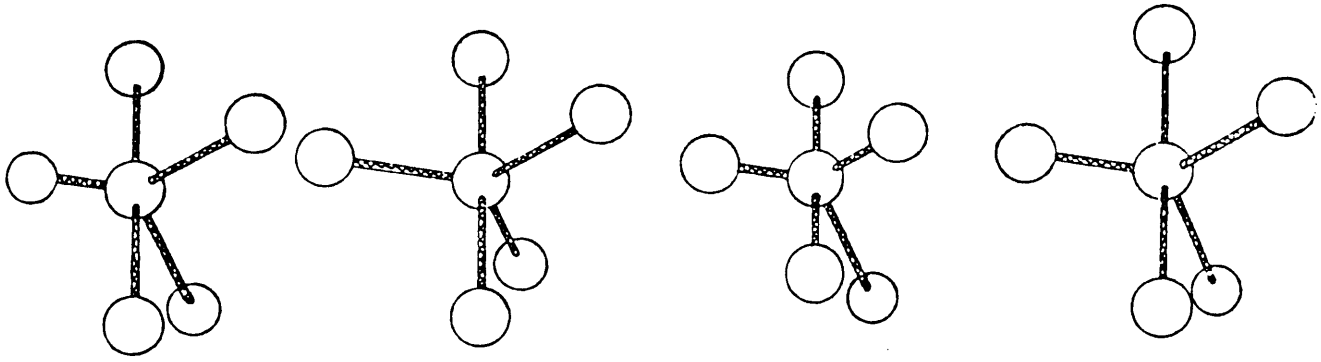
31 . Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 67 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT, and then answer the following question:-

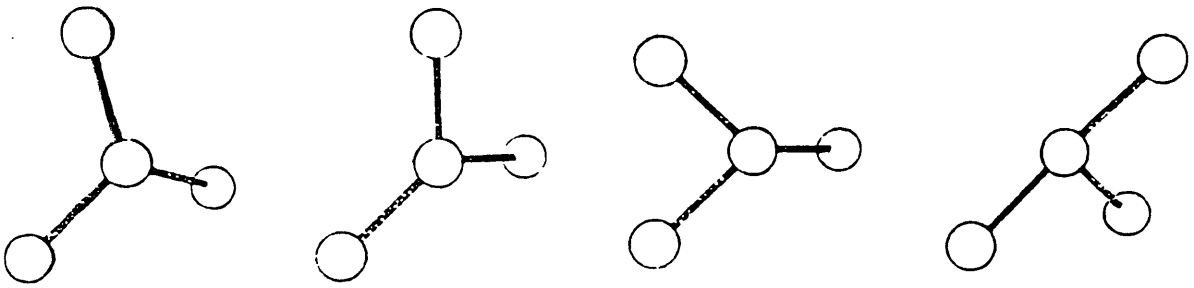
32 . Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 61 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT and then answer the following question:-

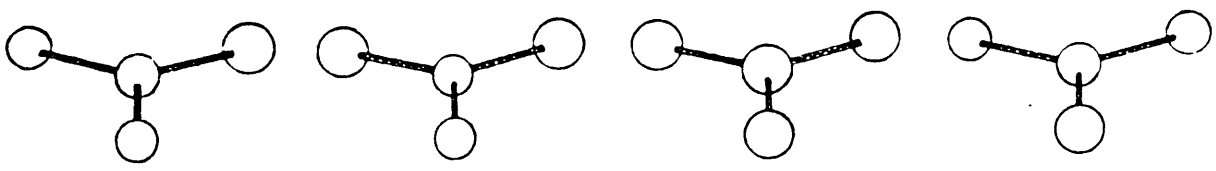
33. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 62 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT and then answer the following question:-

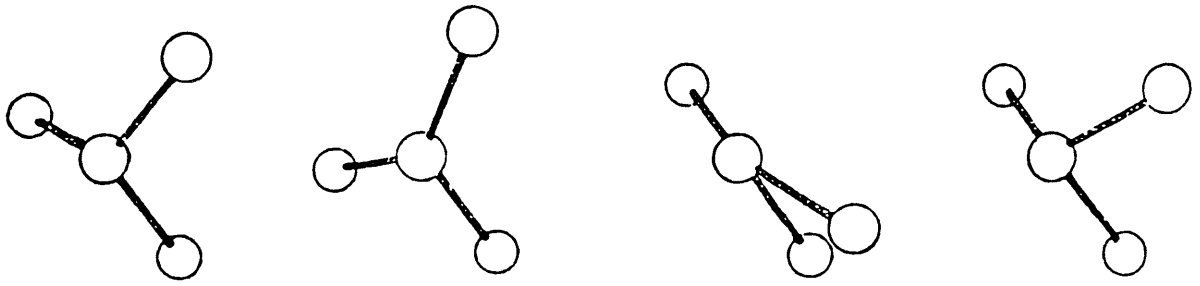
34. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 63 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT and then answer the following question:-

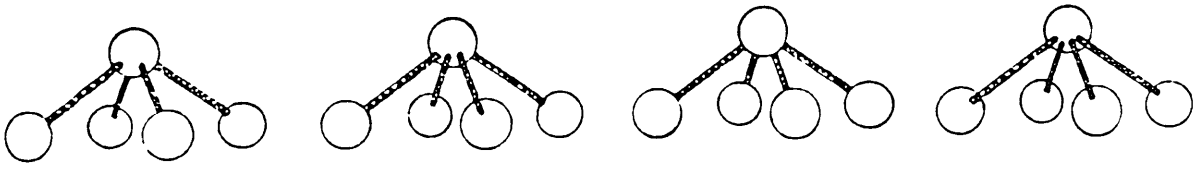
35. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 64 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT, and then answer the following question:-

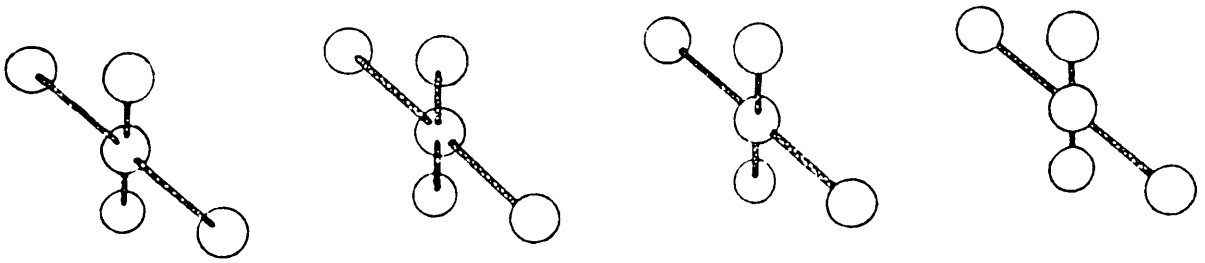
36. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 65 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT, and then answer the following question:-

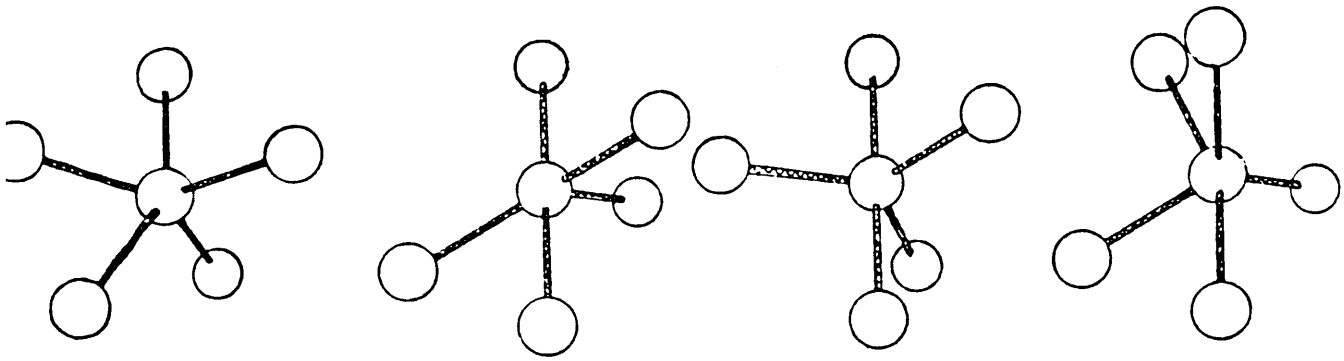
37. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 67 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT and then answer the following question:-

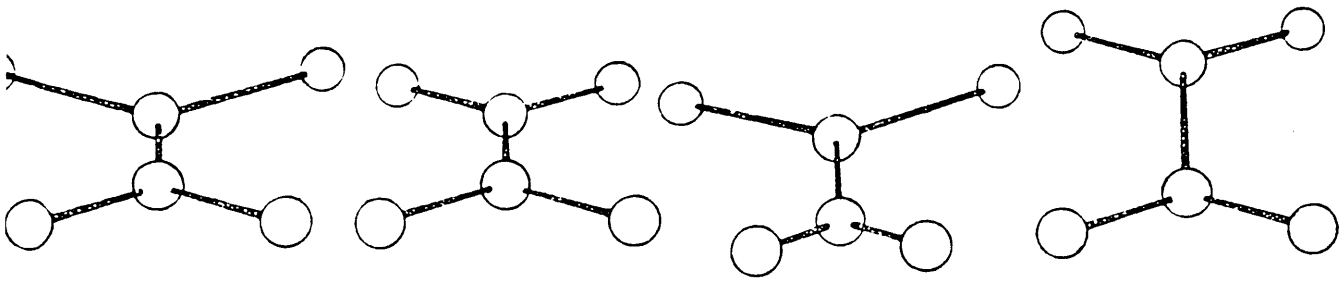
38. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 68 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT, and then answer the following question:-

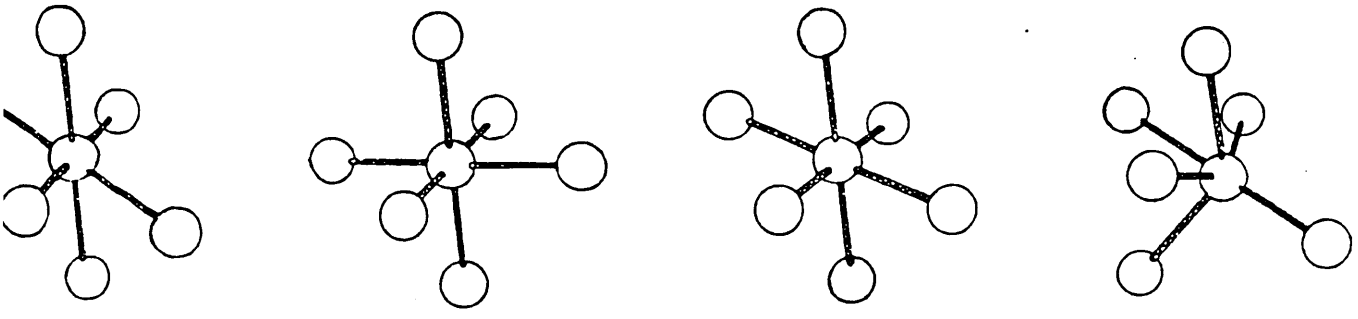
39. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

Place model number 69 in the VIEWING STAND. Look at this model from the CORRECT VIEWPOINT, and then answer the following question:-

40. Which ONE of the diagrams A-D is the best representation of what you can see of the model?



A B C D

APPENDIX 5B

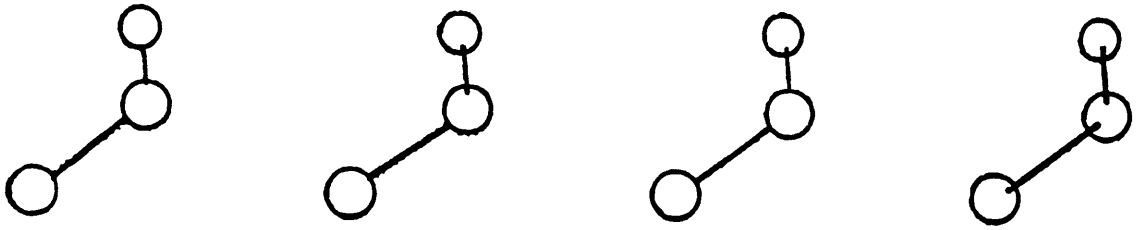
جامعة ايست انجليا

اختبار الكيوز

١٩٨٣

ضع نموذج رقم ٣٠٠ على الحامل ثم انظر اليه من مستوى النظر الصحيح
واجب عن السؤال التالي:-

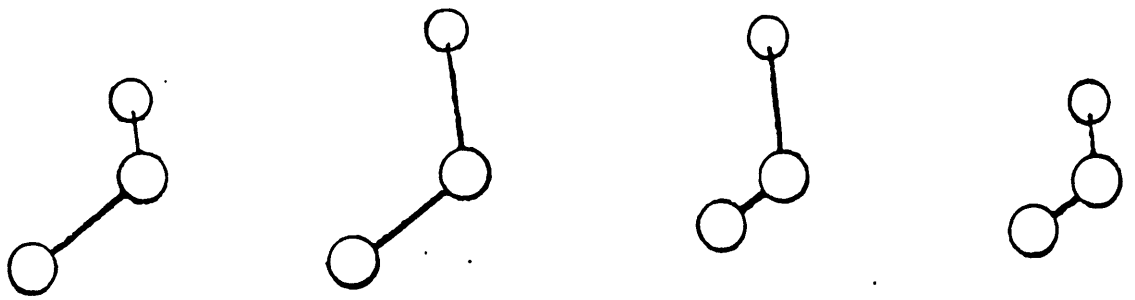
١ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٣٠٠ على الحامل ثم انظر اليه من مستوى النظر الصحيح
واجب عن السؤال التالي:-

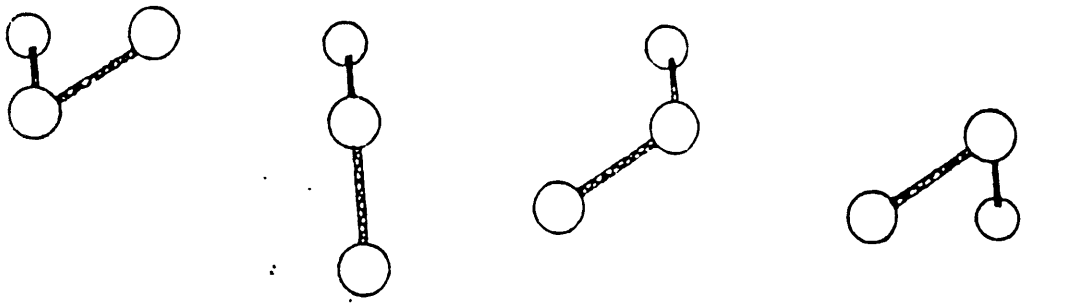
٢ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٢٠٠ على الحامل ثم انظر اليه من مستوى النظر الصحيح
واجب عن السؤال التالي:-

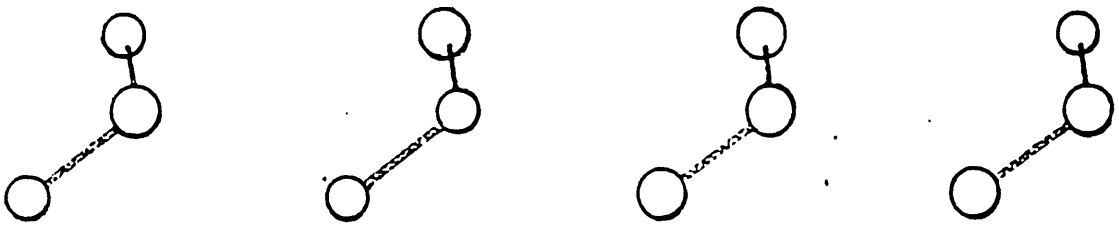
٣ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٢٠٠ على الحامل ثم انظر اليه من مستوى النظر الصحيح
واجب عن السؤال التالي:-

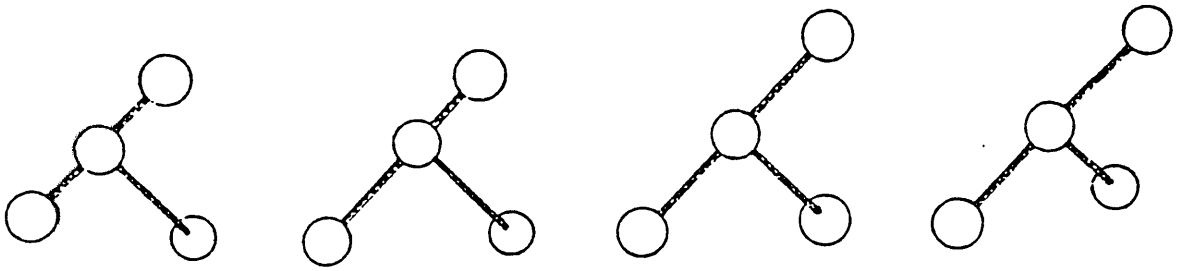
٤ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦١ على الحامل ثم انظر اليه من مستوى النظر الصحيح
واجب عن السؤال التالي:-

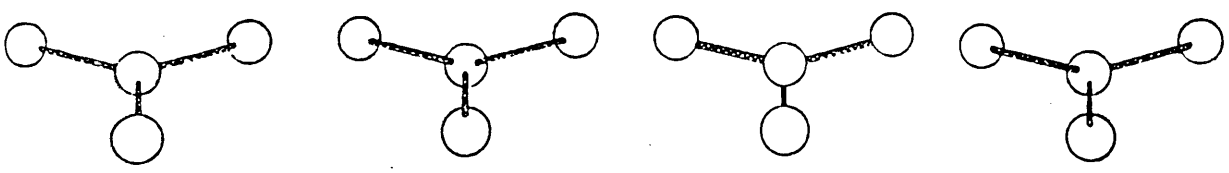
٥ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٢ على الحامل ثم انظر اليه من مستوى النظر الصحيح
واجب عن السؤال التالي:-

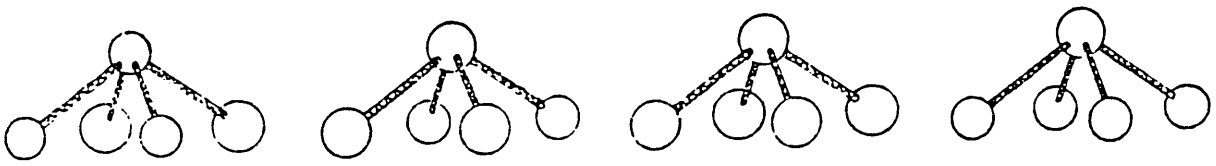
٦ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٤ على الحامل ثم انظر اليه من مستوى النظر الصحيح واجب عن السؤال التالي:-

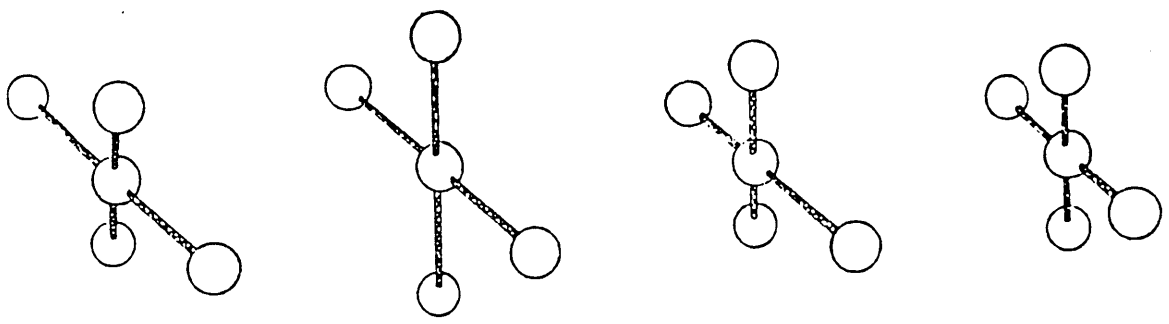
٧ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٥ على الحامل ثم انظر اليه من مستوى النظر الصحيح واجب عن السؤال التالي:-

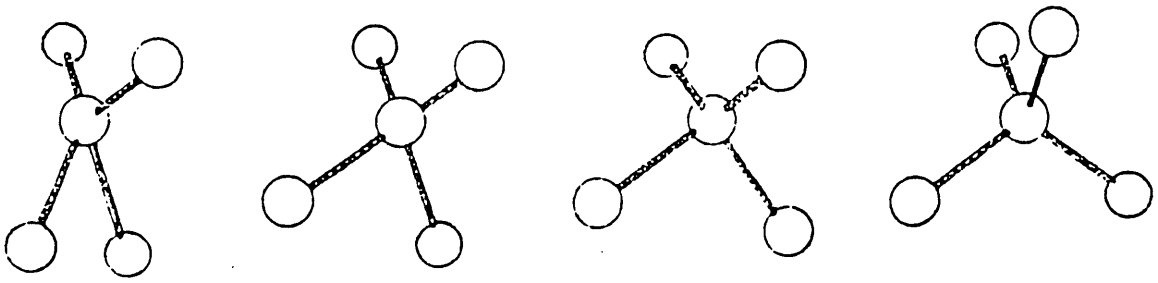
٨ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٦ على الحامل ثم انظر اليه من مستوى النظر الصحيح واجب عن السؤال التالي:-

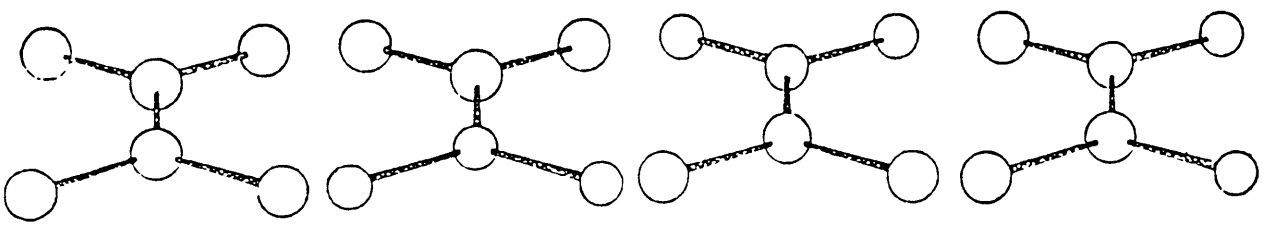
٩ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٨ على الحامل ثم انظر اليه من مستوى النظر الصحيح واجب عن السؤال التالي:-

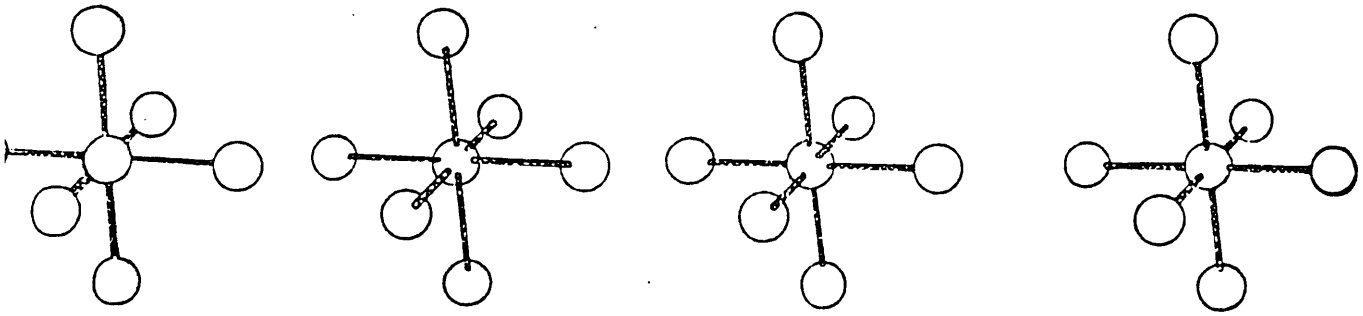
١٠ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٩ على الحامل ثم انظر اليه من مستوى النظر الصحيح
واجب عن السؤال التالي:-

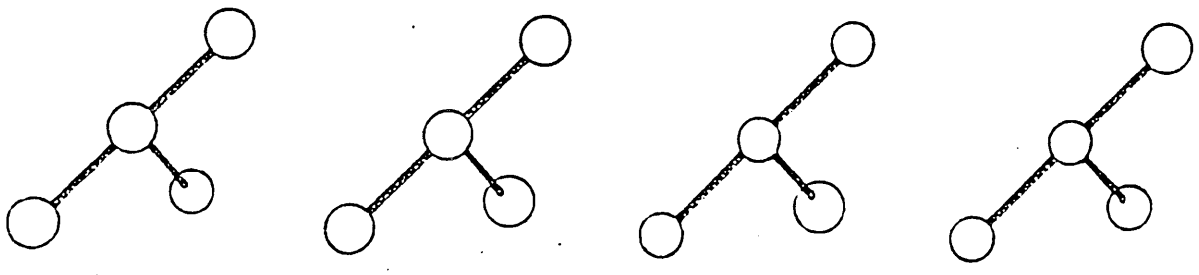
١١ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦١ على الحامل ثم انظر اليه من مستوى النظر الصحيح
واجب عن السؤال التالي:-

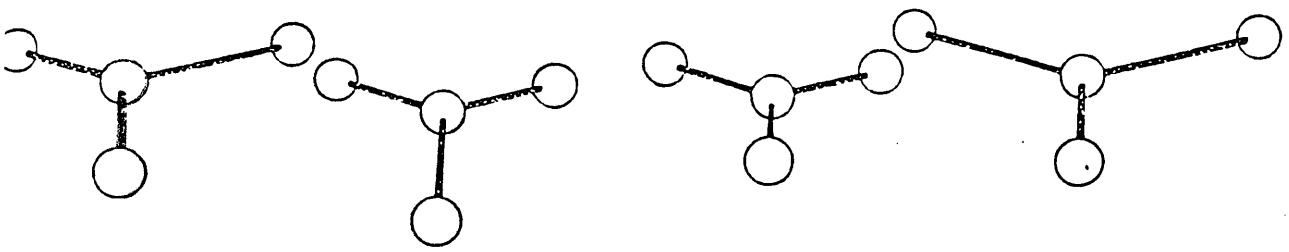
١٢ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٢ على الحامل ثم انظر اليه من مستوى النظر الصحيح واجب عن السؤال التالي:-

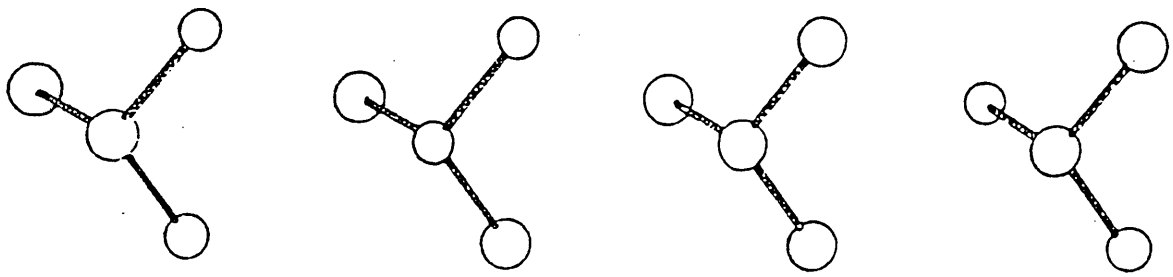
١٣ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٣ على الحامل ثم انظر اليه من مستوى النظر الصحيح واجب عن السؤال التالي:-

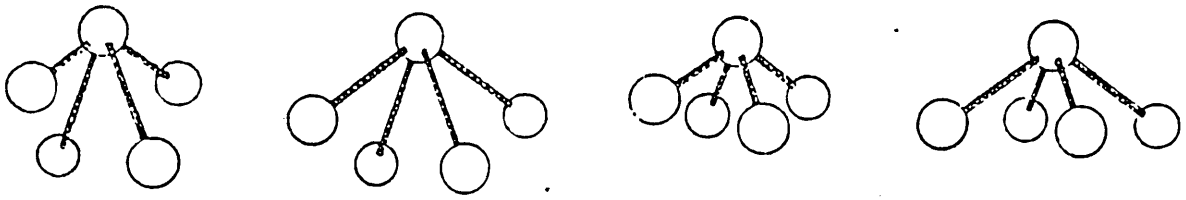
١٤ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٤ على الحامل ثم انظر اليه من مستوى النظر الصحيح
واجب عن السؤال التالي:-

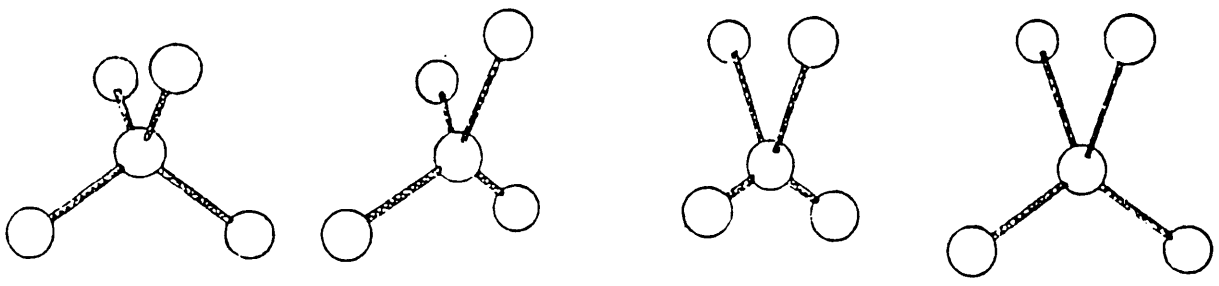
١٥ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٦ على الحامل ثم انظر اليه من مستوى النظر الصحيح
واجب عن السؤال التالي:-

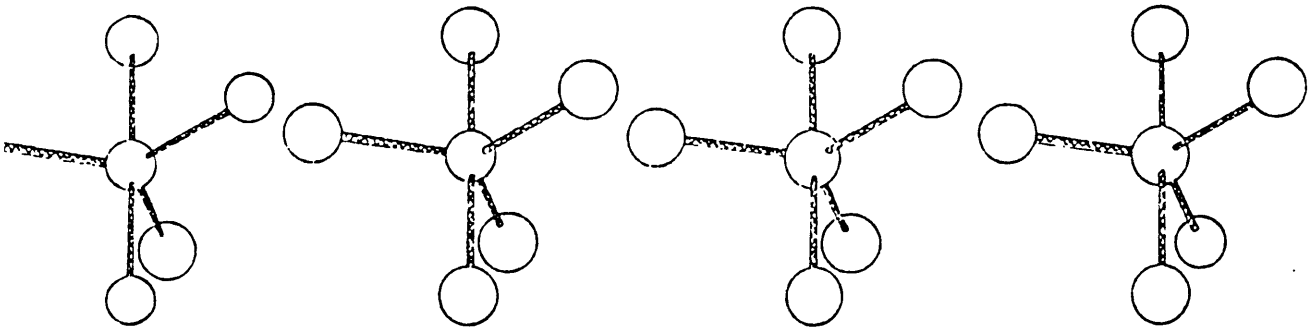
١٦ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٧ على الحامل ثم انظر اليه من مستوى النظر الصحيح واجب عن السؤال التالي:-

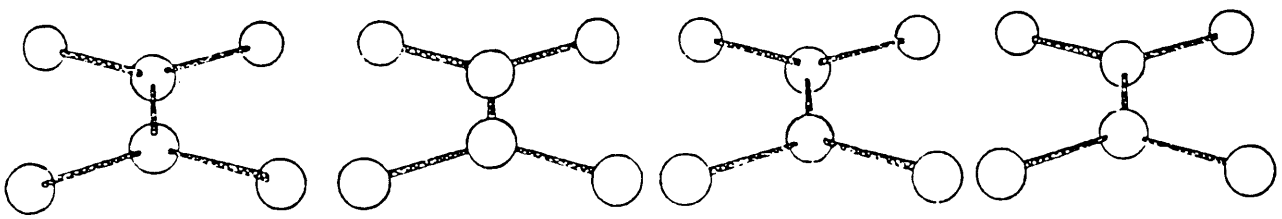
١٧ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٨ على الحامل ثم انظر اليه من مستوى النظر الصحيح واجب عن السؤال التالي:-

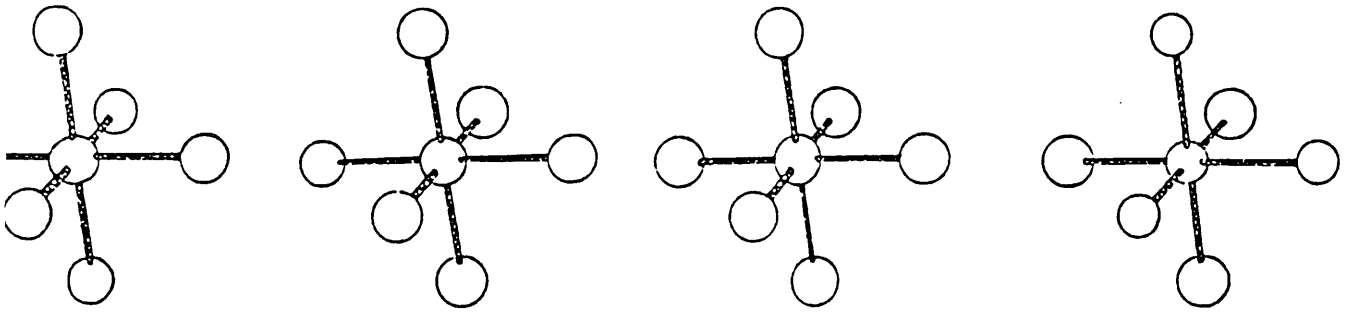
١٨ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٩ على الحامل ثم انظر اليه من مستوى النظر الصحيح
واجب عن السؤال التالي:-

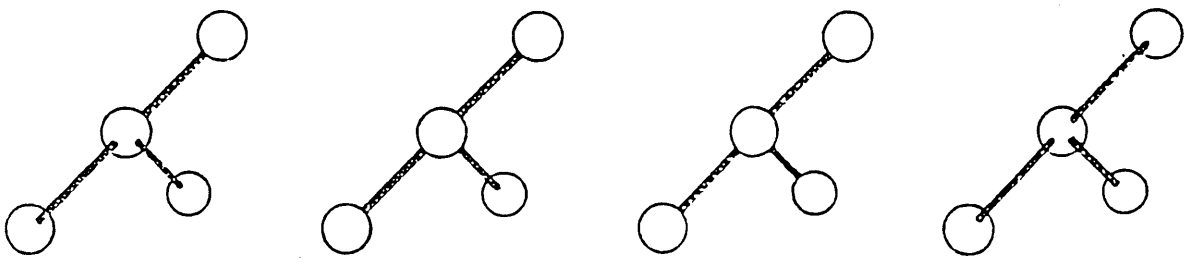
١٩ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦١ على الحامل ثم انظر اليه من مستوى النظر الصحيح
واجب عن السؤال التالي:-

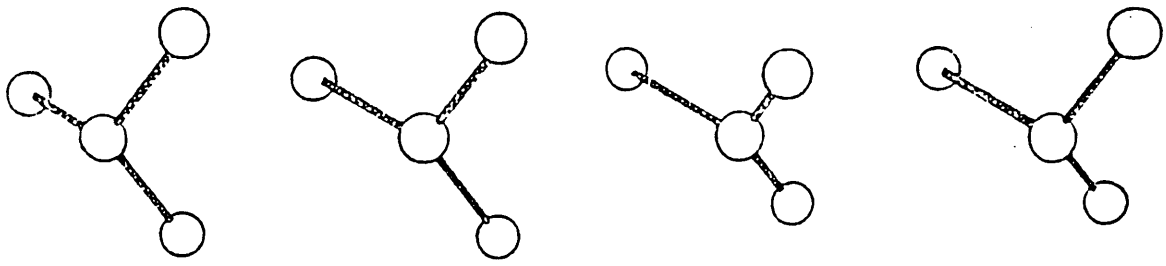
٢٠ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٣ على الحامل ثم انظر اليه من مستوى النظر الصحيح واجب عن السؤال التالي:-

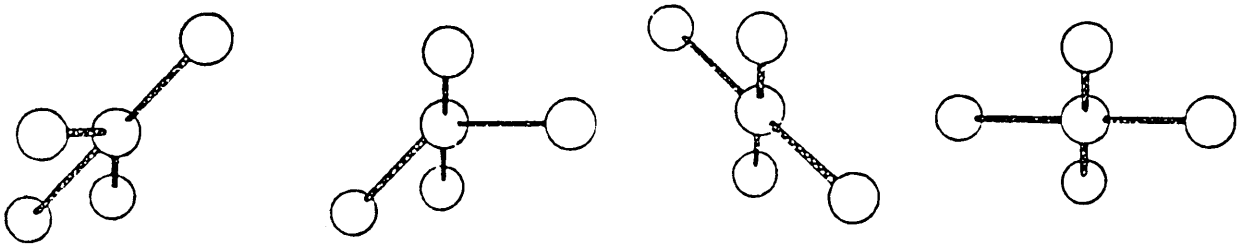
٢١ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٥ على الحامل ثم انظر اليه من مستوى النظر الصحيح واجب عن السؤال التالي:-

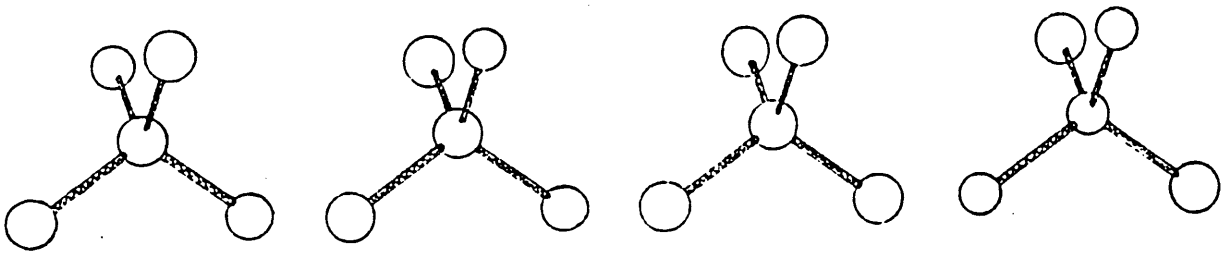
٢٢ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٦ على الحامل ثم انظر اليه من مستوى النظر الصحيح
واجب عن السؤال التالي:-

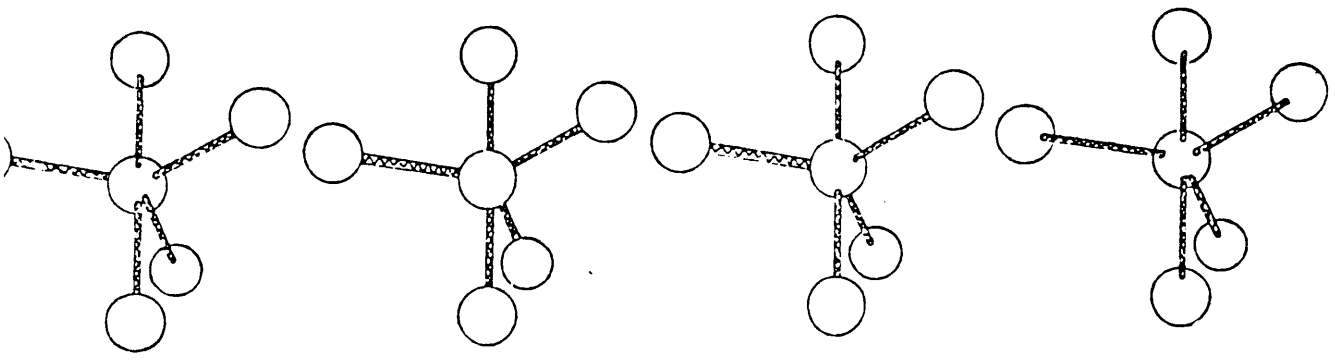
٢٣ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٧ على الحامل ثم انظر اليه من مستوى النظر الصحيح
واجب عن السؤال التالي:-

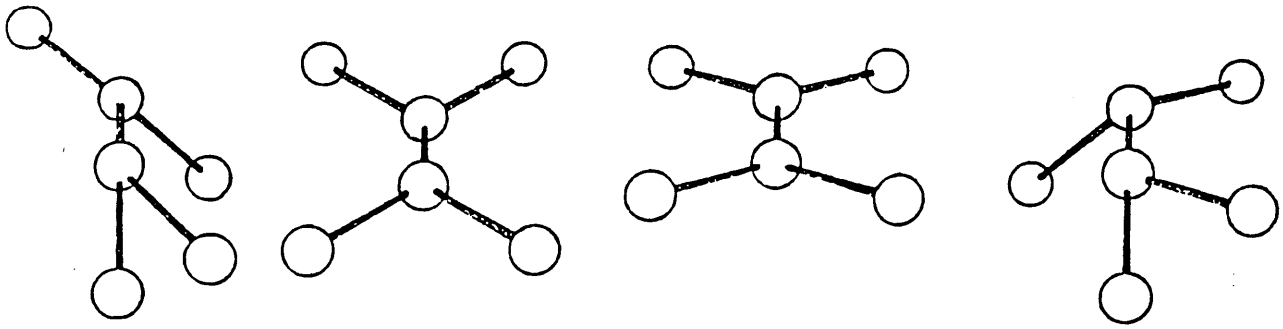
٢٤ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٨ على الحامل ثم انظر اليه من مستوى النظر الصحيح
واجب عن السؤال التالي:-

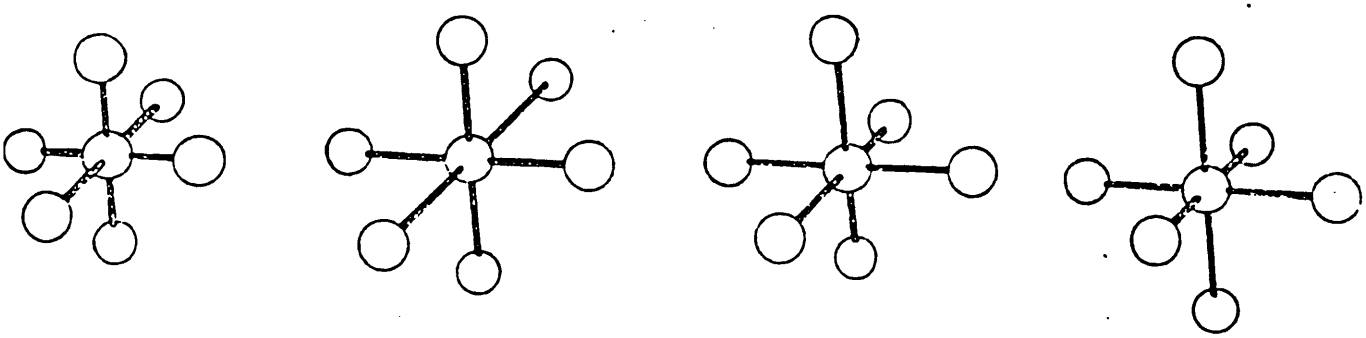
٢٥ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٩ على الحامل ثم انظر اليه من مستوى النظر الصحيح
واجب عن السؤال التالي:-

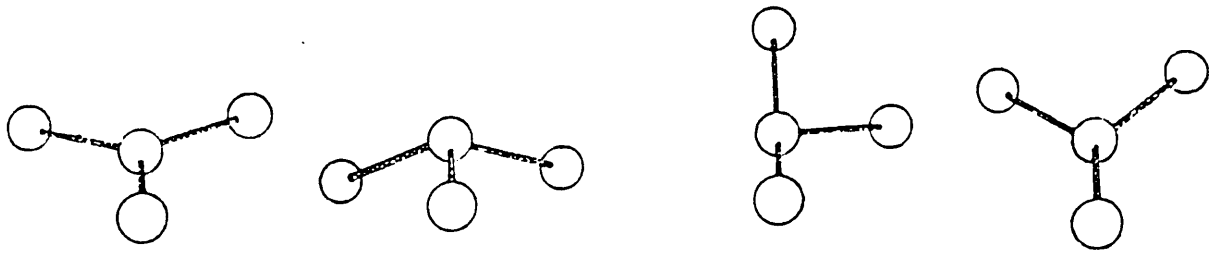
٢٦ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٢ على الحامل ثم انظر اليه من مستوى النظر الصحيح
واجب عن السؤال التالي:-

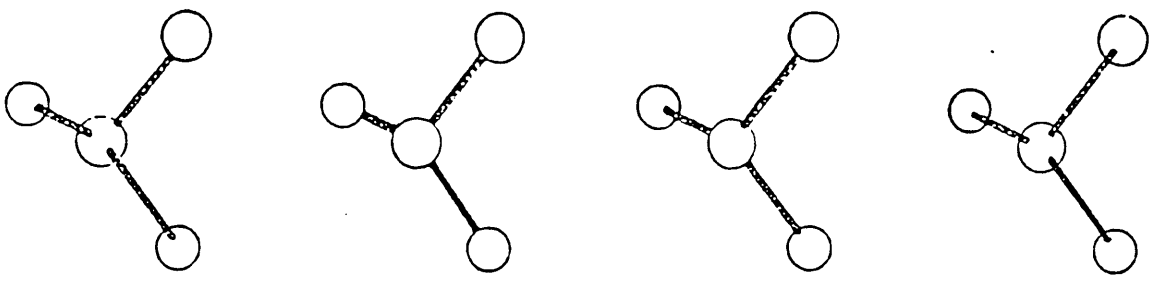
٢٧ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٣ على الحامل ثم انظر اليه من مستوى النظر الصحيح
واجب عن السؤال التالي:-

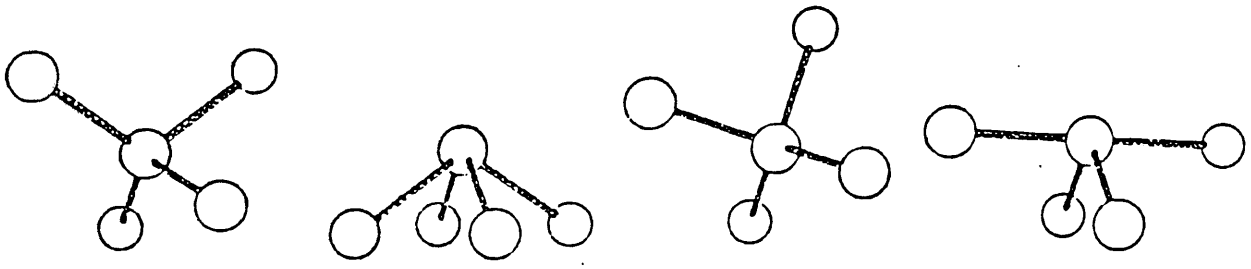
٢٨ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٤ على الحامل ثم انظر اليه من مستوى النظر الصحيح واجب عن السؤال التالي:-

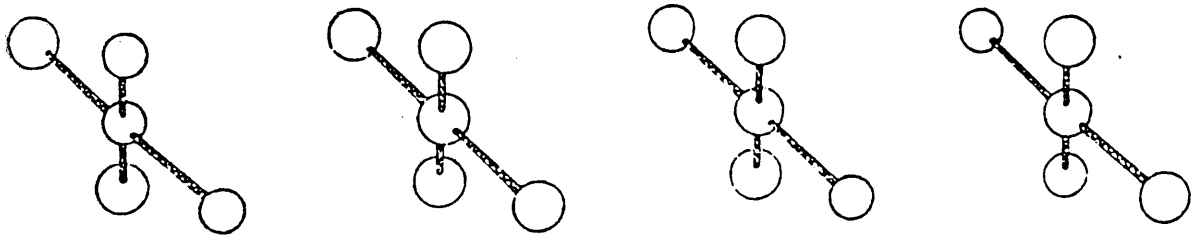
٢٩ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٥ على الحامل ثم انظر اليه من مستوى النظر الصحيح واجب عن السؤال التالي:-

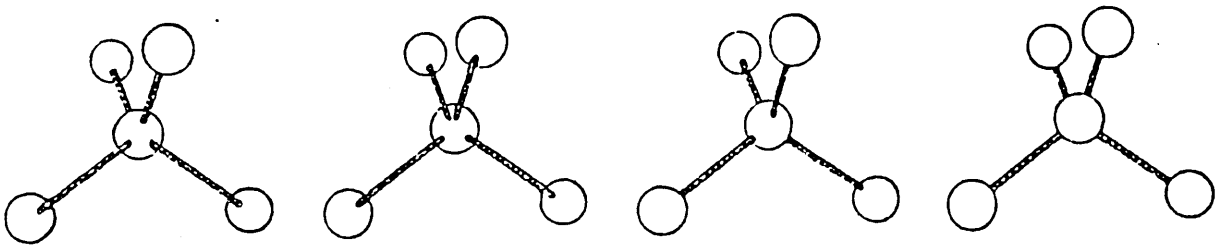
٣٠ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٦ على الحامل ثم انظر اليه من مستوى النظر الصحيح
واجب عن السؤال التالي:-

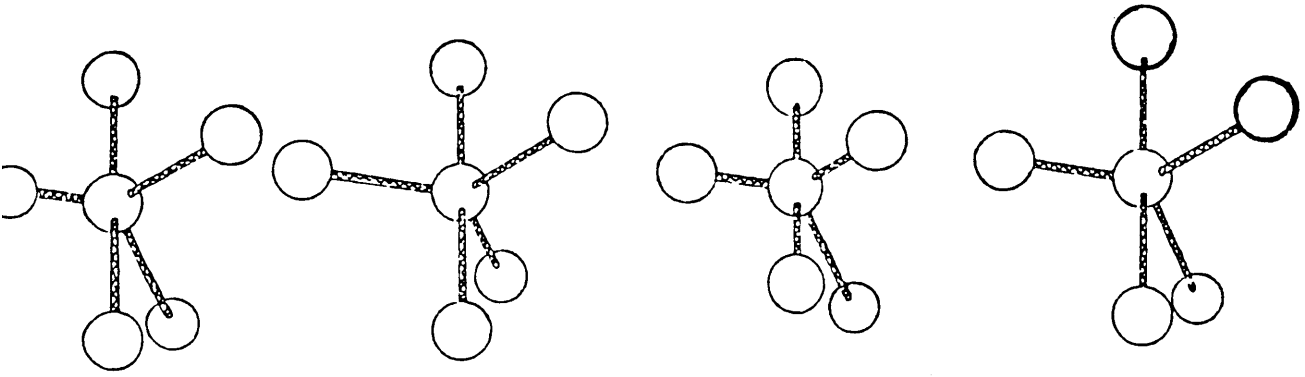
٣١ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٧ على الحامل ثم انظر اليه من مستوى النظر الصحيح
واجب عن السؤال التالي:-

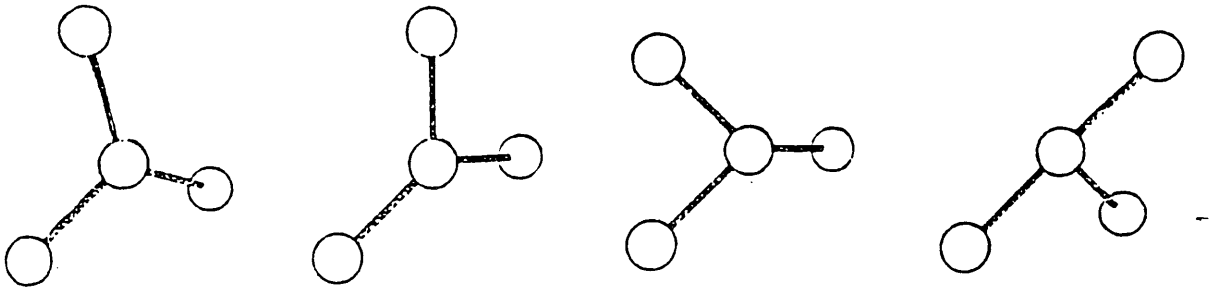
٣٢ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦١ على الحامل ثم انظر اليه من مستوى النظر الصحيح
و اجب عن السؤال التالي:-

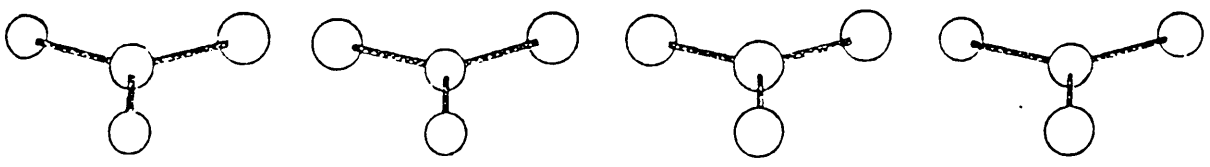
٣٣ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٢ على الحامل ثم انظر اليه من مستوى النظر الصحيح
و اجب عن السؤال التالي:-

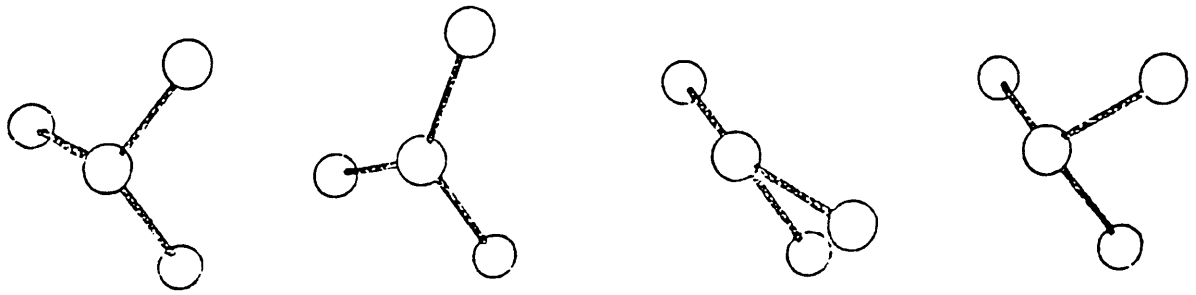
٣٤ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٣ على الحامل ثم انظر اليه من مستوى النظر الصحيح واجب عن السؤال التالي:-

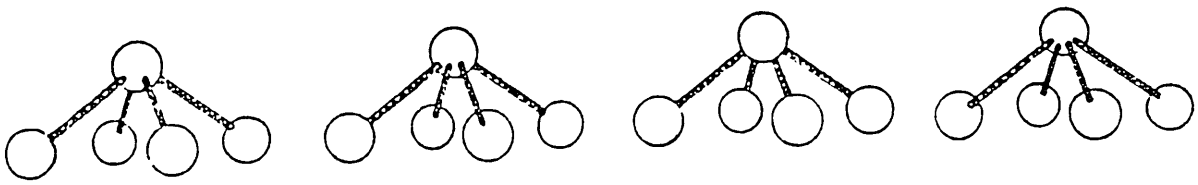
٣٥ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٤ على الحامل ثم انظر اليه من مستوى النظر الصحيح واجب عن السؤال التالي:-

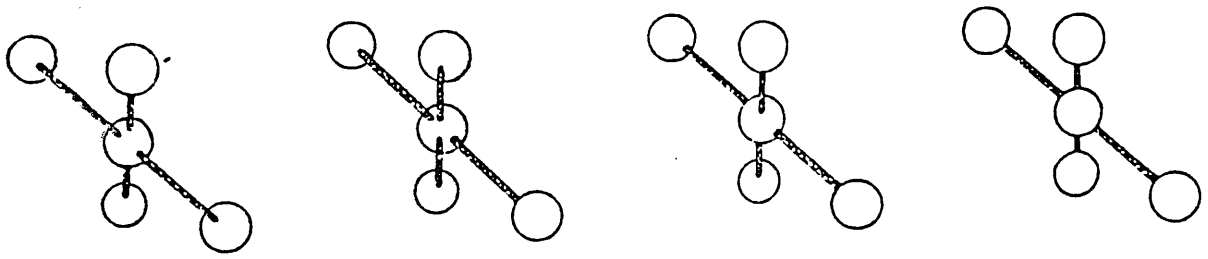
٣٦ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٥ على الحامل ثم انظر اليه من مستوى النظر الصحيح
واجب عن السؤال التالي:-

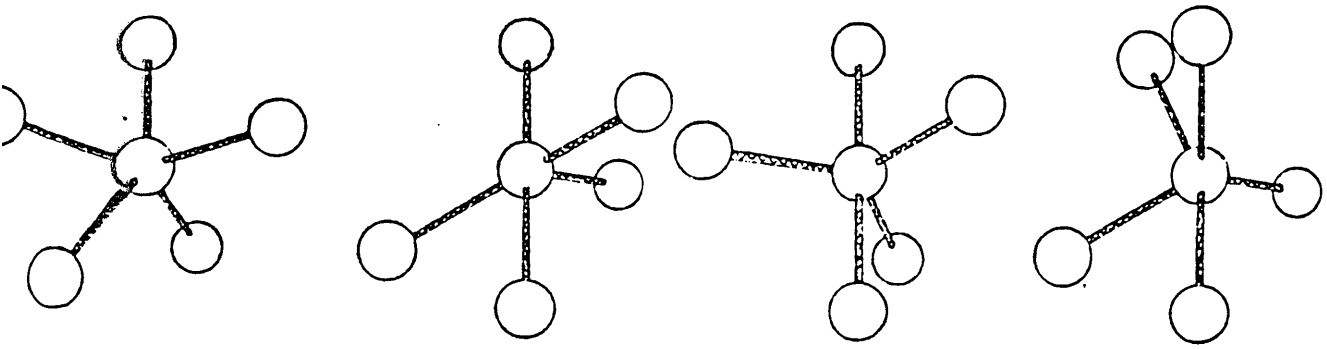
٣٧ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٧ على الحامل ثم انظر اليه من مستوى النظر الصحيح
واجب عن السؤال التالي:-

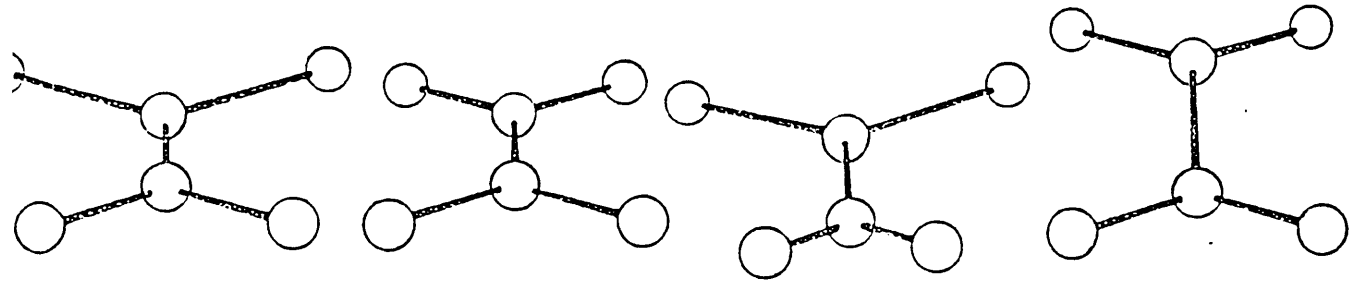
٣٨ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٨ على الحامل ثم انظر اليه من مستوى النظر الصحيح
واجب عن السؤال التالي:-

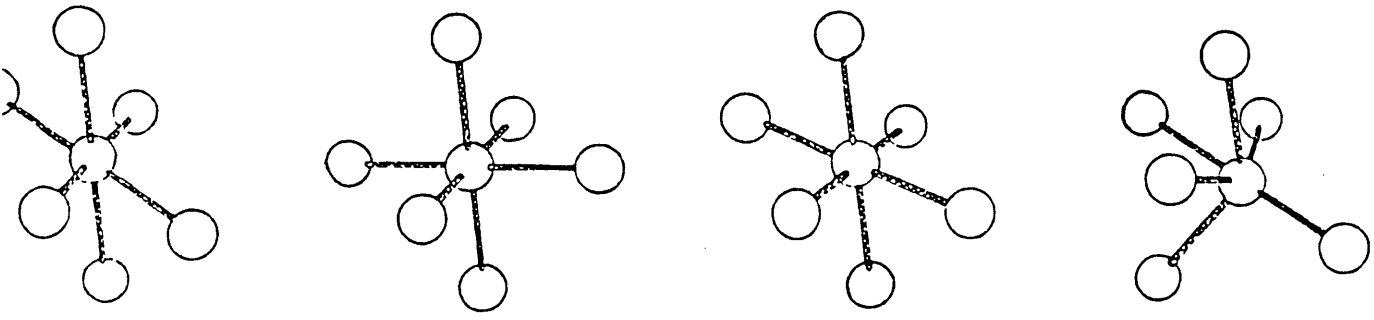
٣٩ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟



١ ٢ ٣ ٤

ضع نموذج رقم ٦٩ على الحامل ثم انظر اليه من مستوى النظر الصحيح
واجب عن السؤال التالي:-

٤٠ - اي شكل من الأشكال (١-٤) يمثل ما تراه من نموذج ؟

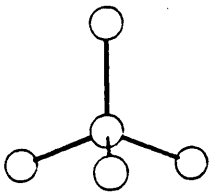


١ ٢ ٣ ٤

APPENDIX 6

COPIES OF OVERHEAD TRANSPARENCIES USED IN TRANSPARENCY INSTRUCTIONAL PROGRAMME

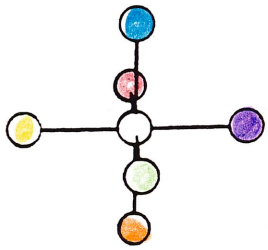
MOLECULAR ROTATION PROGRAMME



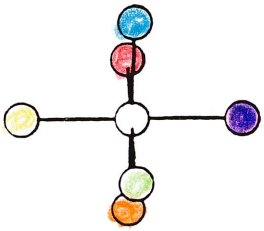
1982

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NORWICH, ENGLAND

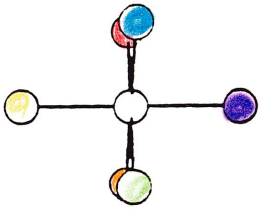
1.



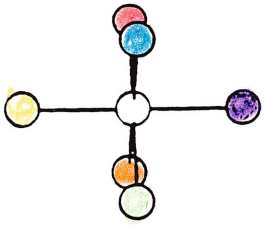
1



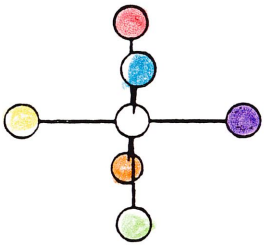
2



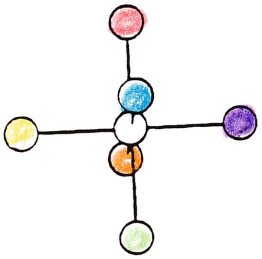
3



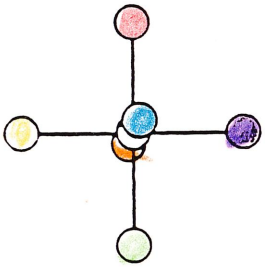
4



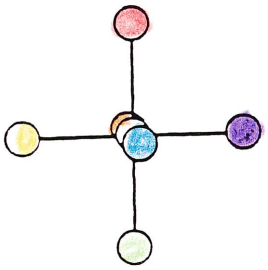
5



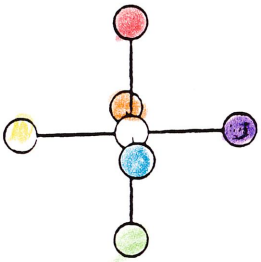
6



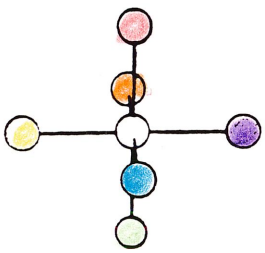
7



8



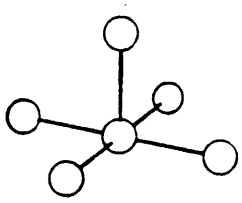
9



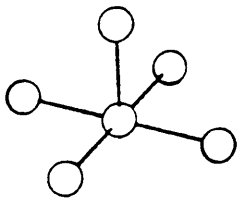
10

CORRECT ANSWER 3

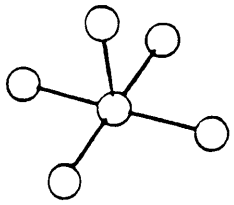
2.



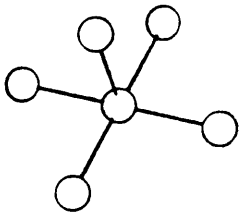
1



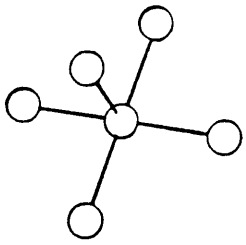
2



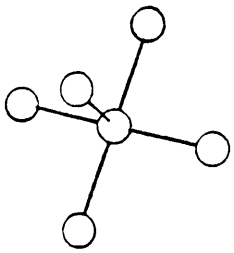
3



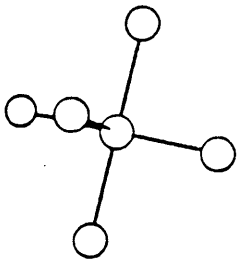
4



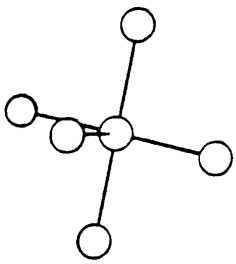
5



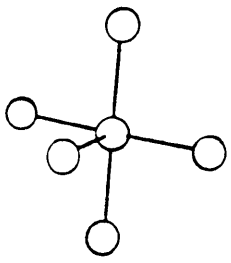
6



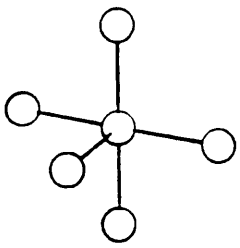
7



8



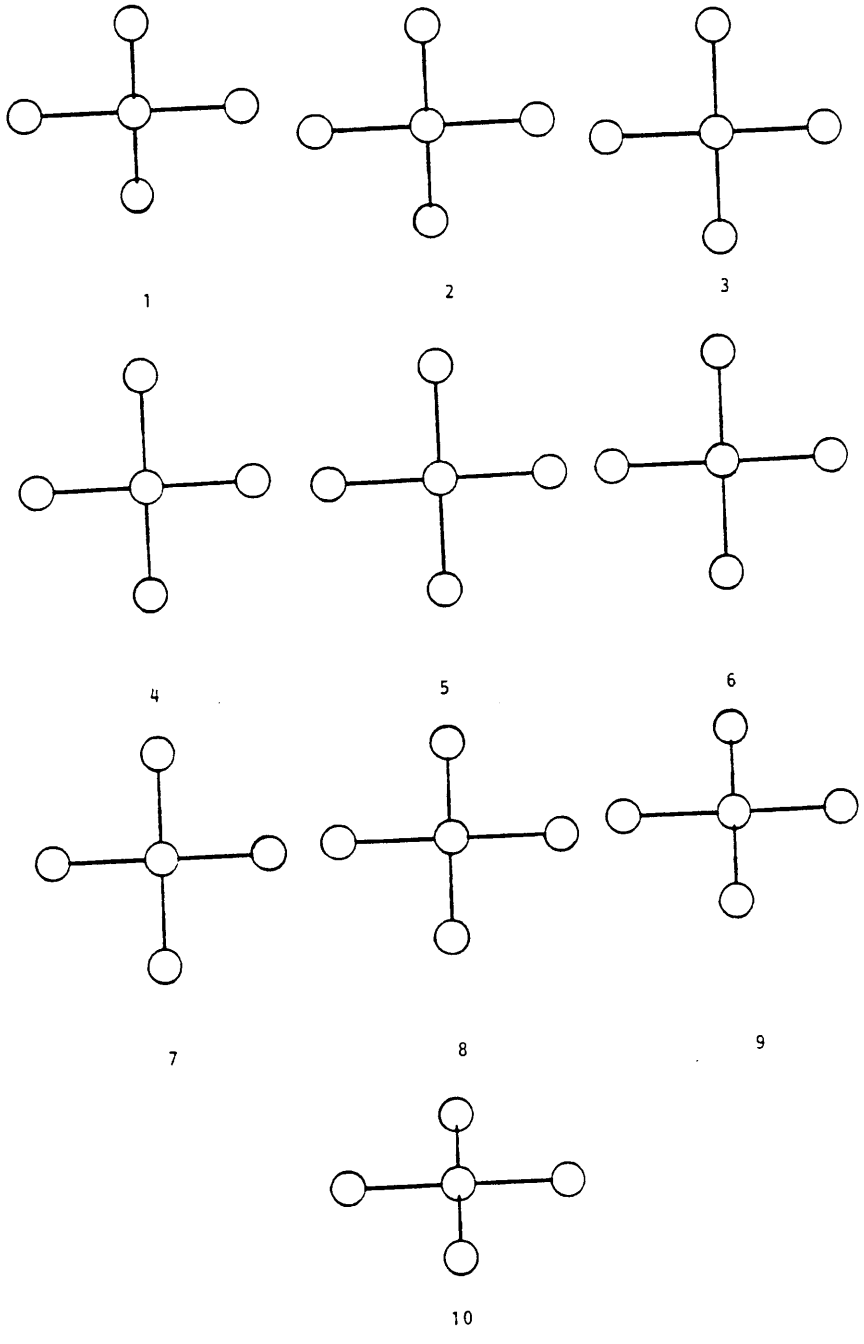
9



10

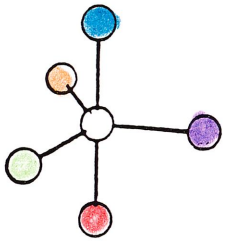
CORRECT ANSWER 5

3.

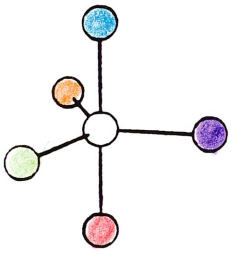


CORRECT ANSWER 5

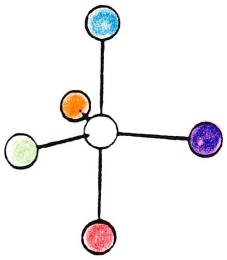
4.



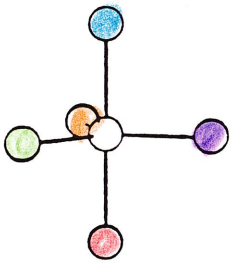
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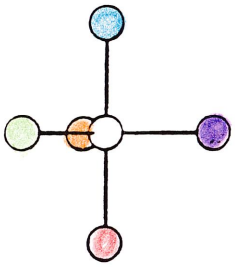
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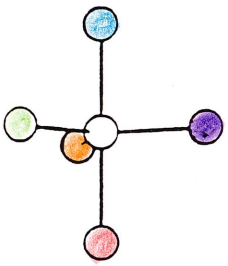
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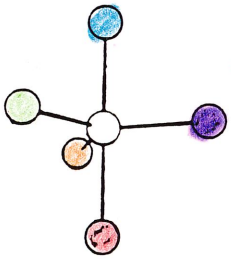
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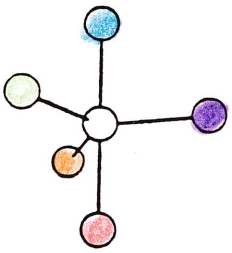
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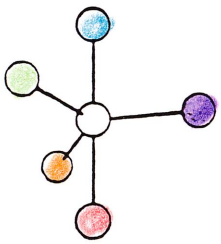
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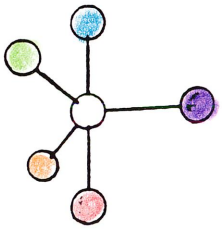
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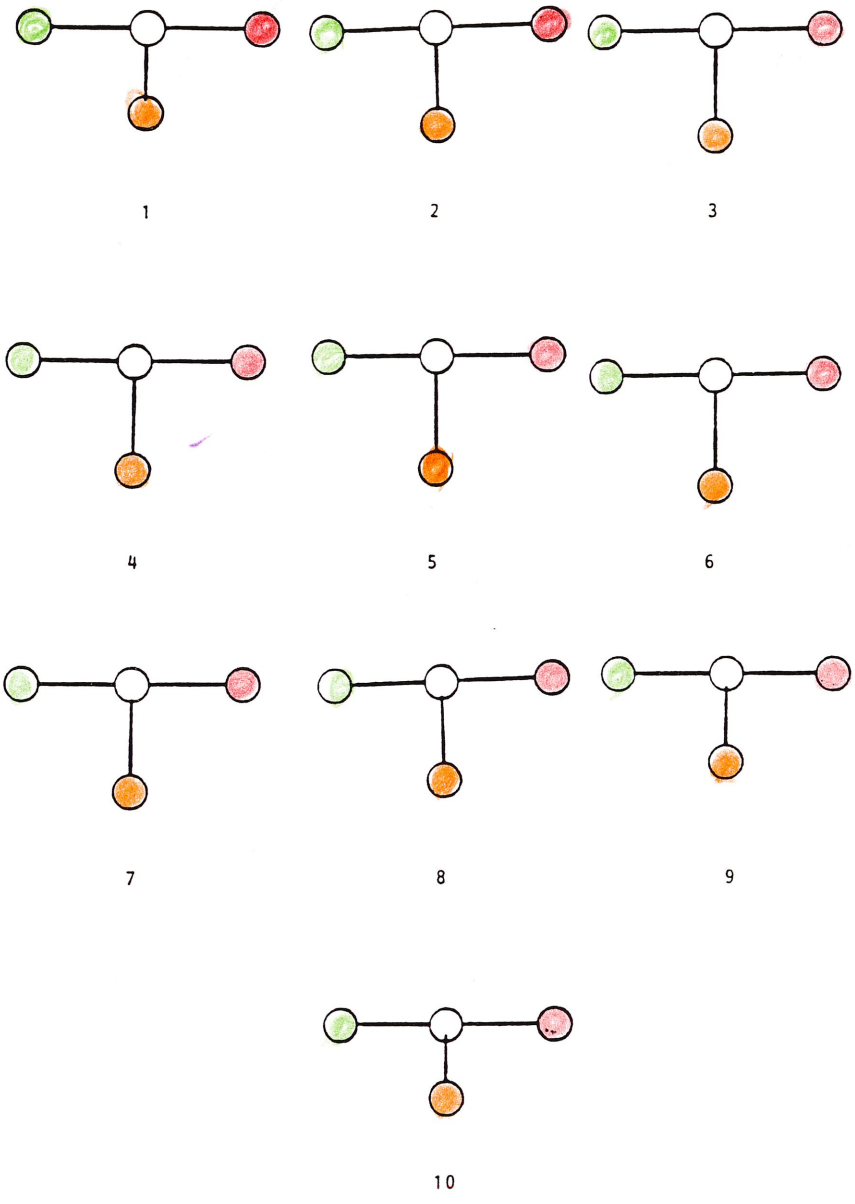
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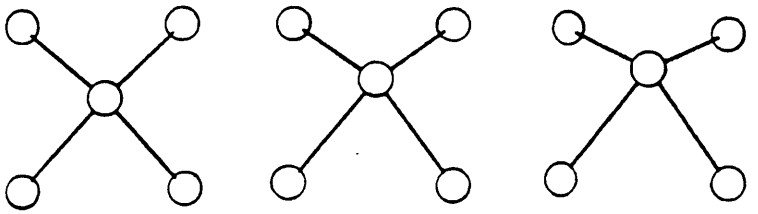
CORRECT ANSWER 2

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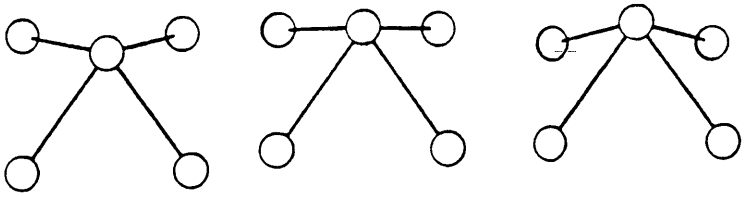


CORRECT ANSWER 5

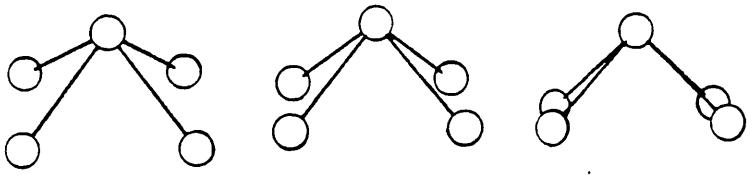
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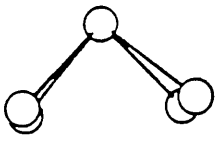
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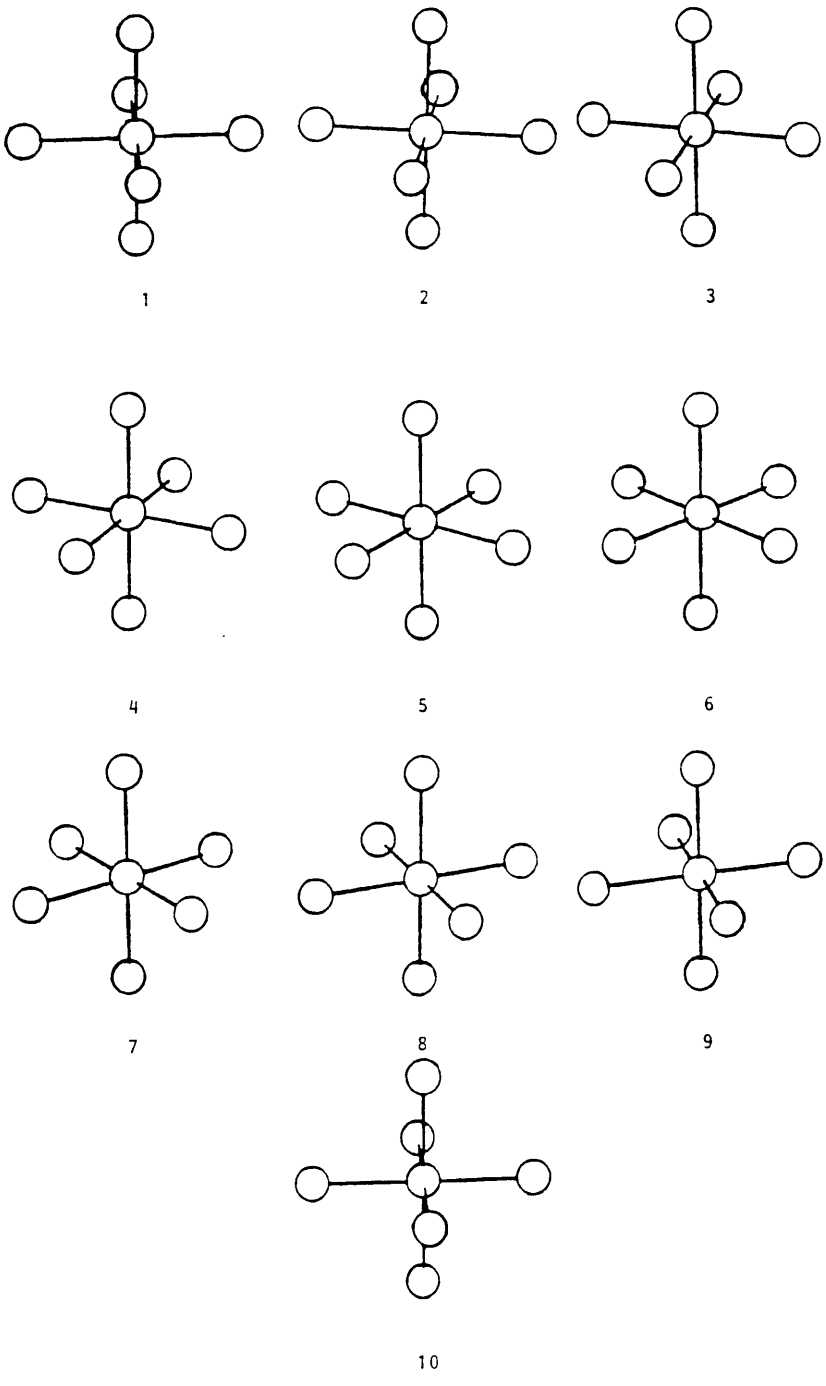
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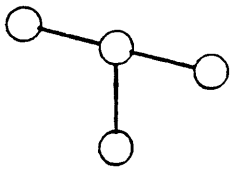
CORRECT ANSWER 2

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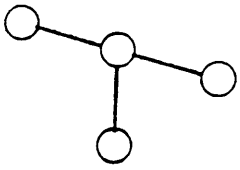


CORRECT ANSWER 5

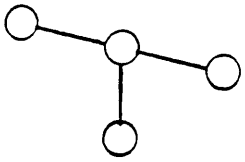
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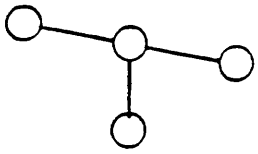
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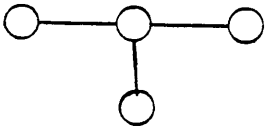
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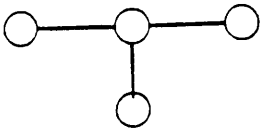
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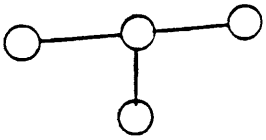
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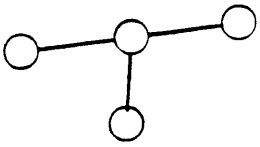
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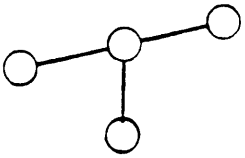
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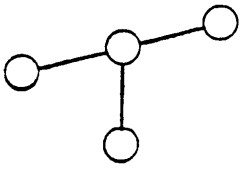
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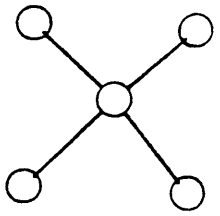
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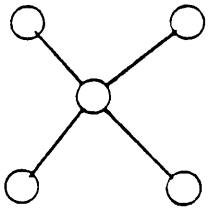
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CORRECT ANSWER 4

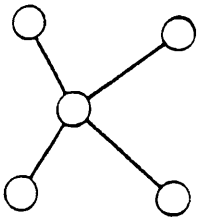
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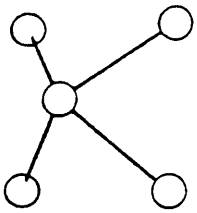
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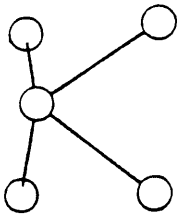
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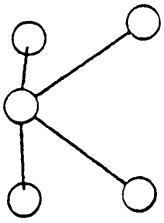
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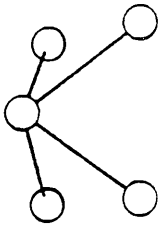
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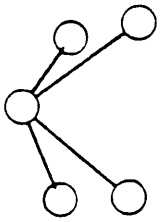
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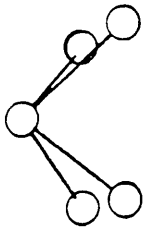
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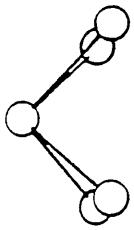
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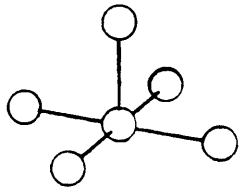
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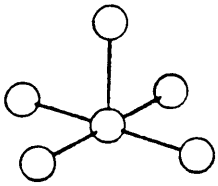
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CORRECT ANSWER 3

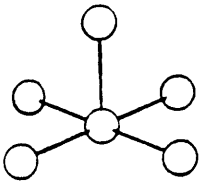
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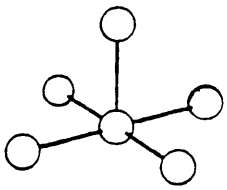
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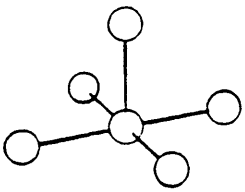
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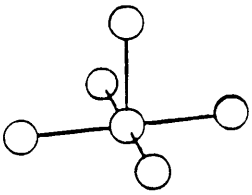
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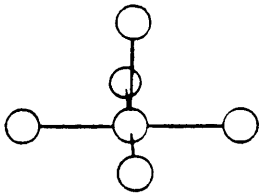
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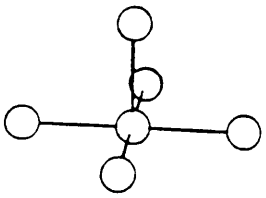
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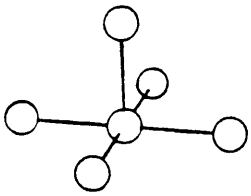
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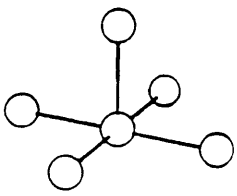
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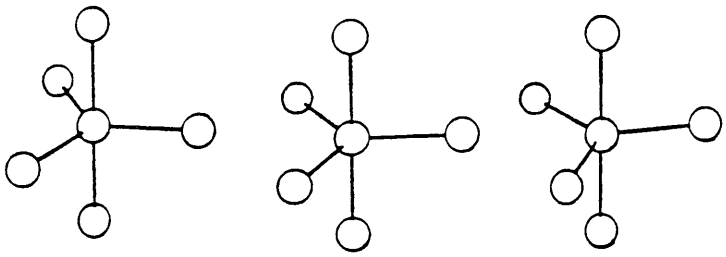
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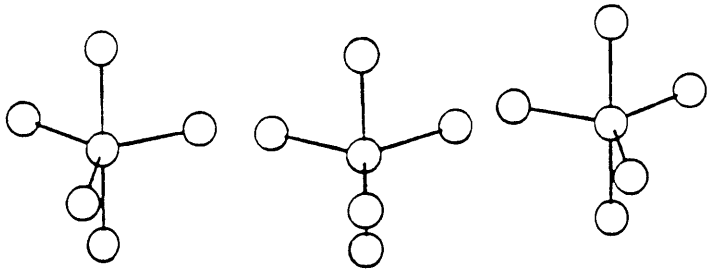
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CORRECT ANSWER 4

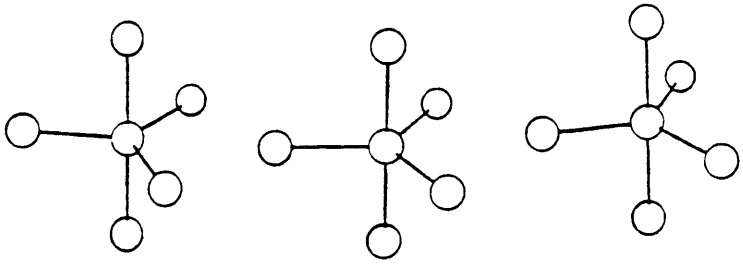
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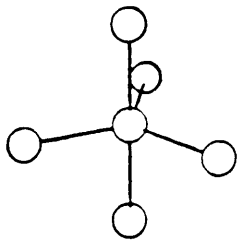
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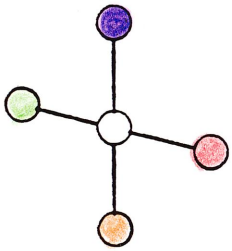
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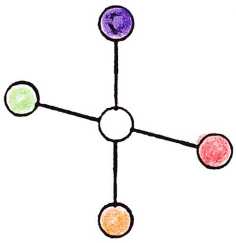
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CORRECT ANSWER 5

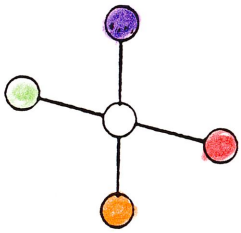
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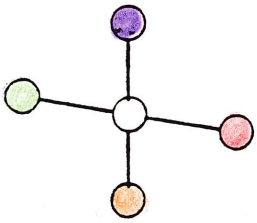
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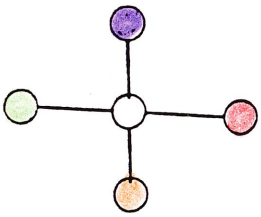
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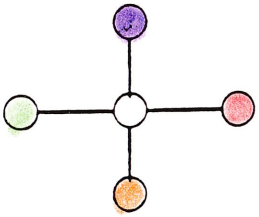
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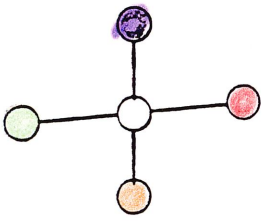
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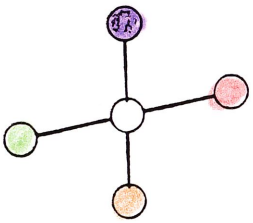
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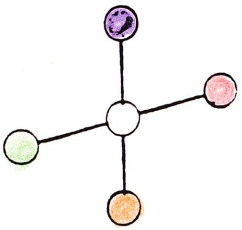
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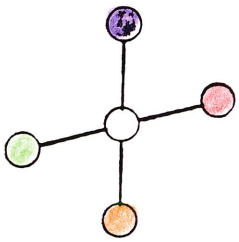
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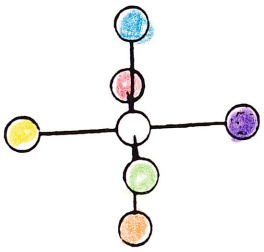
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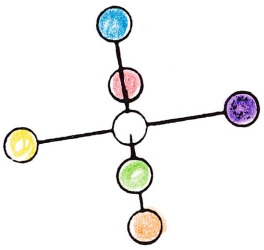
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CORRECT ANSWER 3

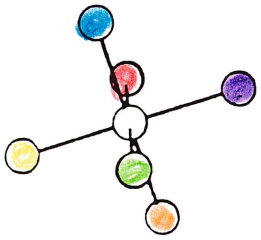
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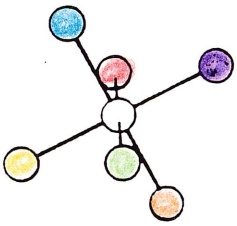
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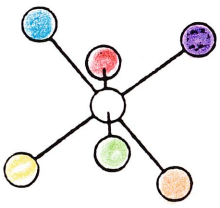
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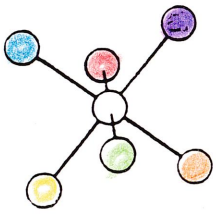
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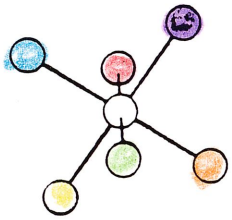
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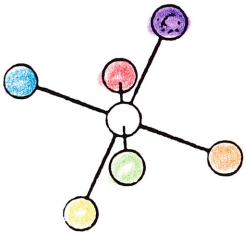
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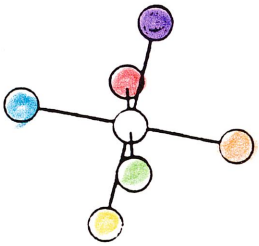
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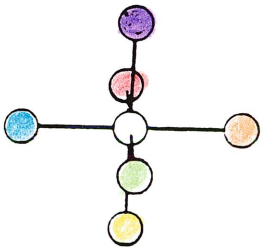
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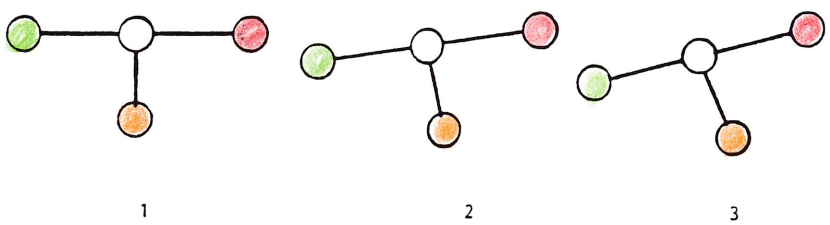
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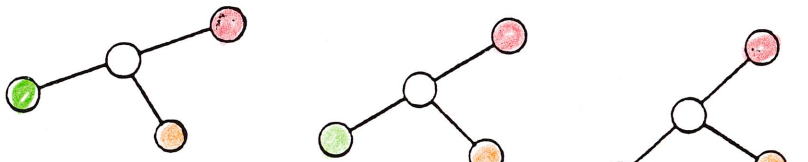
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CORRECT ANSWER 2

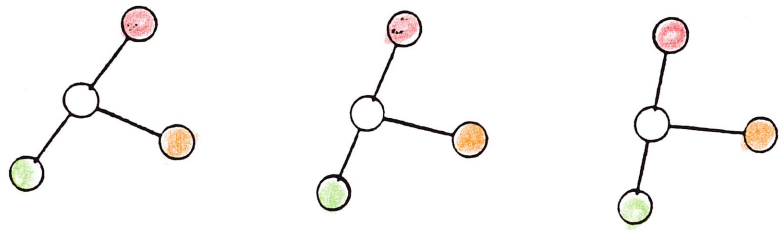
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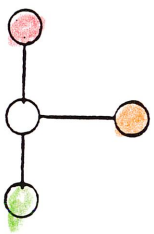
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4 5 6



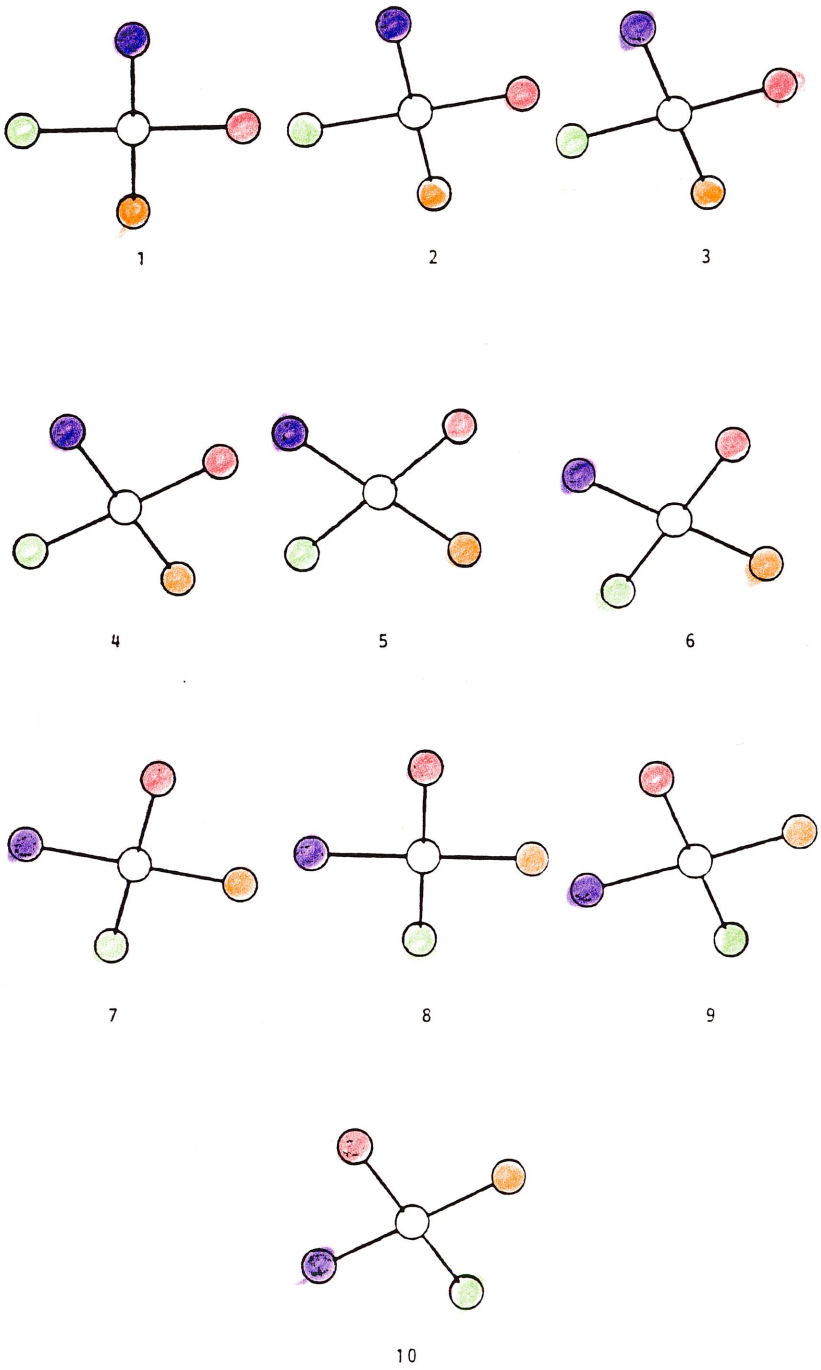
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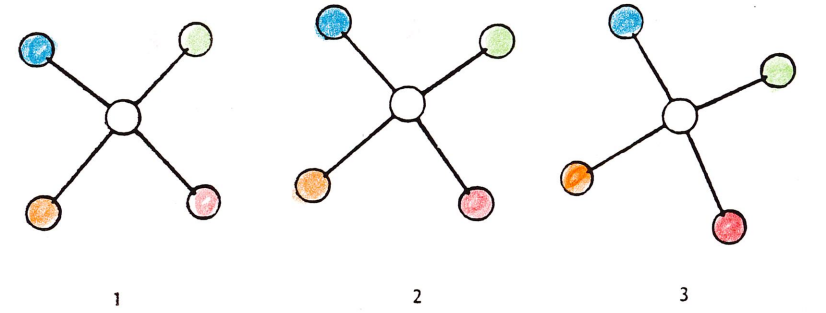
CORRECT ANSWER 3

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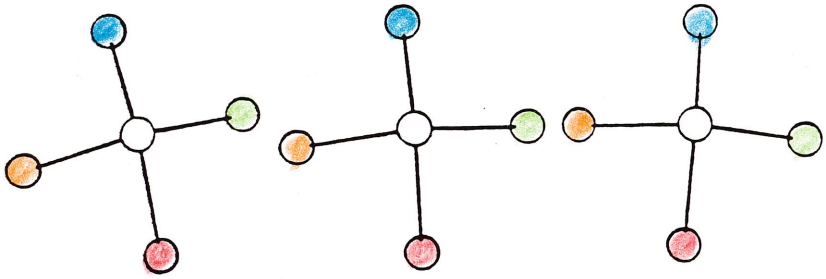


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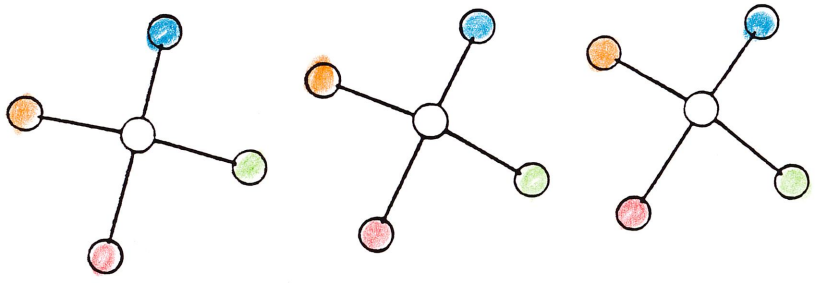
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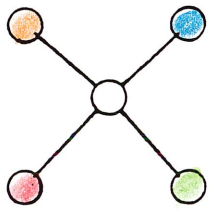
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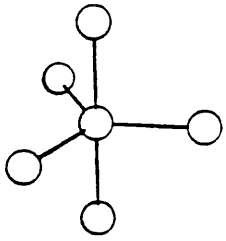
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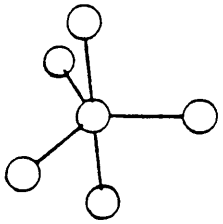
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CORRECT ANSWER 4

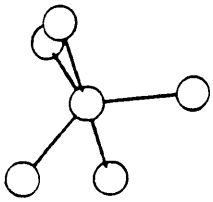
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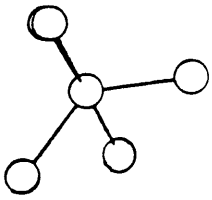
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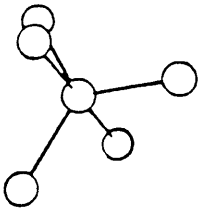
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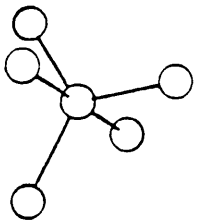
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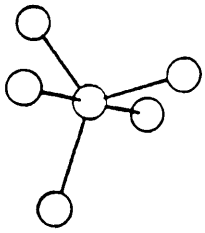
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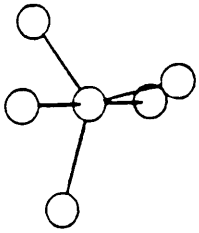
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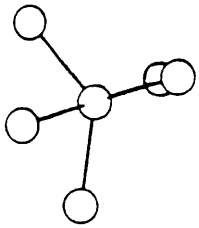
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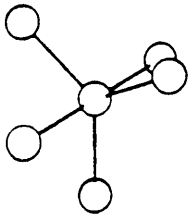
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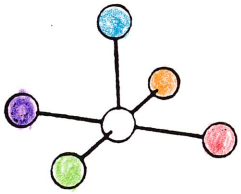
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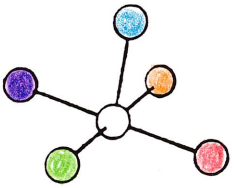
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CORRECT ANSWER 3

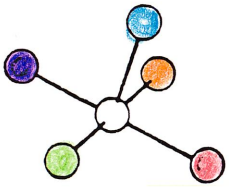
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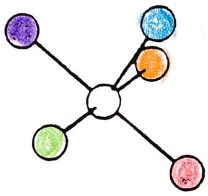
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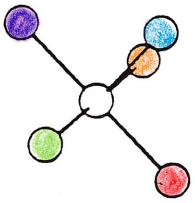
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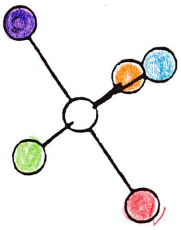
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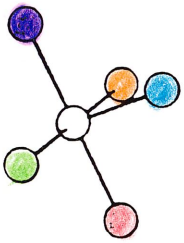
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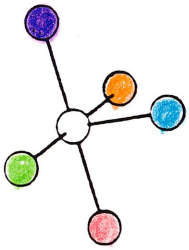
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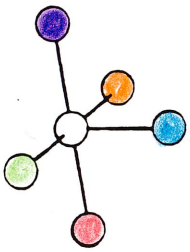
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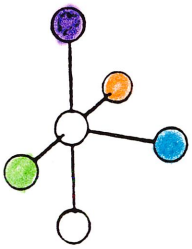
7



8



9



10

CORRECT ANSWER 2

APPENDIX 7

THE DIAGRAMS FROM PROJECTED COLOUR SLIDES

Diagram 1.0 X

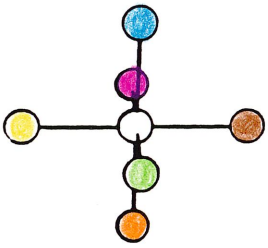


Diagram 1.10 X

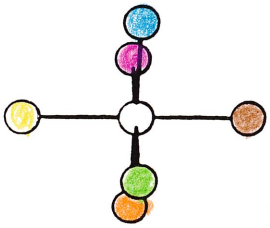
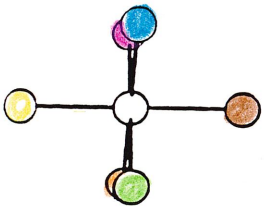


Diagram 1.20 X



INITIAL VIEWPOINT

Diagram 1.30 X

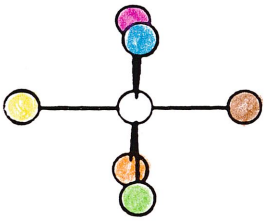


Diagram 1.40 X

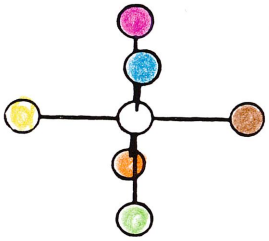


Diagram 1.50 X

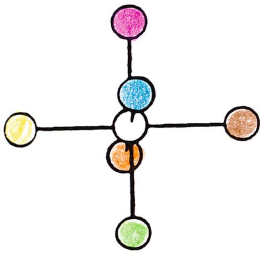


Diagram 1.60 X

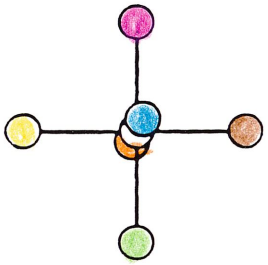


Diagram 1.70 X

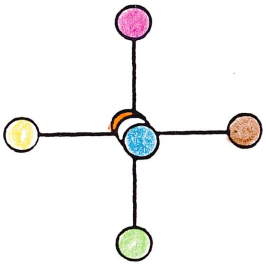


Diagram 1.80 X

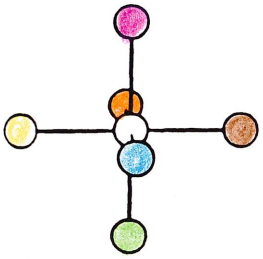
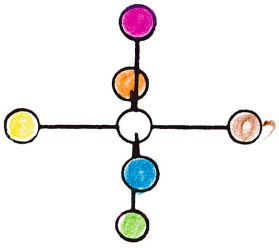


Diagram 1.90 X



CORRECT ANSWER 3

Diagram 2.0 X

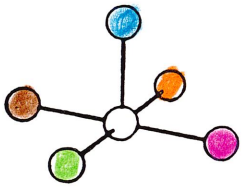


Diagram 2.10 X

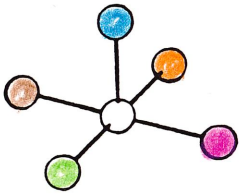
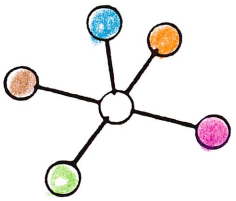


Diagram 2.20 X



INITIAL VIEWPOINT

Diagram 2.30 X

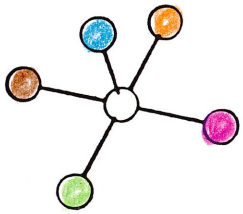


Diagram 2.40 X

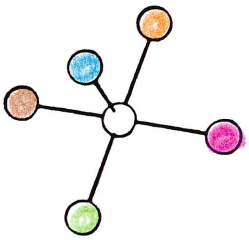


Diagram 2.50 X

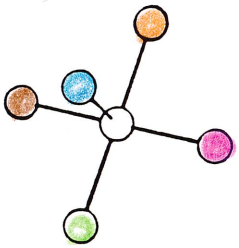


Diagram 2.60 X

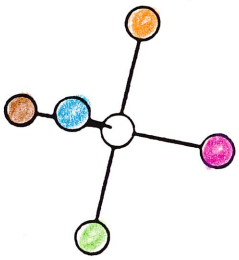


Diagram 2.70 X

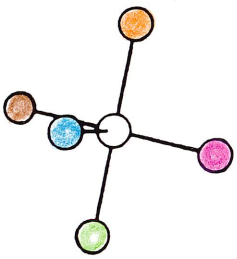


Diagram 2.80 X

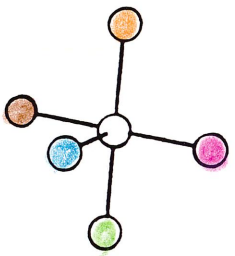
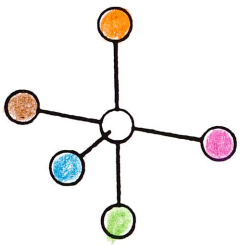
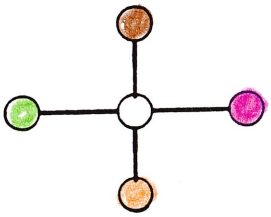


Diagram 2.90 X



CORRECT ANSWER 5

Diagram 3.0 X



INITIAL VIEWPOINT

Diagram 3.10 X

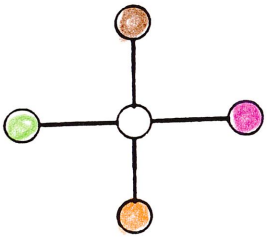


Diagram 3.20 X

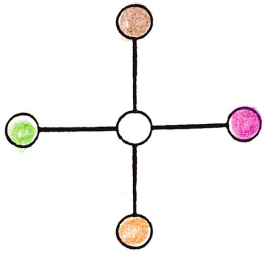


Diagram 3.30 X

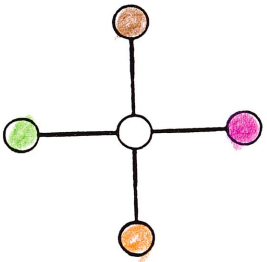


Diagram 3.40 X

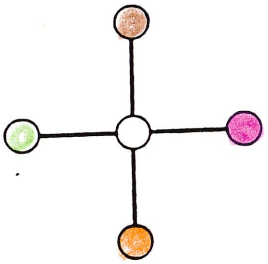


Diagram 3.50 X

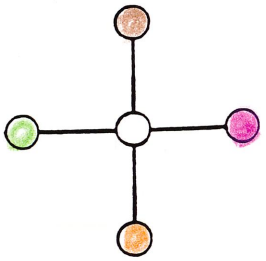


Diagram 3.60 X

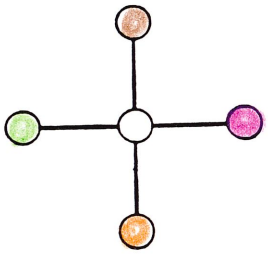


Diagram 3.70 X

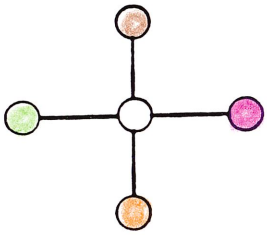


Diagram 3.80 X

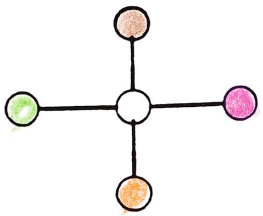
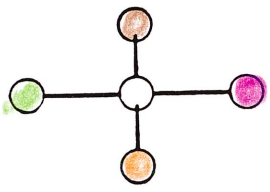
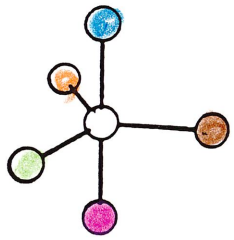


Diagram 3.90 X



CORRECT ANSWER 5

Diagram 4.0 X



INITIAL VIEWPOINT

Diagram 4.10 X

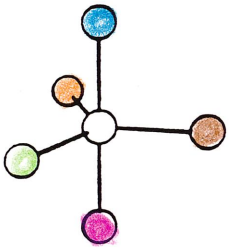


Diagram 4.20 X

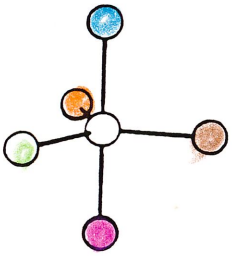


Diagram 4.30 X

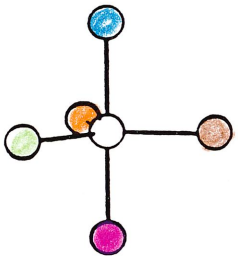


Diagram 4.40 X

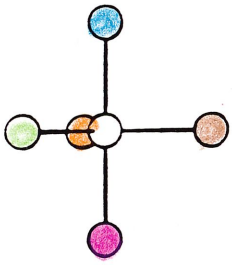


Diagram 4.50 X

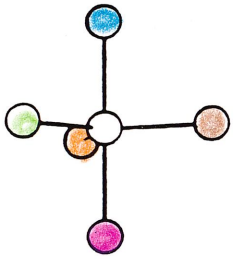


Diagram 4.60 X

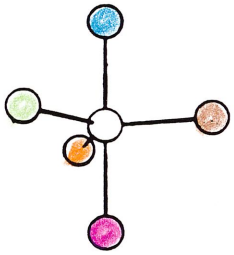


Diagram 4.70 X

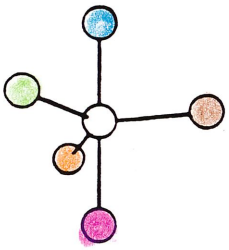


Diagram 4.80 X

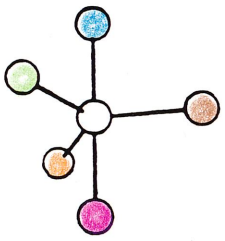
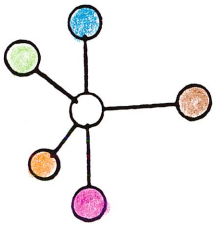


Diagram 4.90 X



CORRECT ANSWER 2

Diagram 5.0 X

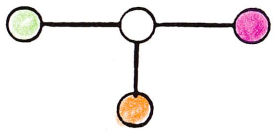


Diagram 5.10 X

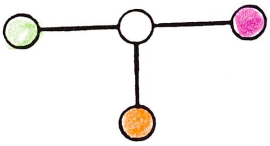
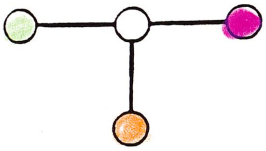


Diagram 5.20 X



INITIAL VIEWPOINT

Diagram 5.30 X

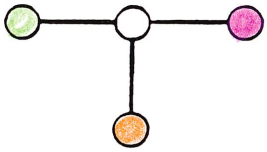


Diagram 5.40 X

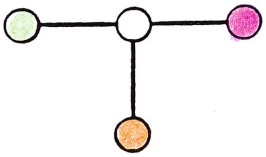


Diagram 5.50 X

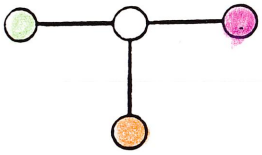


Diagram 5.60 X

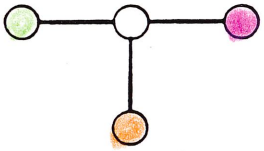


Diagram 5.70 X

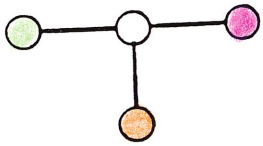


Diagram 5.80 X

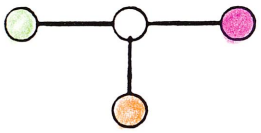
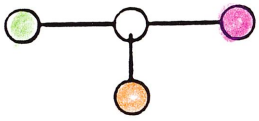
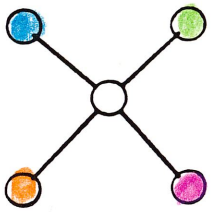


Diagram 5 .90 X



CORRECT ANSWER 5

Diagram 6.0 X



INITIAL VIEWPOINT

Diagram 6.10 X

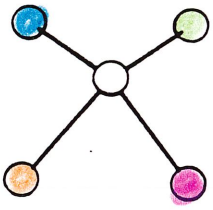


Diagram 6.20 X

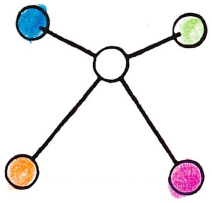


Diagram 6.30 X

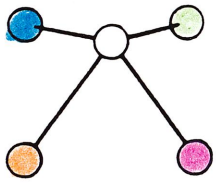


Diagram 6.40 X

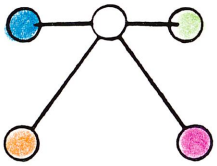


Diagram 6.50 X

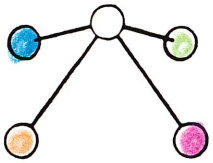


Diagram 6.60 X

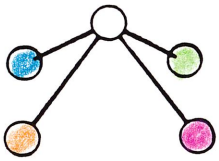


Diagram 6.70 X

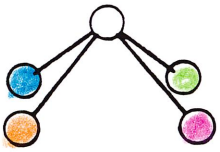


Diagram 6.80 X

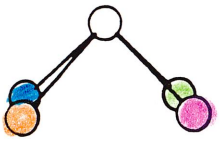
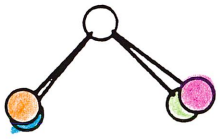
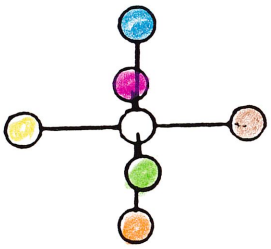


Diagram 6.90 X



CORRECT ANSWER 2

Diagram 7.0 Y



INITIAL VIEWPOINT

Diagram 7.10 Y

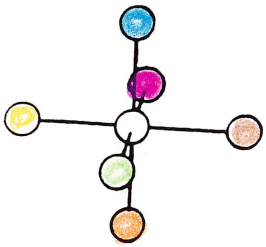


Diagram 7.20 Y

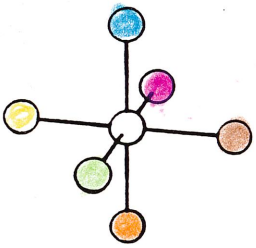


Diagram 7.30 Y

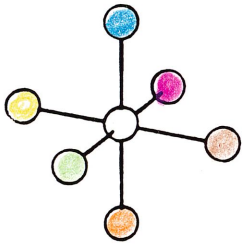


Diagram 7.40 Y

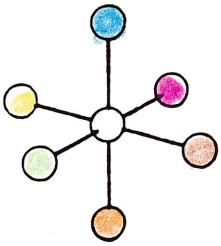


Diagram 7.50 Y

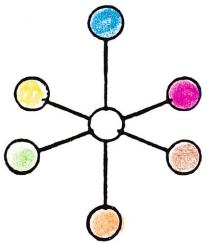


Diagram 7.60 Y

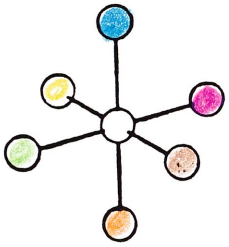


Diagram 7.70 Y

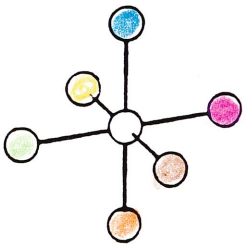


Diagram 7.80 Y

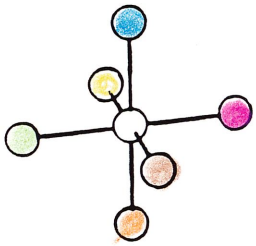
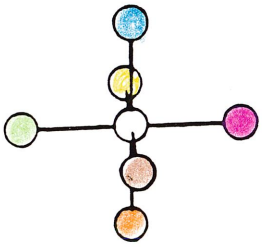
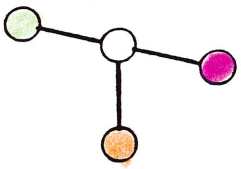


Diagram 7.90 Y



CORRECT ANSWER 5

Diagram 8.0 Y



INITIAL VIEWPOINT

Diagram 8.10 Y

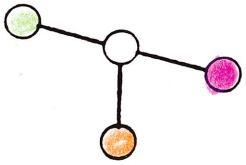


Diagram 8.20 Y

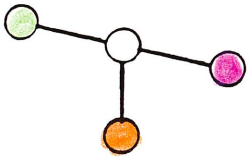


Diagram 8.30 Y

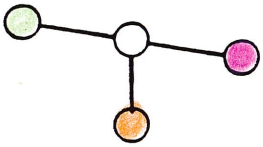


Diagram 8.40 Y

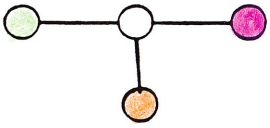


Diagram 8.50 Y

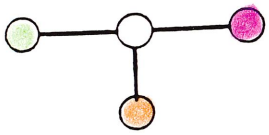


Diagram 8.60 Y

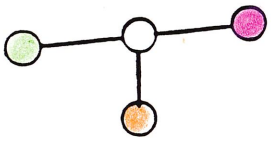


Diagram 8.70 Y

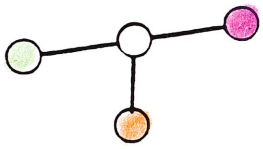


Diagram 8.80 Y

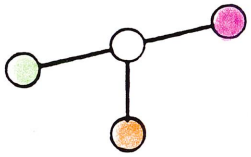
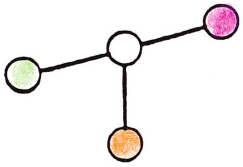
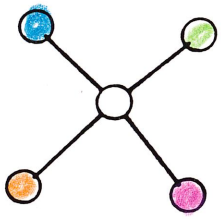


Diagram 8.90 Y



CORRECT ANSWER 4

Diagram 9.0 Y



INITIAL VIEWPOINT

Diagram 9.10 Y

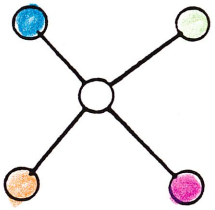


Diagram 9.20 Y

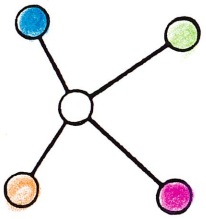


Diagram 9.30 Y

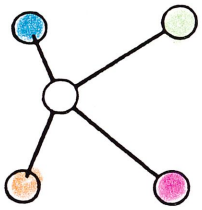


Diagram 9.40 Y

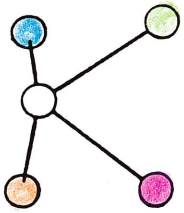


Diagram 9.50 Y

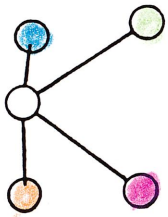


Diagram 9.60 Y

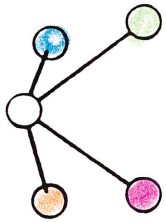


Diagram 9.70 Y

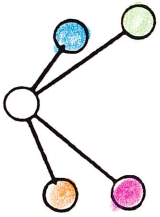


Diagram 9.80 Y

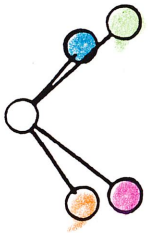
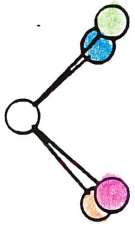
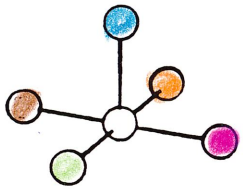


Diagram 9.90 Y



CORRECT ANSWER 3

Diagram 10.0 Y



INITIAL VIEWPOINT

Diagram 10.10 Y

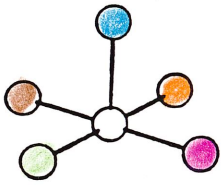


Diagram 10.20 Y

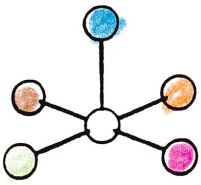


Diagram 10.30 Y

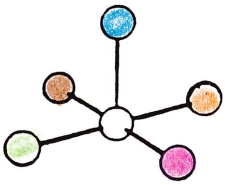


Diagram 10.40 Y

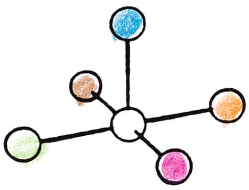


Diagram 10.50 Y

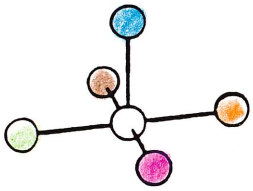


Diagram 10.60 Y

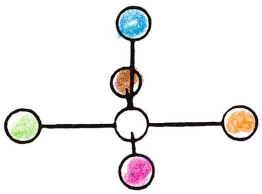


Diagram 10.70 Y

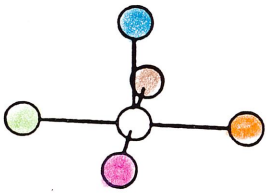


Diagram 10.80 Y

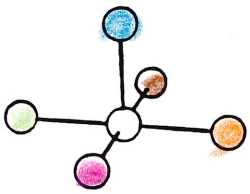
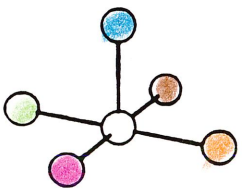
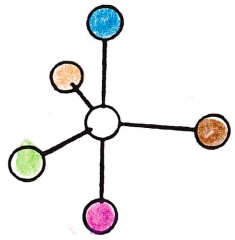


Diagram 10.90 Y



CORRECT ANSWER 4

Diagram 11.0 Y



INITIAL VIEWPOINT

Diagram 11.10 Y

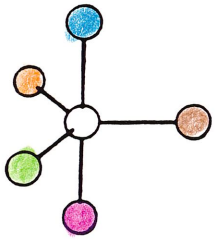


Diagram 11.20 Y

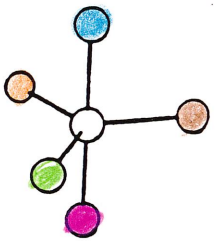


Diagram 11.30 Y

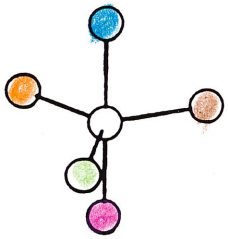


Diagram 11.40 Y

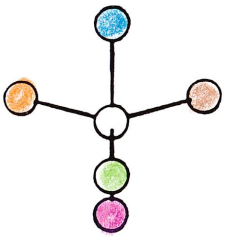


Diagram 11.50 Y

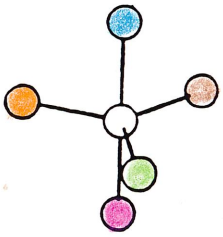


Diagram 11.60 Y

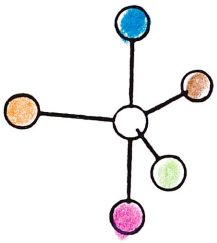


Diagram 11.70 Y

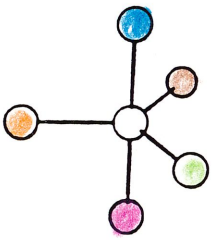


Diagram 11.80 Y

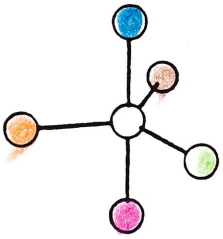
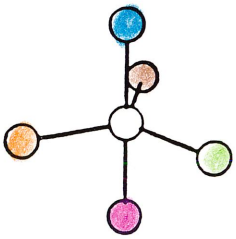
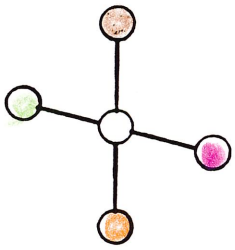


Diagram 11.90 Y



CORRECT ANSWER 5

Diagram 12.0 Y



INITIAL VIEWPOINT

Diagram 12.10 Y

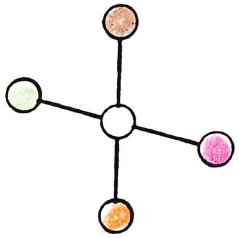


Diagram 12.20 Y

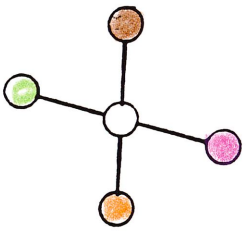


Diagram 12.30 Y

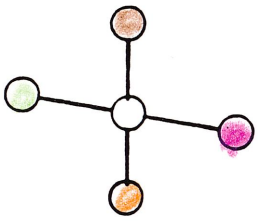


Diagram 12.40 Y

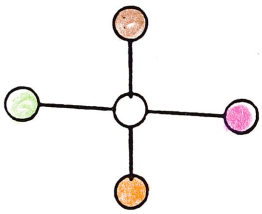


Diagram 12.50 Y

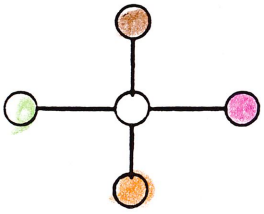


Diagram 12.60 Y

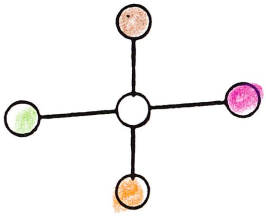


Diagram 12.70 Y

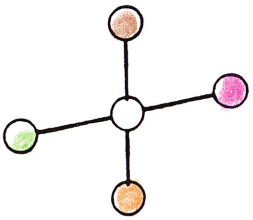


Diagram 12.80 Y

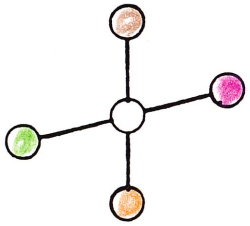
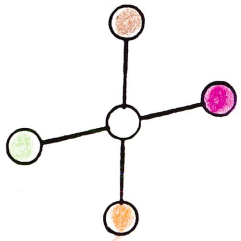
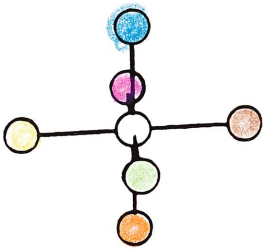


Diagram 12.90 Y



CORRECT ANSWER 3

Diagram 13.0 Z



INITIAL VIEWPOINT

Diagram 13.10 Z

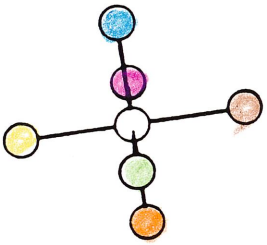


Diagram 13.20 Z

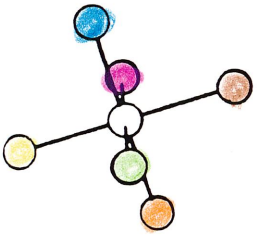


Diagram 13.30 Z

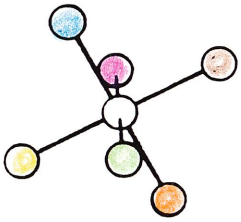


Diagram 13.40 Z

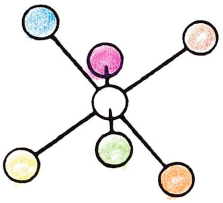


Diagram 13.50 Z

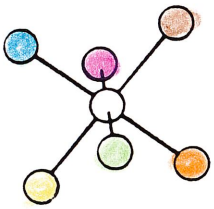


Diagram 13.60 Z

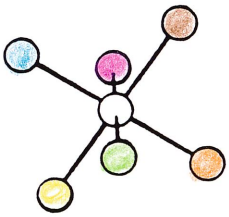


Diagram 13.70 Z

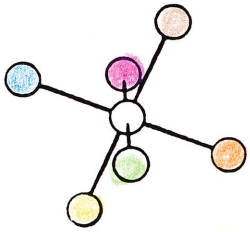


Diagram 13.80 Z

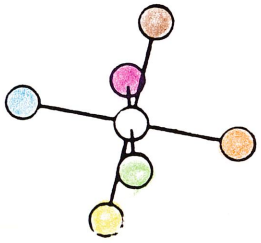
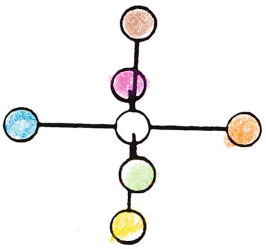
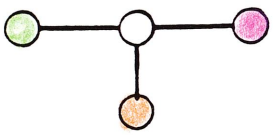


Diagram 13.90 Z



CORRECT ANSWER 2

Diagram 14.0 Z



INITIAL VIEWPOINT

Diagram 14.10 Z

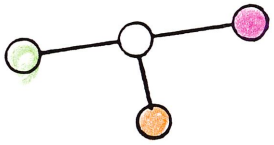


Diagram 14.20 Z

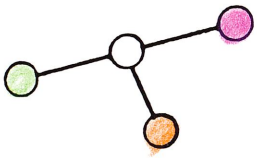


Diagram 14.30 Z

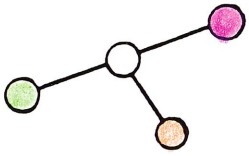


Diagram 14.40 Z

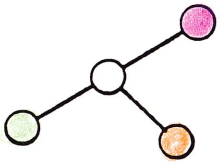


Diagram 14.50 Z

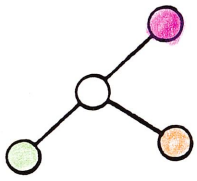


Diagram 14.60 Z

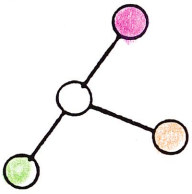


Diagram 14.70 Z

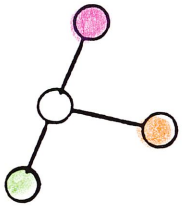


Diagram 14.80 Z

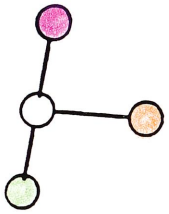
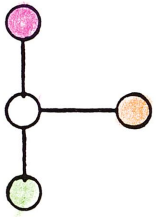


Diagram 14.90 Z



CORRECT ANSWER 3

Diagram 15.0 Z

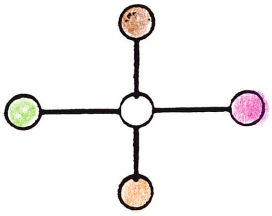


Diagram 15.10 Z

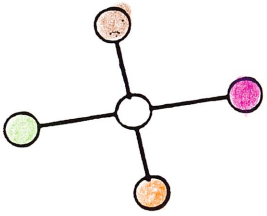
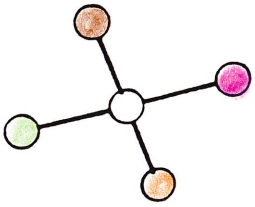


Diagram 15.20 Z



INITIAL VIEWPOINT

Diagram 15.30 Z

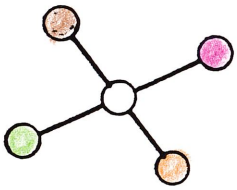


Diagram 15.40 Z

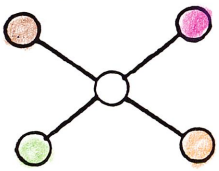


Diagram 15.50 Z

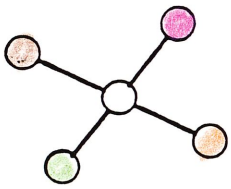


Diagram 15.60 Z

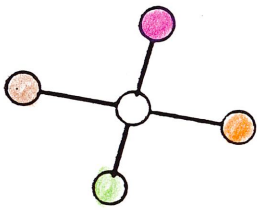


Diagram 15.70 Z

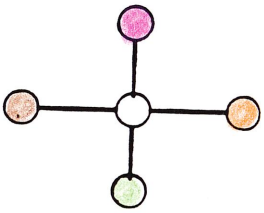


Diagram 15.80 Z

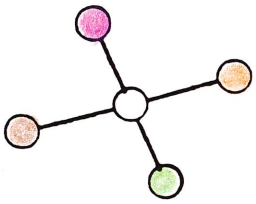
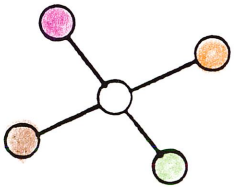
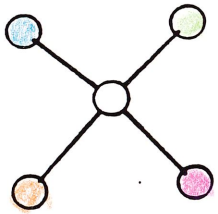


Diagram 15.90 Z



CORRECT ANSWER 4

Diagram 16.0 Z



INITIAL VIEWPOINT

Diagram 16.10 Z

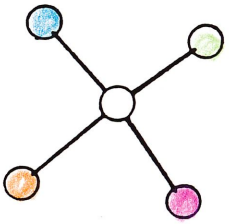


Diagram 16.20 Z

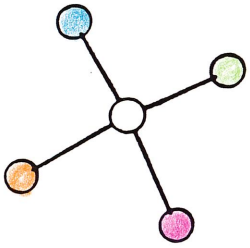


Diagram 16.30 Z

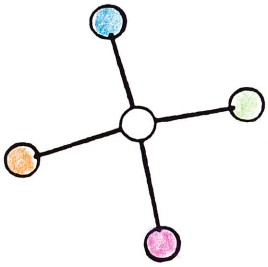


Diagram 16.40 Z

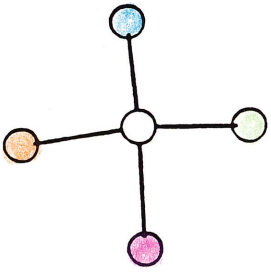


Diagram 16.50 Z

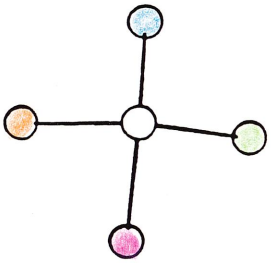


Diagram 16.60 Z

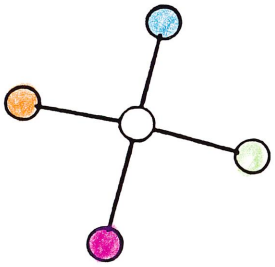


Diagram 16.70 Z

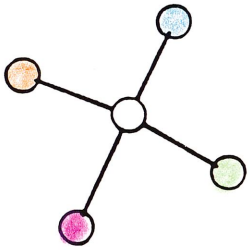


Diagram 16.80 Z

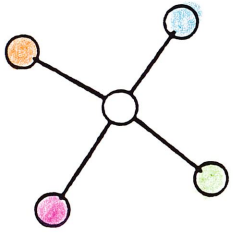
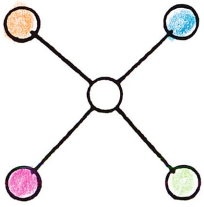
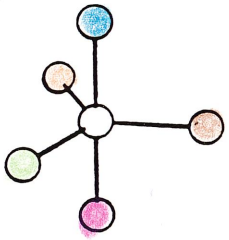


Diagram 16.90 Z



CORRECT ANSWER 4

Diagram 17.0 Z



INITIAL VIEWPOINT

Diagram 17.10 Z

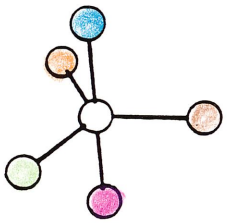


Diagram 17.20 Z

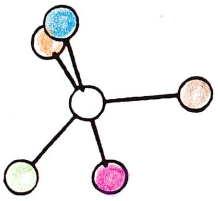


Diagram 17.30 Z

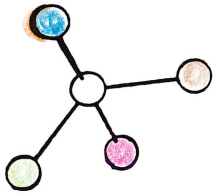


Diagram 17.40 Z

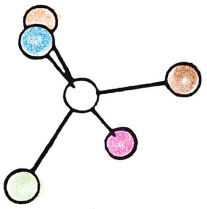


Diagram 17.50 Z

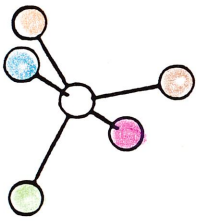


Diagram 17.60 Z

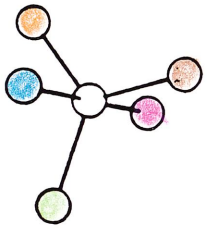


Diagram 17.70 Z

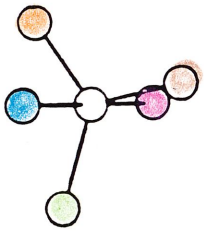


Diagram 17.80 Z

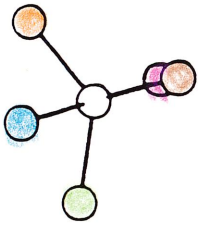
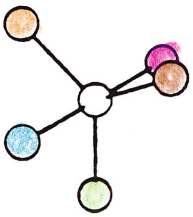
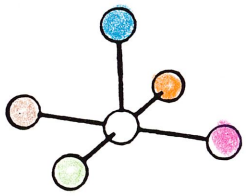


Diagram 17.90 Z



CORRECT ANSWER 3

Diagram 18.0 Z



INITIAL VIEWPOINT

Diagram 18.10 Z

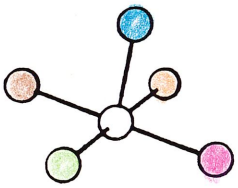


Diagram 18.20 Z

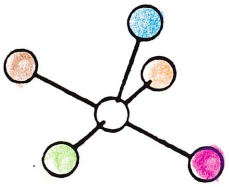


Diagram 18.30 Z

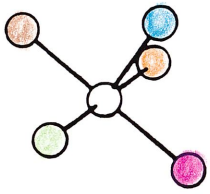


Diagram 18.40 Z

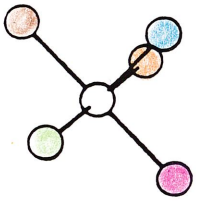


Diagram 18.50 Z

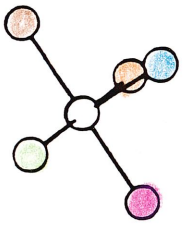


Diagram 18.60 Z

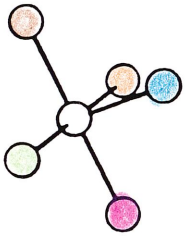


Diagram 18.70 Z

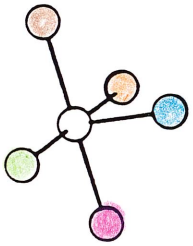


Diagram 18.80 Z

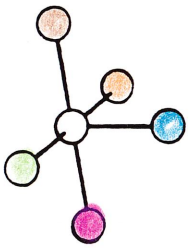
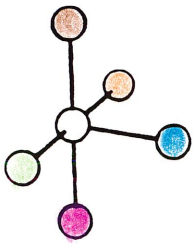


Diagram 18.90 Z



CORRECT ANSWER 2

APPENDIX 8

EXAMPLES OF DDRP BOOKLETS SHOWING

DIFFERENT VERSIONS OF THE PROGRAMMES

A - COMPLETE BOOKLET 9D, 18-DEGREE OF COLOURING, ENGLISH

B - COMPLETE BOOKLET 9D, 0-DEGREE OF COLOURING, ARABIC

C - SAMPLE PAGE FROM 6D, 18-DEGREE OF COLOURING, ENGLISH

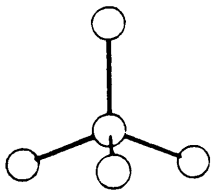
D - SAMPLE PAGE FROM 6D, 18-DEGREE OF COLOURING, ARABIC

E - SAMPLE PAGE FROM 3D, 0-DEGREE OF COLOURING, ENGLISH

F - SAMPLE PAGE FROM 6D, 0-DEGREE OF COLOURING, ARABIC

APPENDIX 8A

MOLECULAR ROTATION PROGRAMME



1982

UNIVERSITY OF EAST ANGLIA
NORWICH, ENGLAND

Introduction:

This course is to improve your ability to understand diagrams of molecules.

The diagrams show molecules rotating. Each one rotates about either the X, the Y, or the Z axis.

What to do:

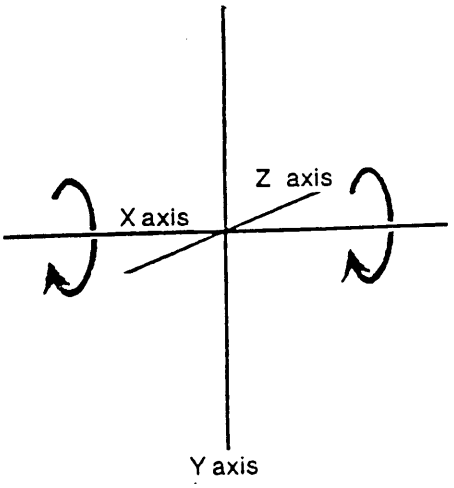
You will see diagrams of molecules rotating. The diagrams show a series of stages in the rotation. You will be asked to answer a question after you have seen some of the stages. After you have answered the question, you will be shown the correct answer.

Write your answer on a separate piece of paper.

Do not write in this booklet.

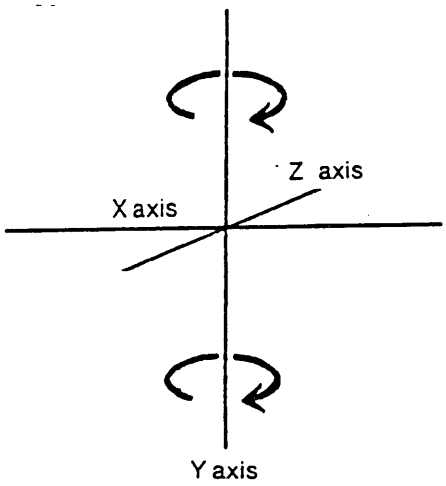
Study these diagrams before you start the test and make sure you know what is meant by the questions.

Turning around the X axis

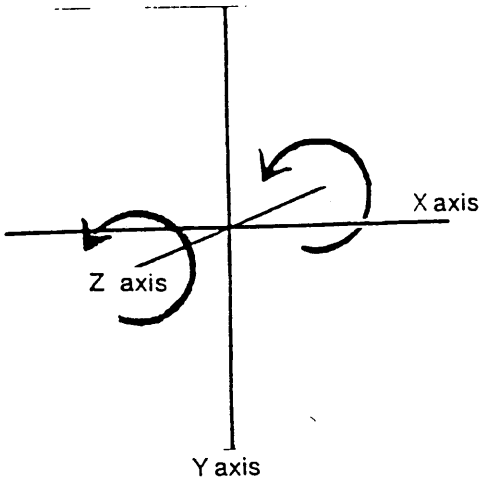


Note: The X axis and the Y axis are flat on the page. The Z axis is coming out of the page towards you.

Turning around the Y axis

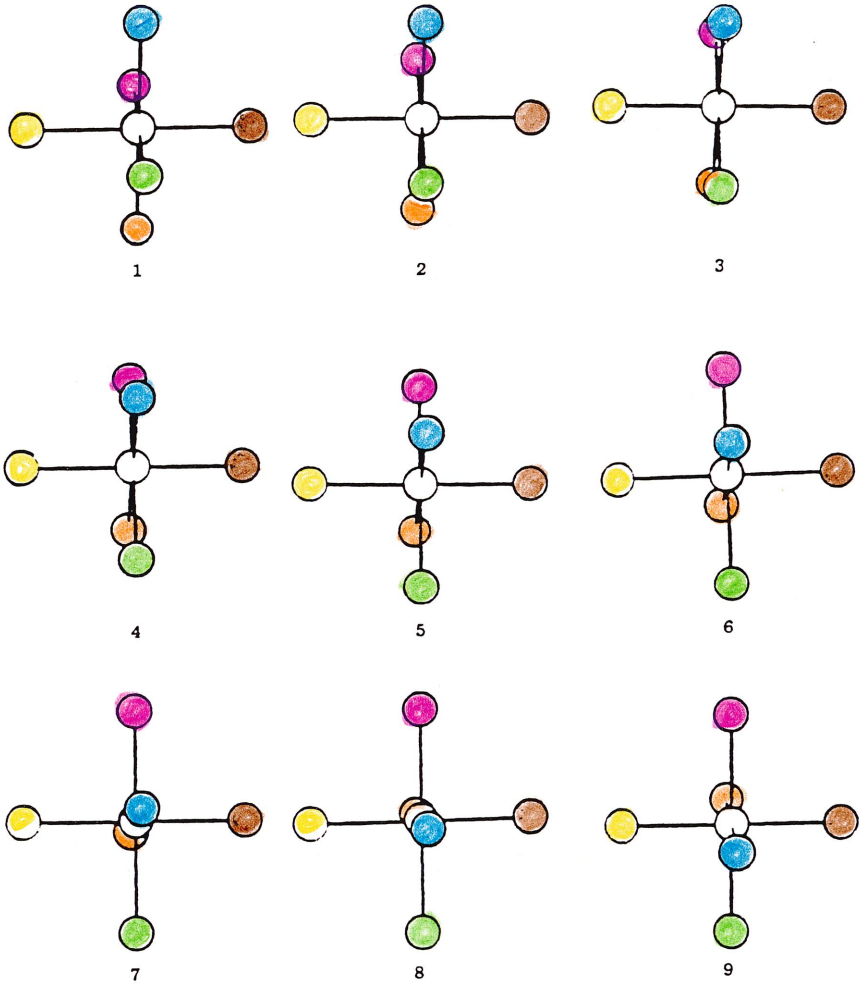


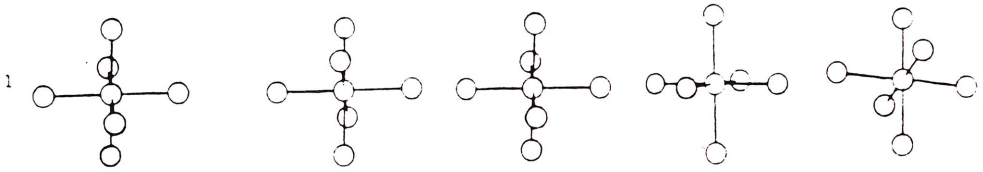
Turning around the Z axis



Write your answers on the paper provided.
Please do not write in this booklet.

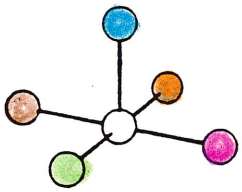
Section – X



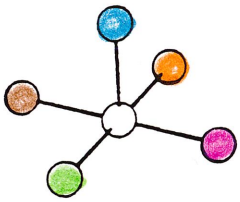


If the structure in diagram 1 were rotated about the X-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

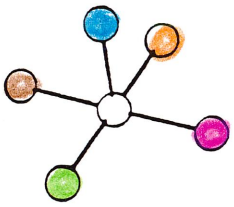
CORRECT ANSWER 3



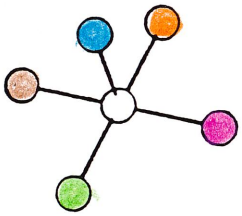
1



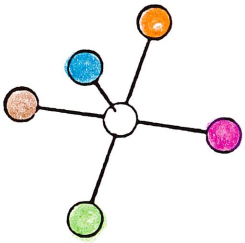
2



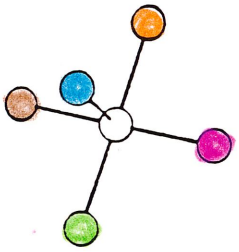
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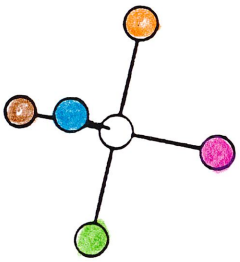
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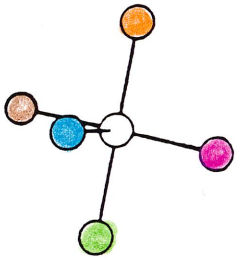
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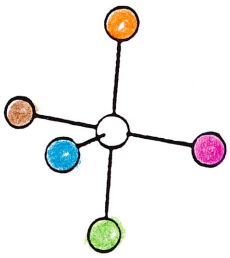
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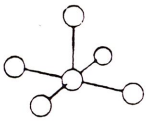


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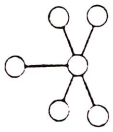


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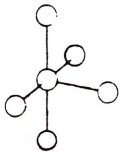
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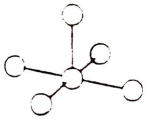
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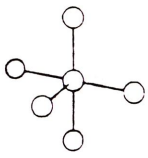
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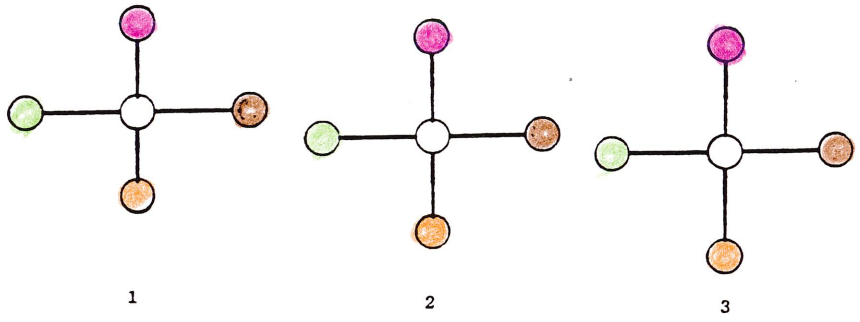
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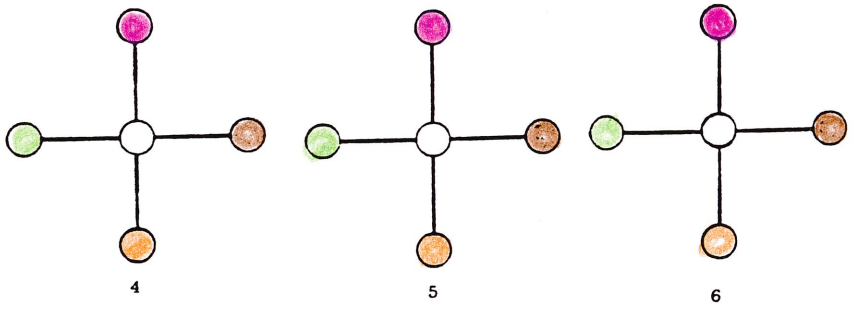
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If the structure in diagram 1 were rotated about the X-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

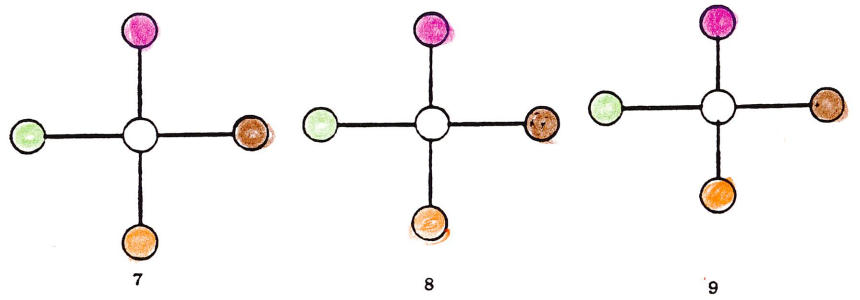
CORRECT ANSWER 5



1 2 3

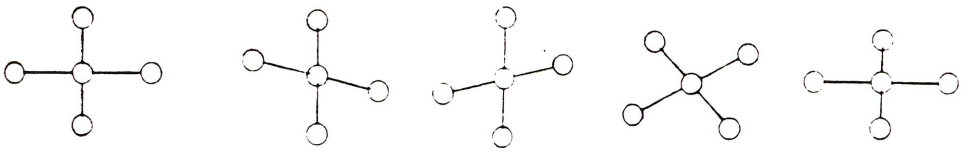


4 5 6



7 8 9

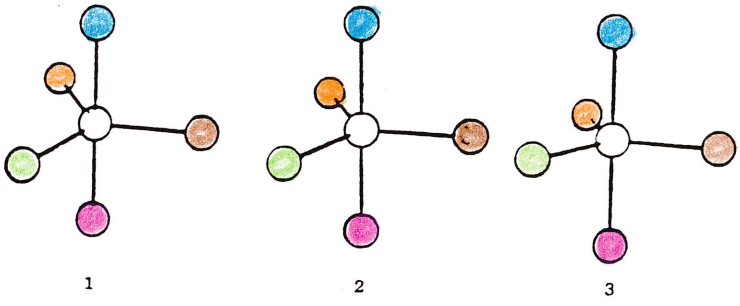
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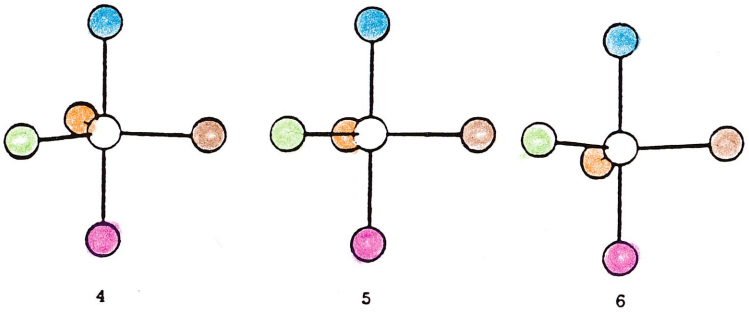
1 2 3 4 5

If the structure in diagram 1 were rotated about the X-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

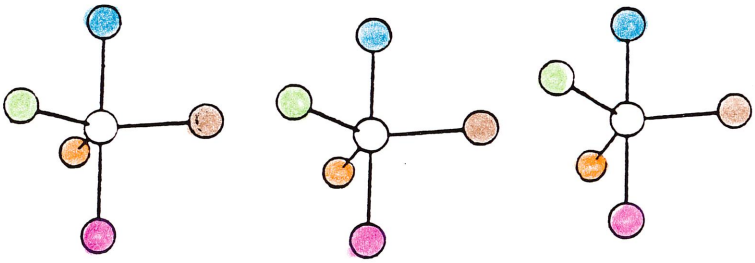
CORRECT ANSWER 5



1 2 3

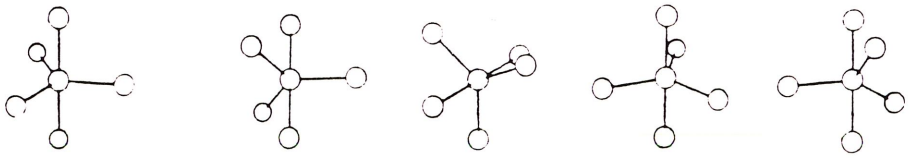


4 5 6



7 8 9

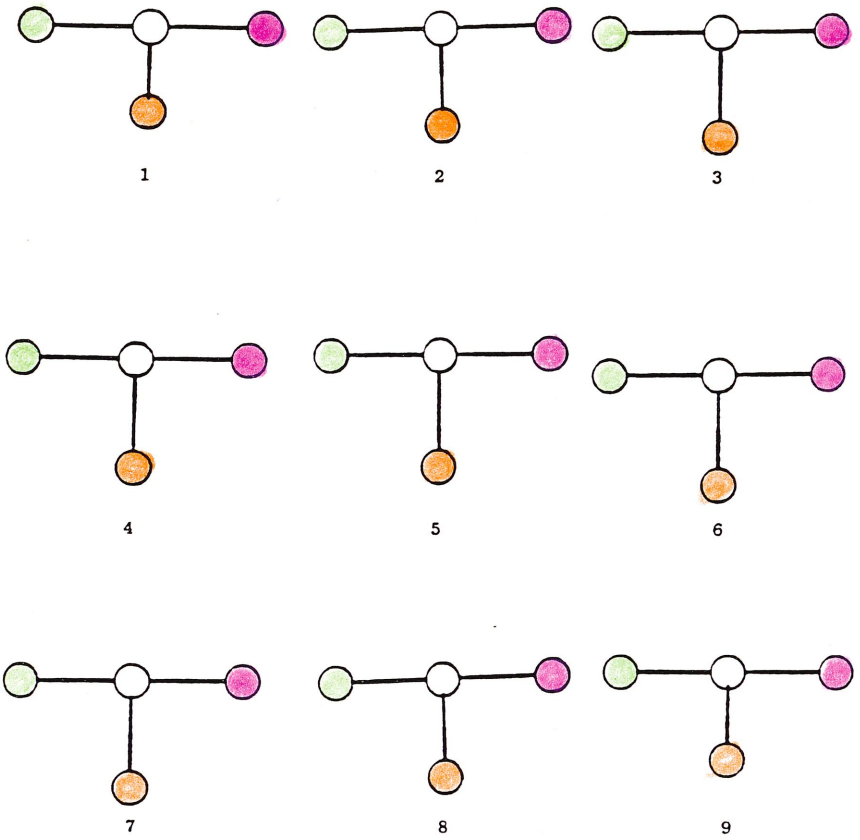
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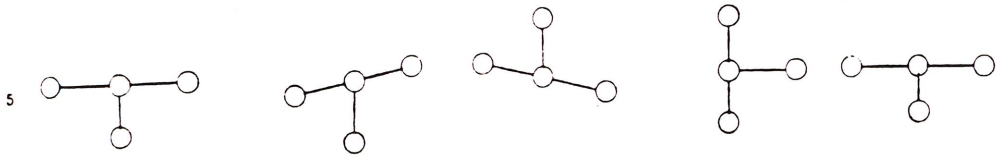


1 2 3 4 5

If the structure in diagram 1 were rotated about the X-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

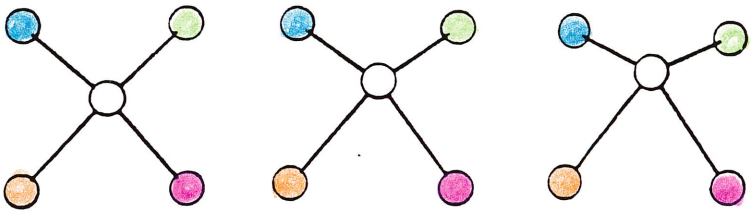
CORRECT ANSWER 2



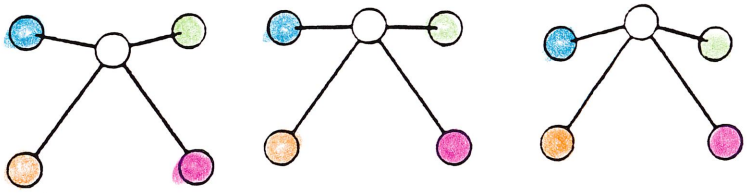


If the structure in diagram 1 were rotated about the X-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

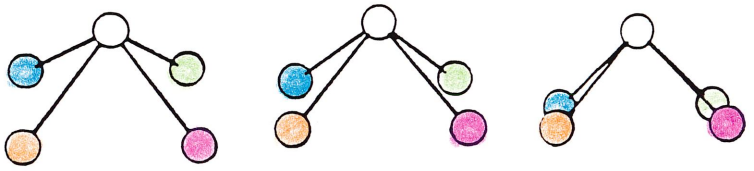
CORRECT ANSWER 5



1 2 3

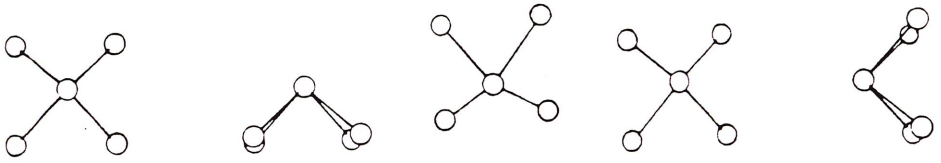


4 5 6



7 8 9

6

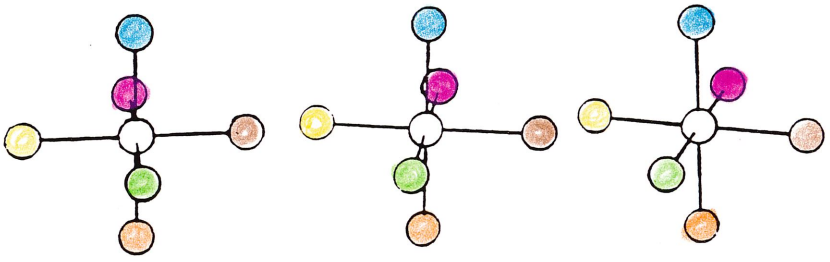


1 2 3 4 5

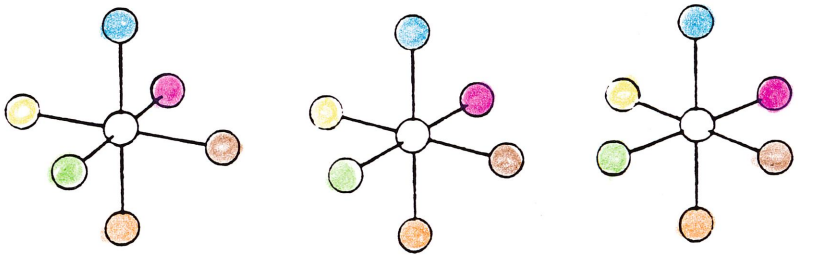
If the structure in diagram 1 were rotated about the X-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

CORRECT ANSWER 2

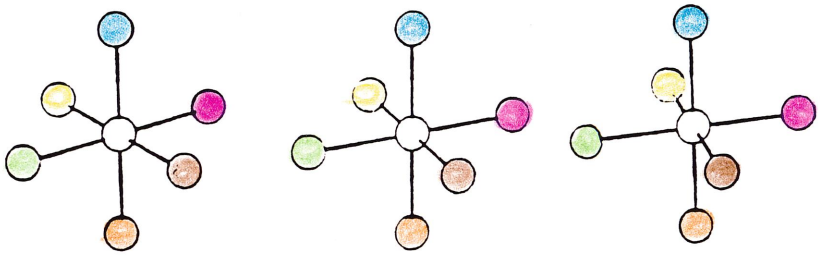
Section – Y



1 2 3

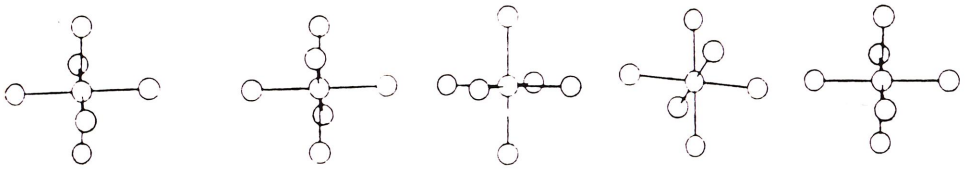


4 5 6



7 8 9

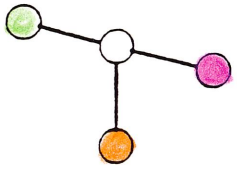
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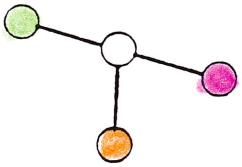
1 2 3 4 5

If the structure in diagram 1 were rotated about the Y- axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

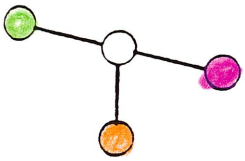
CORRECT ANSWER 5



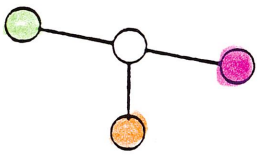
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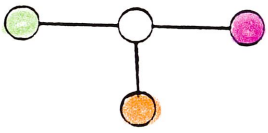
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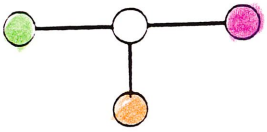
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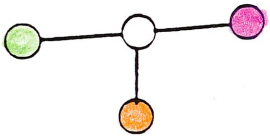
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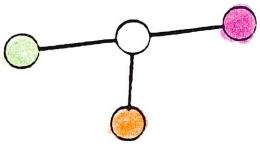
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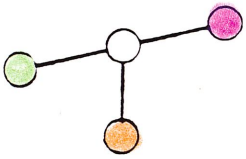
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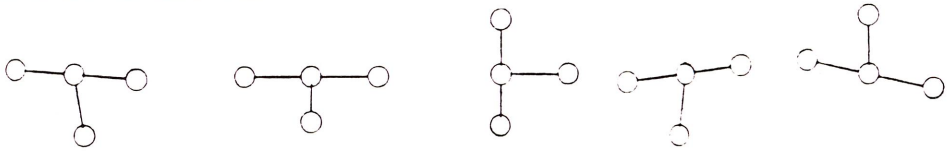


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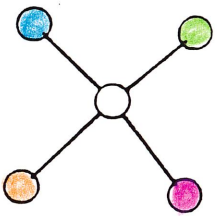
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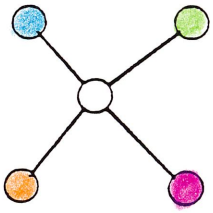
1 2 3 4 5

If the structure in diagram 1 were rotated about the Y-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

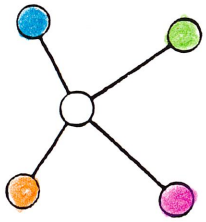
CORRECT ANSWER 4



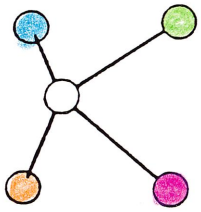
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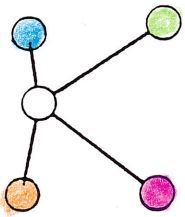
2



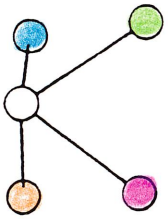
3



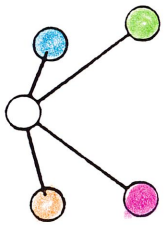
4



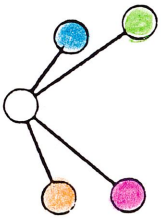
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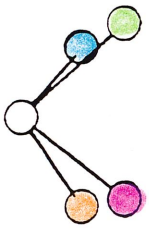
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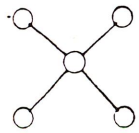
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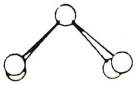


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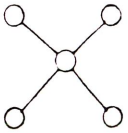


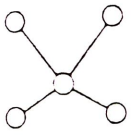
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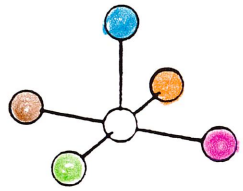




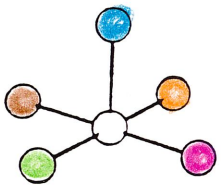
1 2 3 4 5

If the structure in diagram 1 were rotated about the Y-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

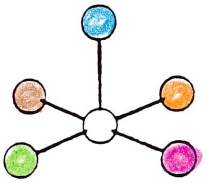
CORRECT ANSWER 3



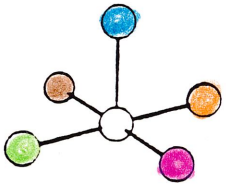
1



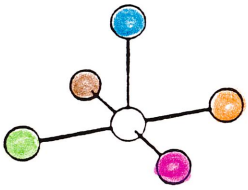
2



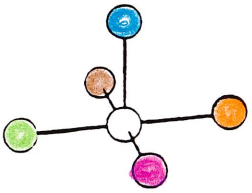
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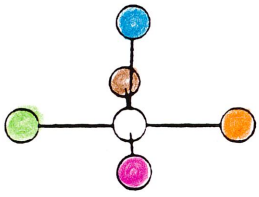
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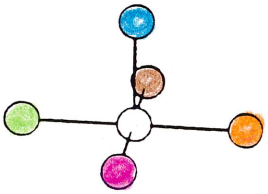
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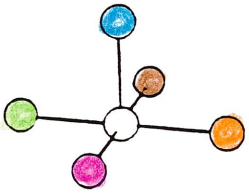
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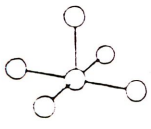


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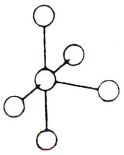


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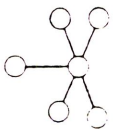
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1



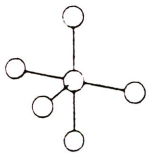
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3



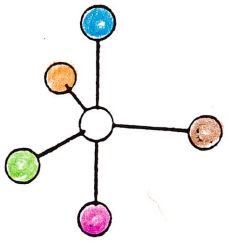
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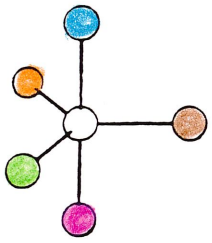
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If the structure in diagram 1 were rotated about the Y-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

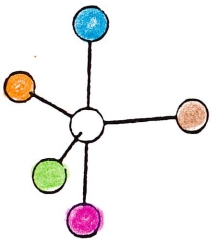
CORRECT ANSWER 4



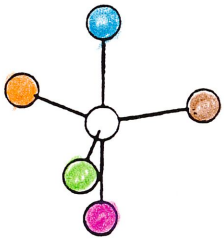
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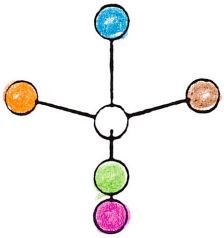
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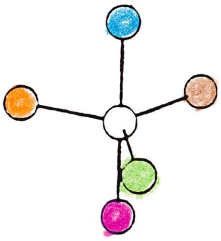
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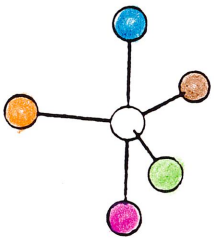
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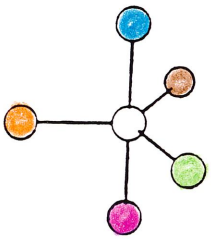
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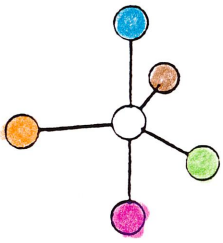
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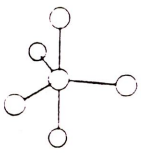


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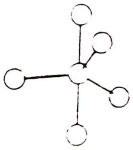


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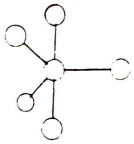
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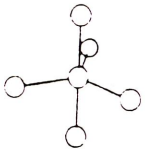
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3



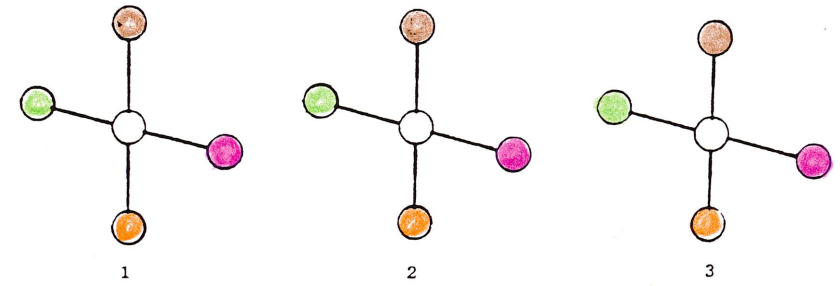
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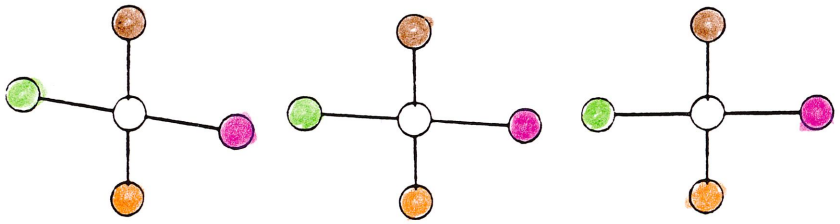
5

If the structure in diagram 1 were rotated about the Y-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

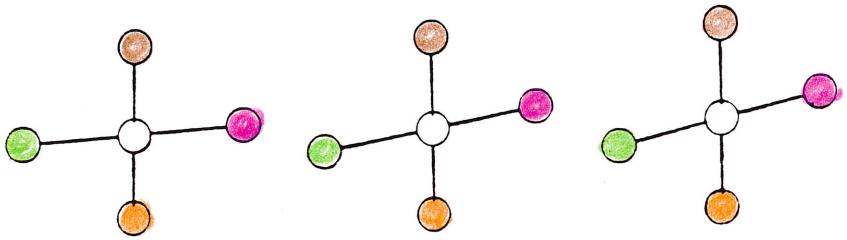
CORRECT ANSWER 5



1 2 3

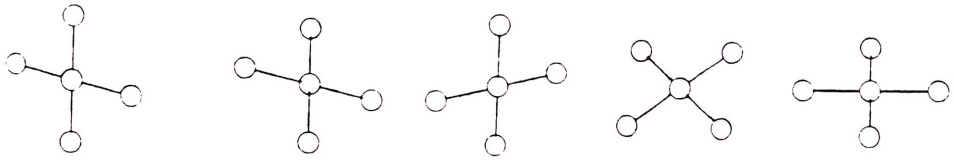


4 5 6



7 8 9

12

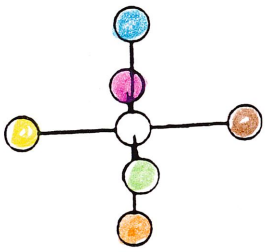


1 2 3 4 5

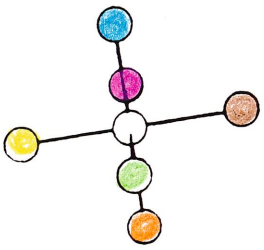
If the structure in diagram 1 were rotated about the Y-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

CORRECT ANSWER 3

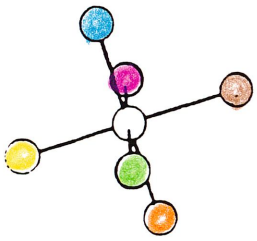
Section - Z



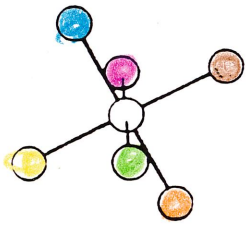
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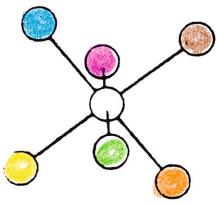
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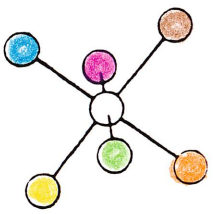
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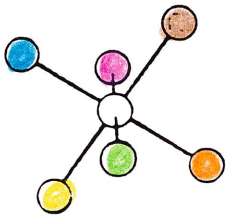
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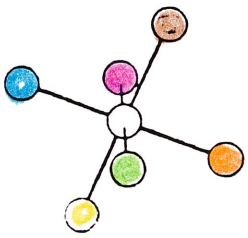
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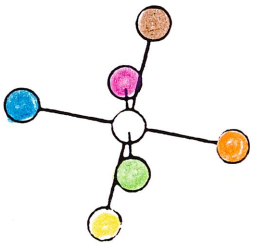
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7

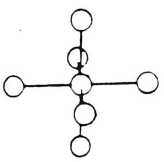


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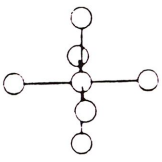


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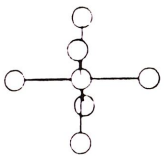
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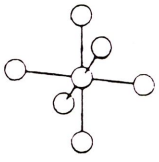
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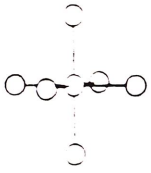
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3



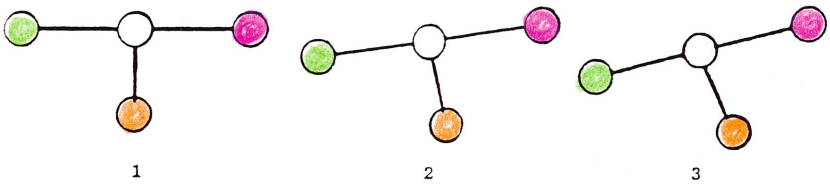
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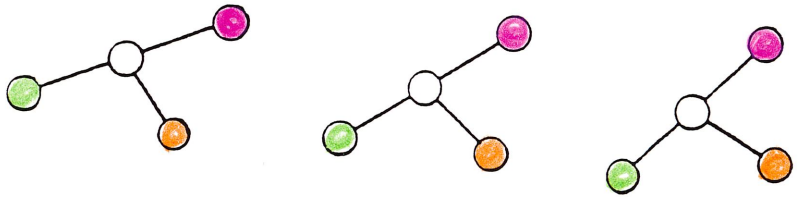
5

If the structure in diagram 1 were rotated about the Z-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

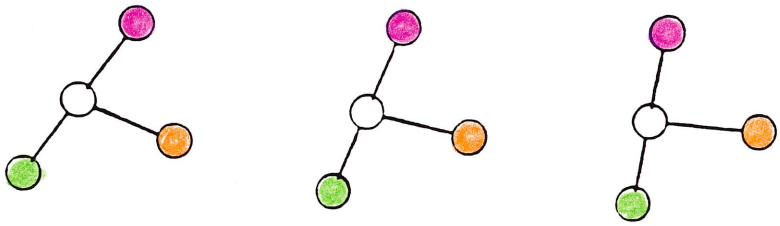
CORRECT ANSWER 2



1 2 3

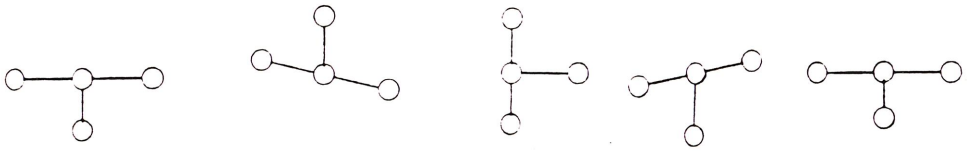


4 5 6



7 8 9

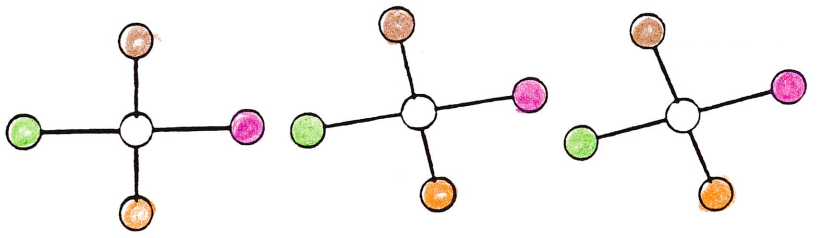
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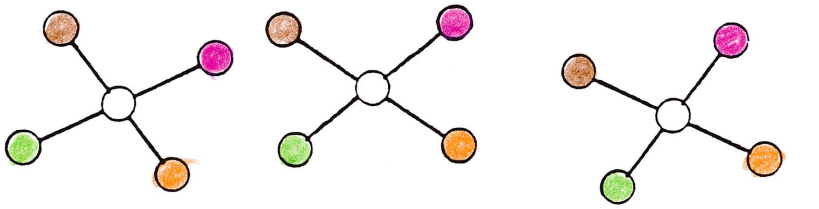
1 2 3 4 5

If the structure in diagram 1 were rotated about the Z-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

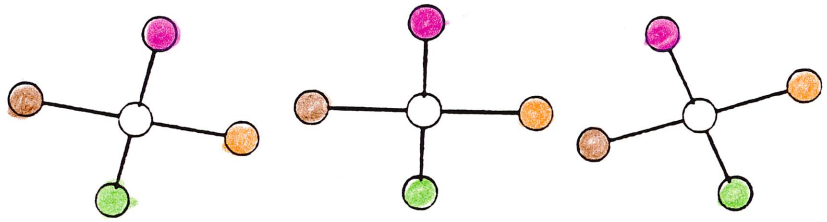
CORRECT ANSWER 3



1 2 3

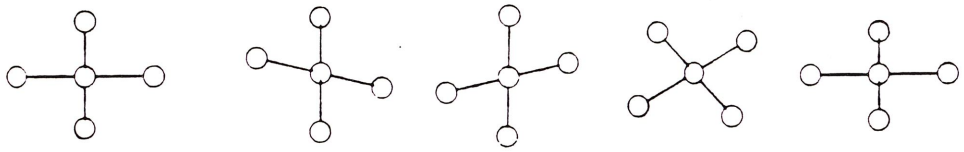


4 5 6



7 8 9

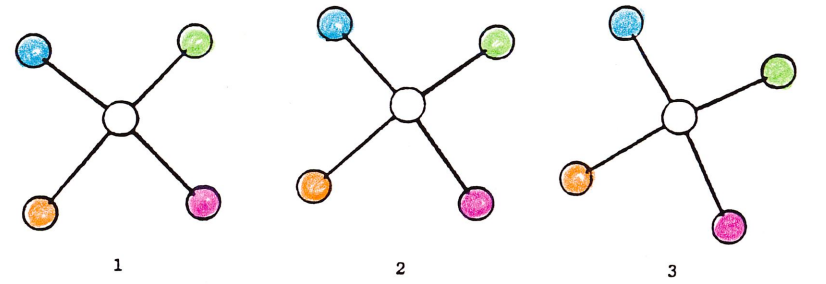
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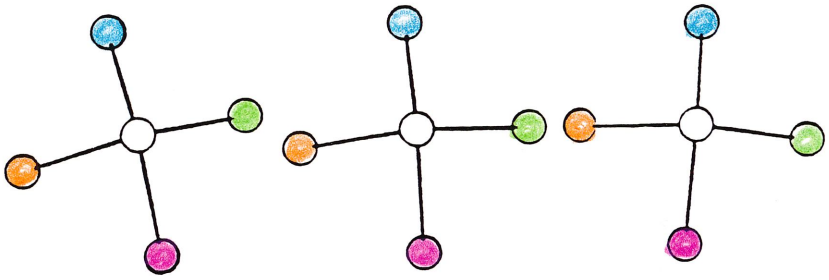
1 2 3 4 5

If the structure in diagram 1 were rotated about the Z-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

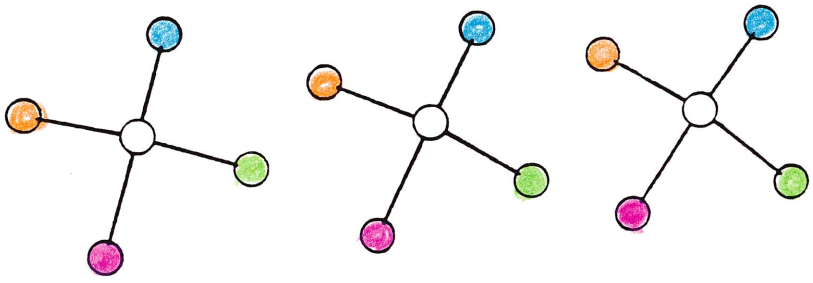
CORRECT ANSWER 4



1 2 3

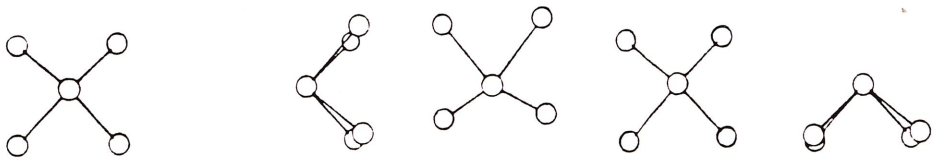


4 5 6



7 8 9

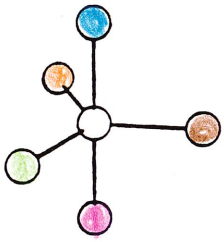
16



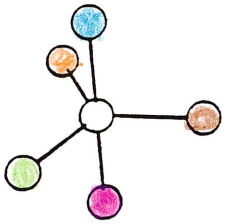
1 2 3 4 5

If the structure in diagram 1 were rotated about the Z-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

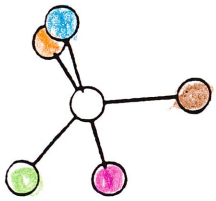
CORRECT ANSWER 4



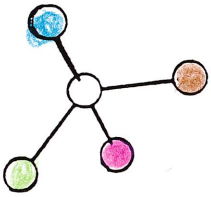
1



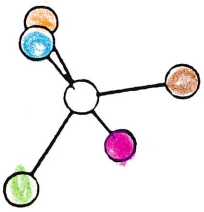
2



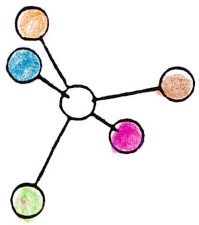
3



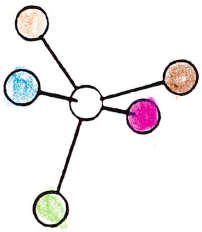
4



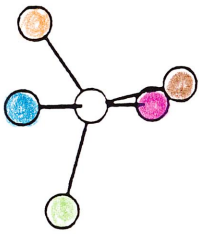
5



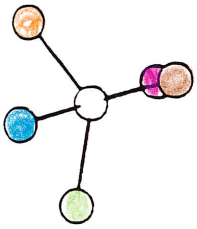
6



7

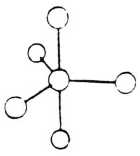


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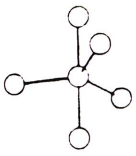


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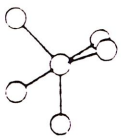
17



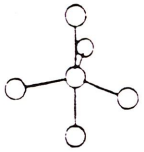
1



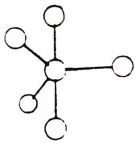
2



3



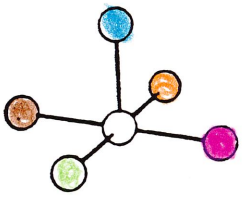
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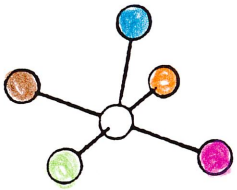
5

If the structure in diagram 1 were rotated about the Z- axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

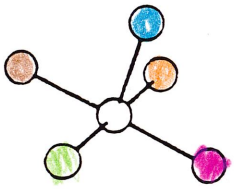
CORRECT ANSWER 3



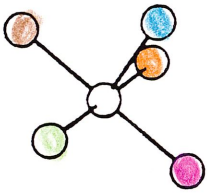
1



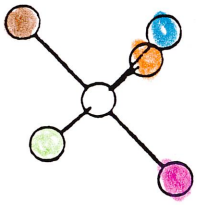
2



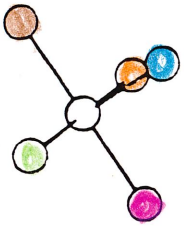
3



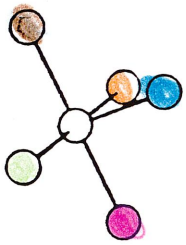
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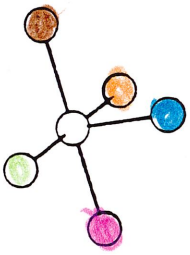
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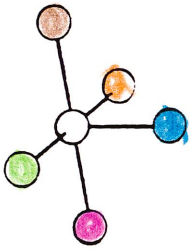
6



7

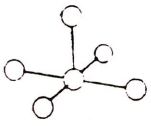


8

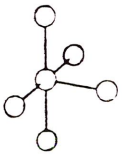


9

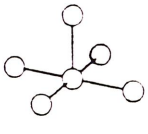
18



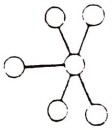
1



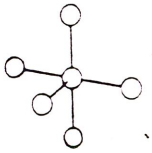
2



3



4



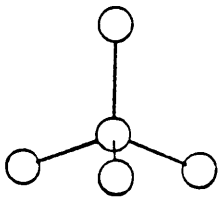
5

If the structure in diagram 1 were rotated about the Z-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

CORRECT ANSWER 2

APPENDIX 8B

برنامج الدوران الجزيئ



جامعة ايست انجليا
نورج ـ انجلترا

١٩٨٤

مقدمـــــــة :

ان الهدف من هذا الكتيب هو تدريبك لغرض المساعدة على تحسين مقدرتك على تصور دوران الاشكال التي تبين التراكيب الجزيئية حول محور واحد من المحاور الفراغية الثلاث س ، ص ، ع المتعامدة على بعضها البعض .

ماهو المطلوب منك عملـــــــة :

ان الشكل الموجود على الورقة يمثل مراحل متعددة لدوران تركيب جزيئي واحد حول المحور س ،ص ،ع ، المطلوب منك اجابة لبعض الاسئلة المتعلقة بهذه الاشكال و الواردة في هذا الكتيب .

المطلوب منك هو كتابة اجابتك على هذه الأسئلة في ورقة منفصلة وبعد محاولتك على كل سؤال سوف ترى الاجابة الصحيحة .

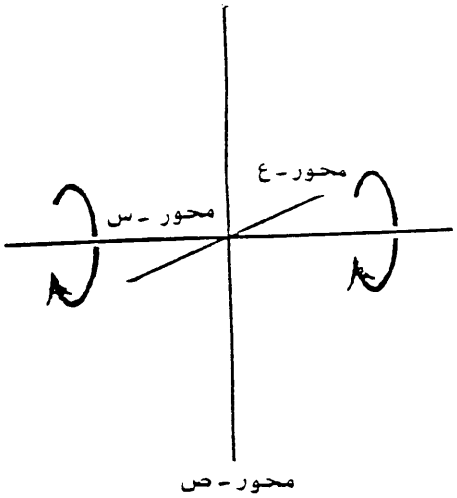
تنبيـــــة :

لا تكتب او تعلم على هذا الكتيب

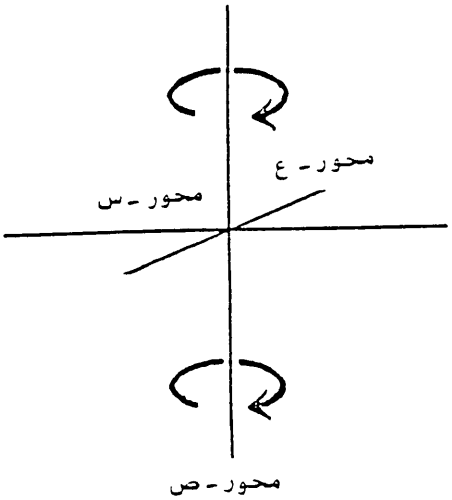
ادرس الأشكال التالية جيدا قبل البدء
في البرنامج .

ان محور-س و محور-ص في مستوي
الورقة. اما المحور-ع فإنه خارج من
الورقة باتجاهك .

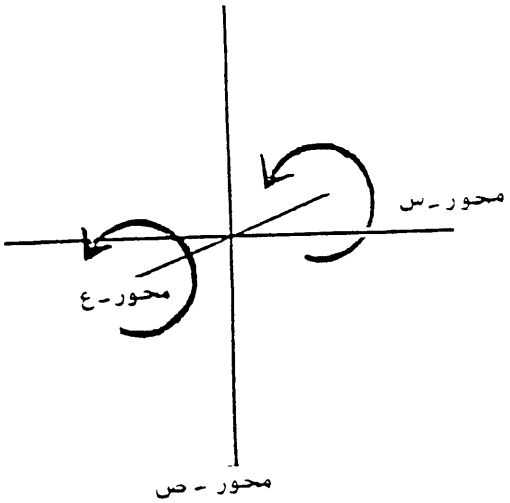
الدوران حول المحور- س



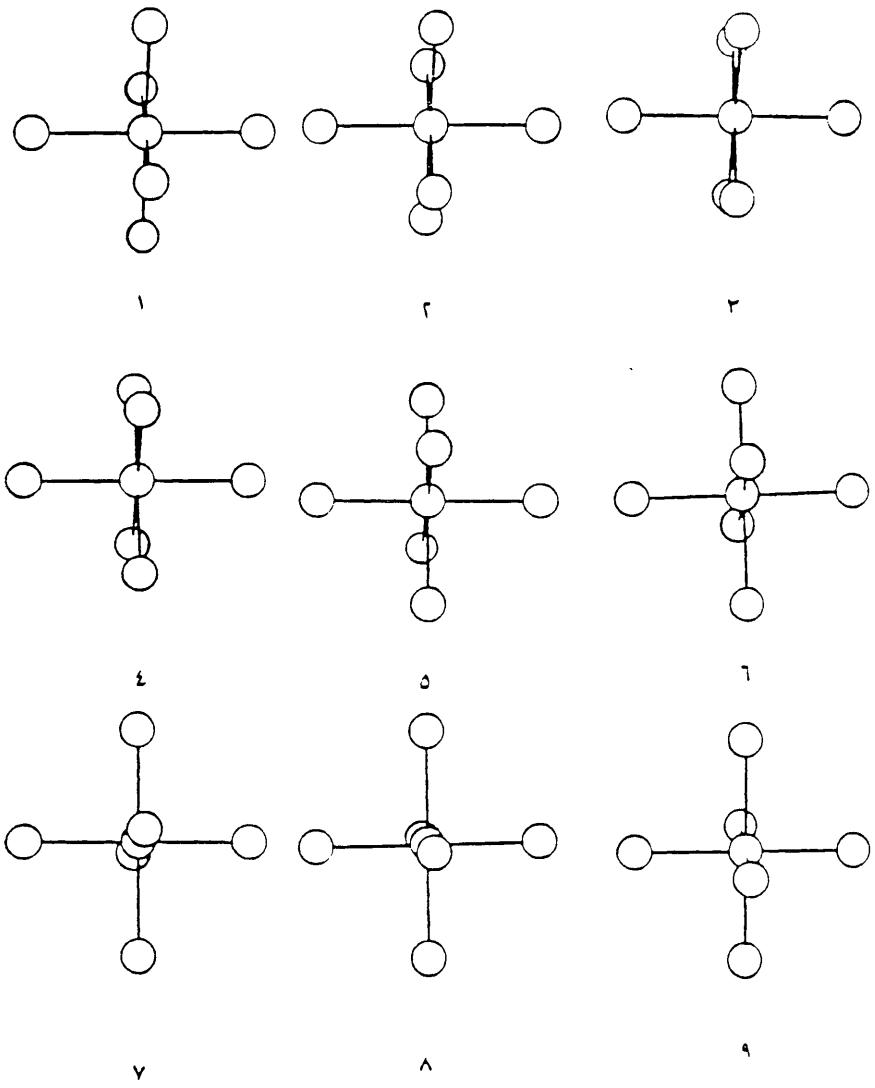
الدوران حول المحور- ص



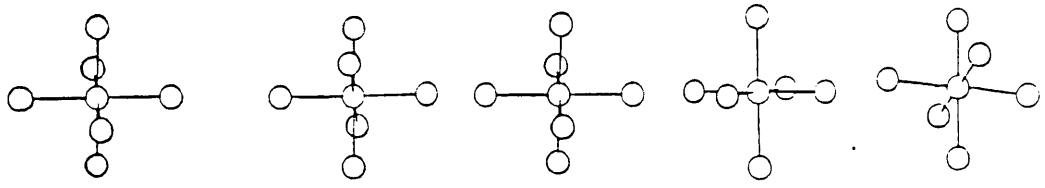
الدوران حول المحور- ع



قسم ـ س



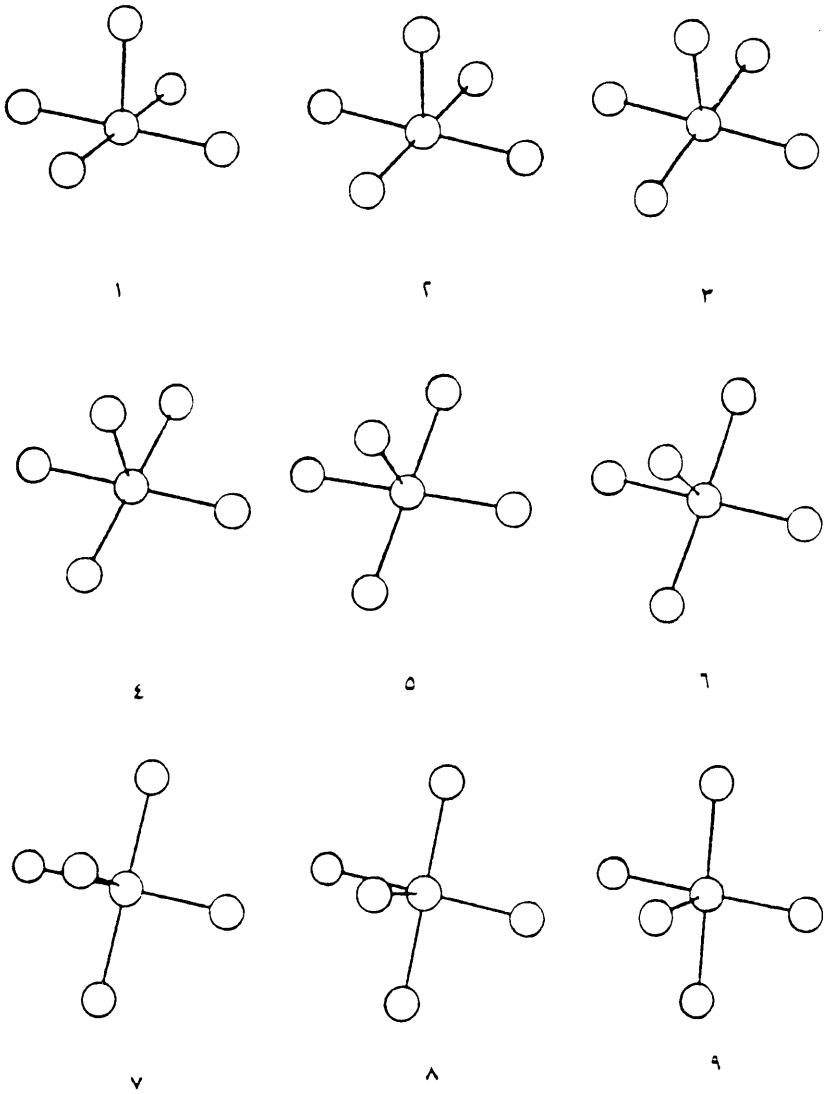
١



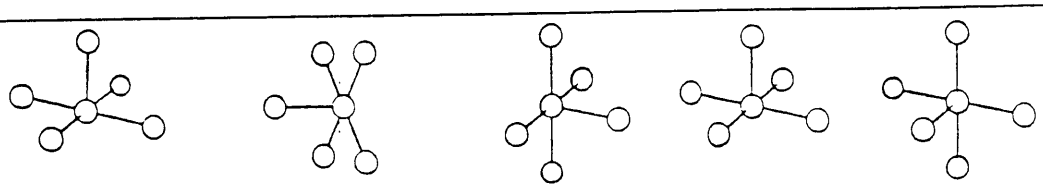
عند دوران التركيب المبين في شكل (١) حول محور السينات (س) ، اى من الأشكال (٢ ـ ٥) يمثل التركيب بعد عملية الدوران .

الجواب ٢

الجواب ٣

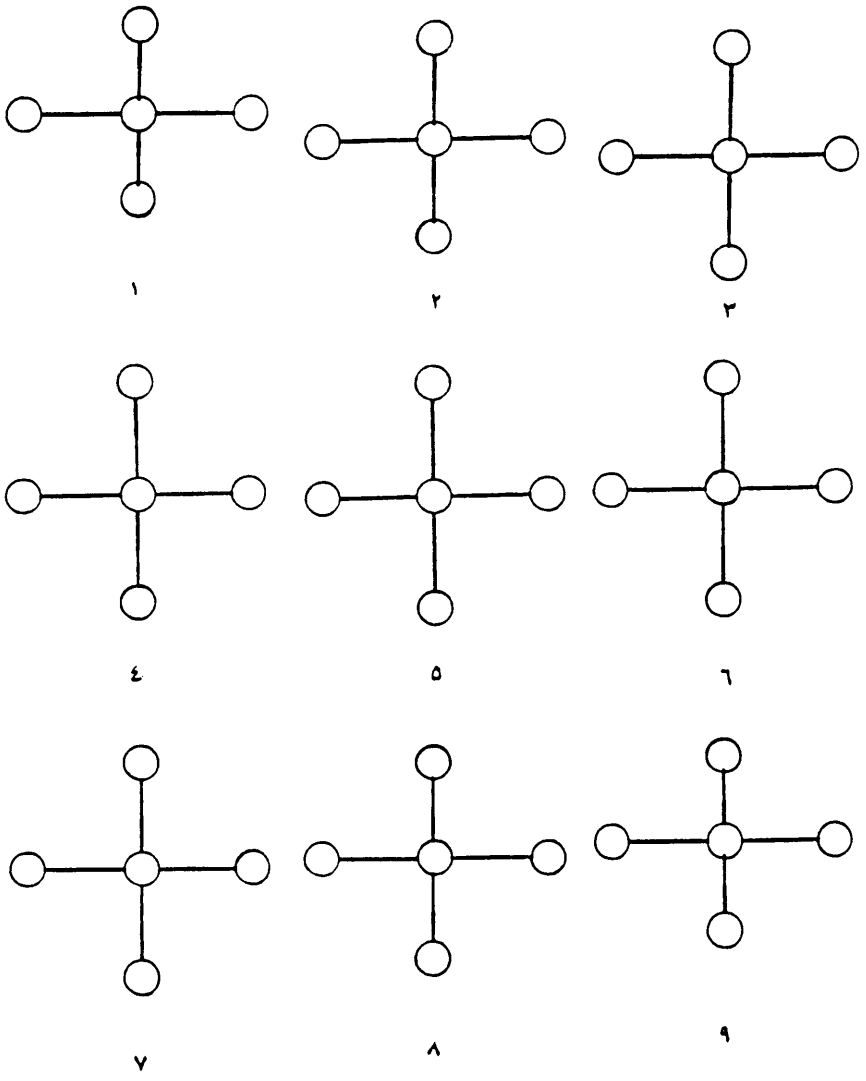


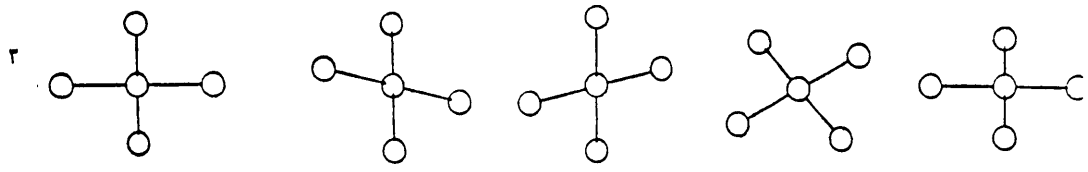
٢



عند دوران التركيب المبين في شكل (١) حول محور السينات (س) ، اى من الأشكال (٢ – ٥) يمثل التركيب بعد عملية الدوران .

الجواب ٥

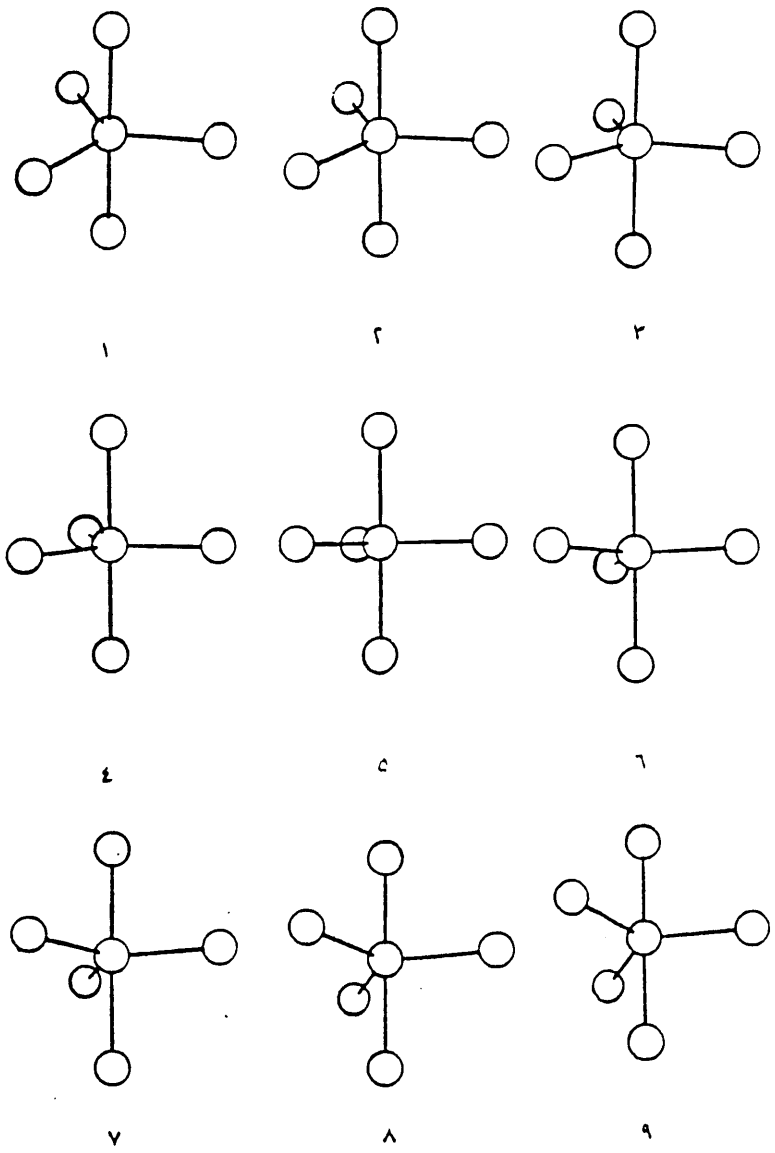


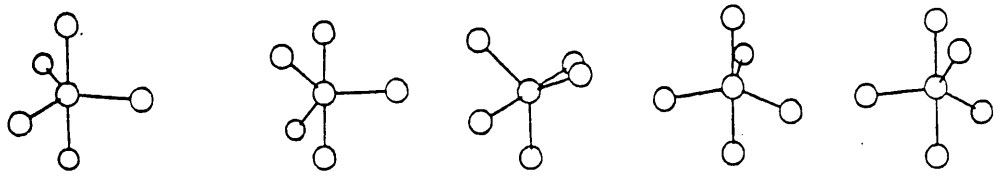


عند دوران التركيب المبين في شكل (١) حول محور السينات (س) ، اى من الأشكال (٢ – ٥) يمثل التركيب بعد عملية الدوران .

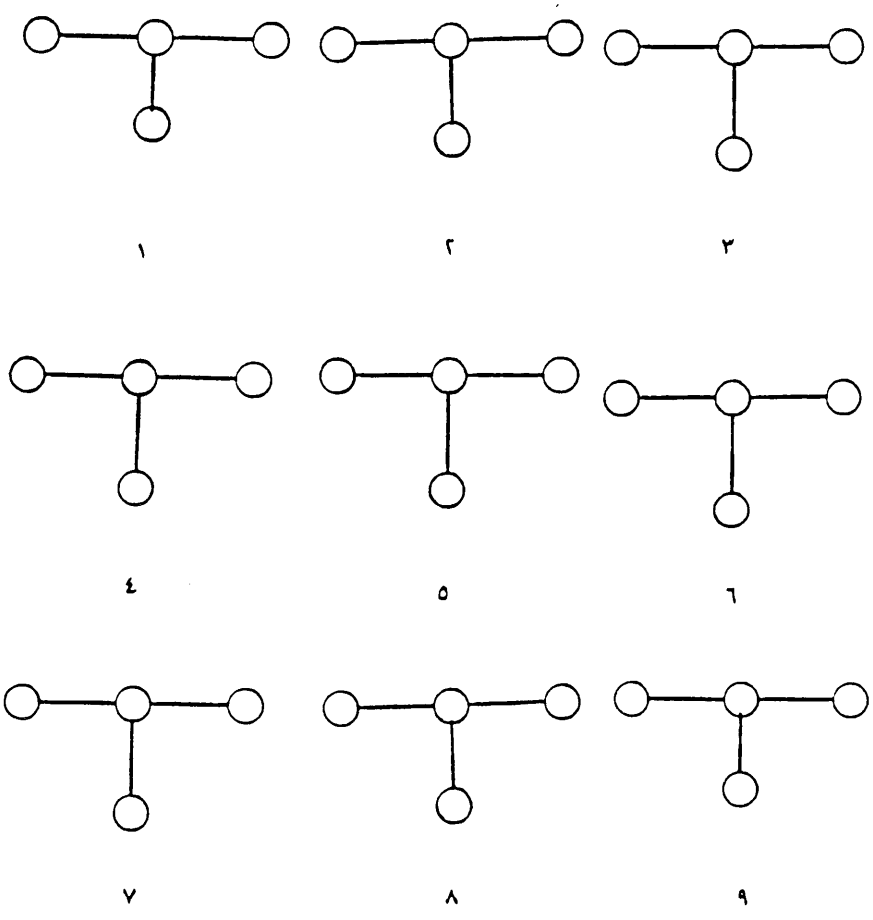
الجواب ٥

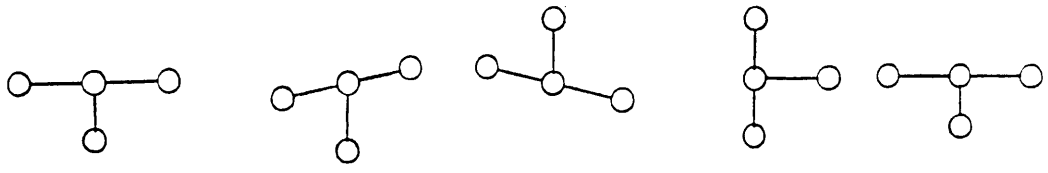
الجواب ٥



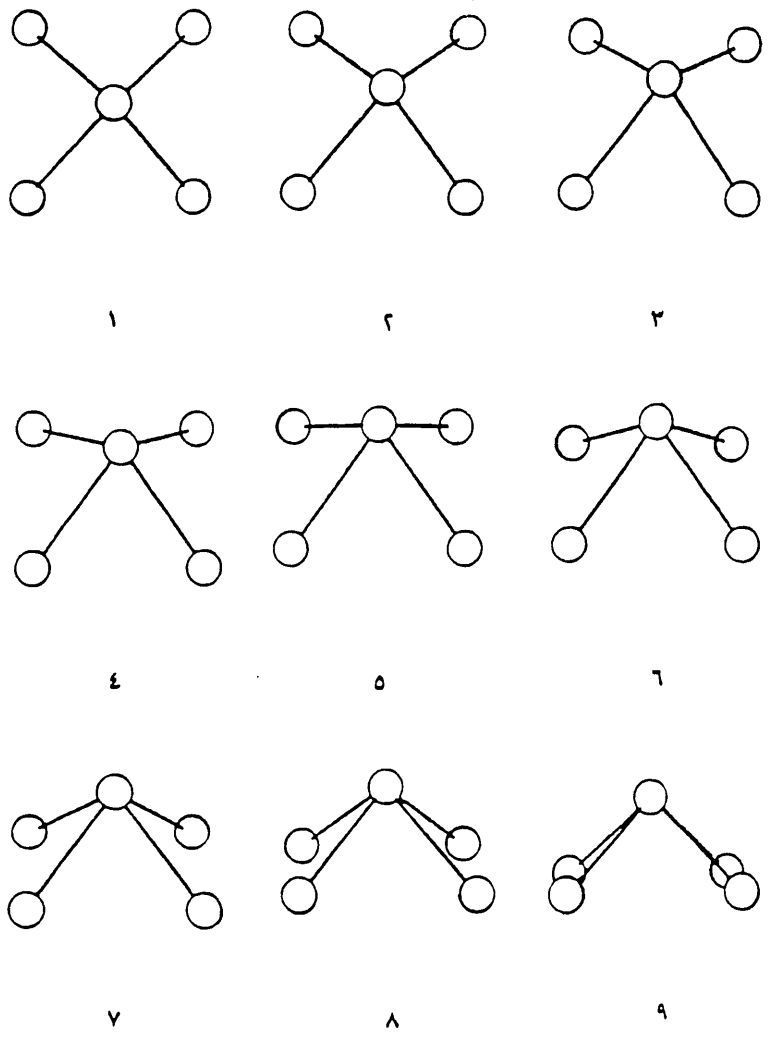


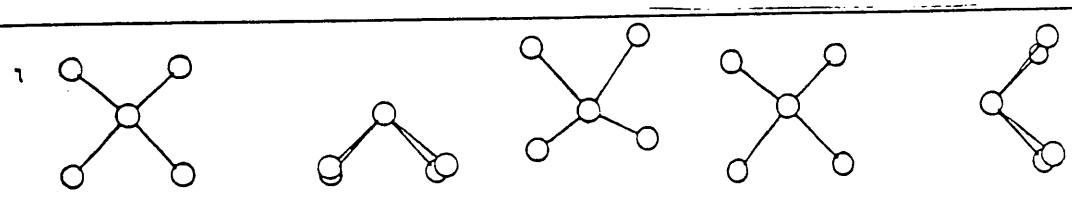
عند دوران التركيب المبين في شكل (١) حول محور السينات (س) ، اى من الأشكال (٢ – ٥) يمثل التركيب بعد عملية الدوران .





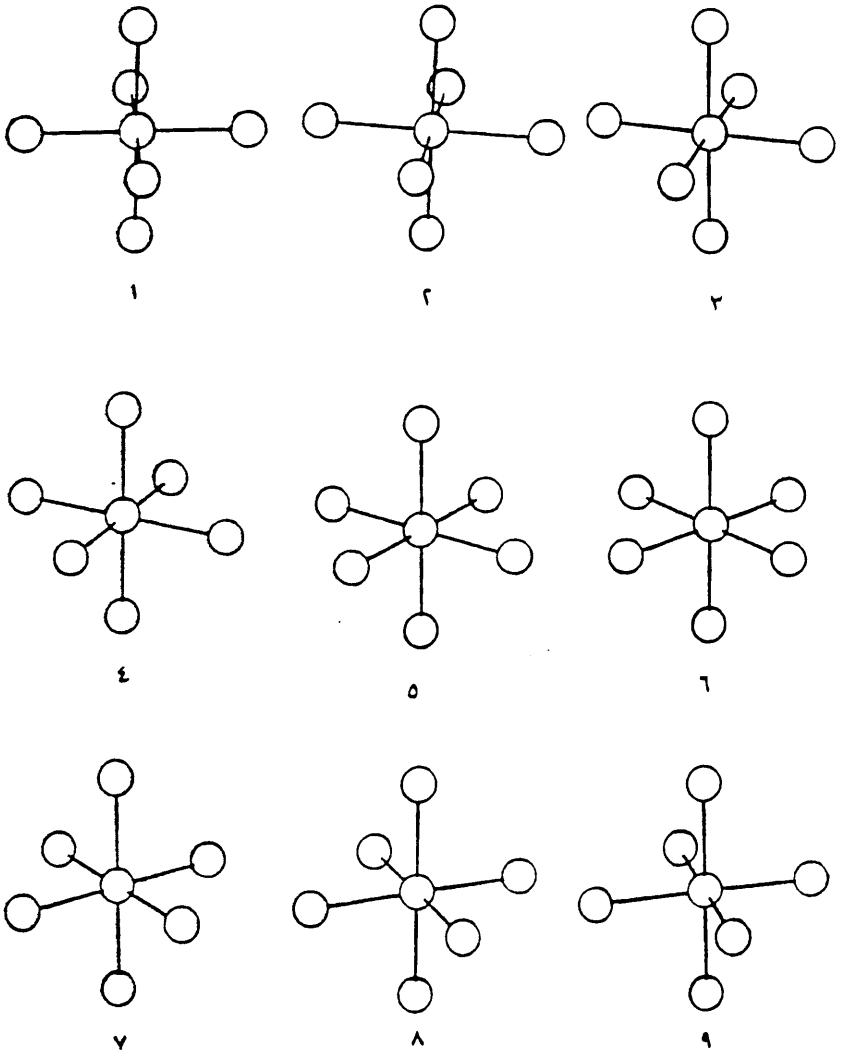
عند دوران التركيب المبين في شكل (١) حول محور السينات (س) ، اى من الأشكال (٢ – ٥) يمثل التركيب بعد عملية الدوران .

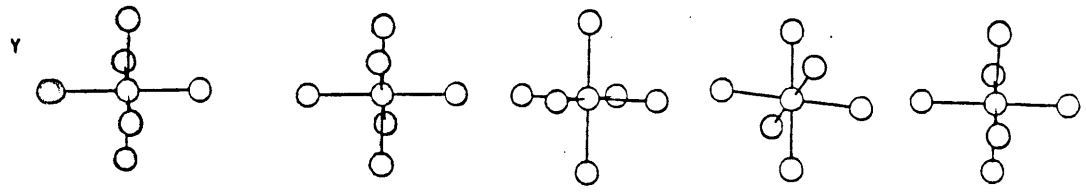




عند دوران التركيب السبين في شكل (١) حول محور السينات (س) ، اى من الأشكال (٢ – ٥) يمثل التركيب بعد عملية الدوران .

قسم ـ ص

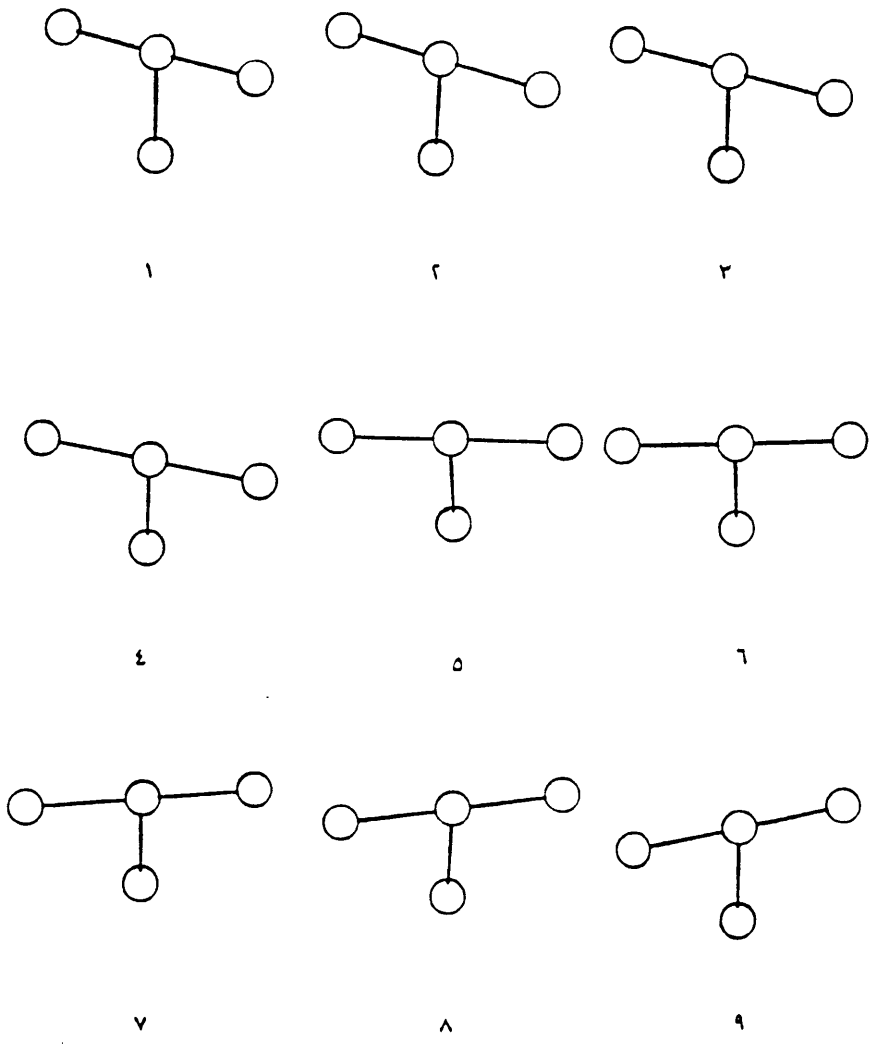




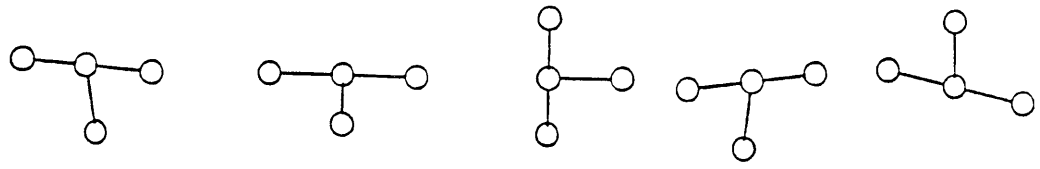
عند دوران التركيب المبين في شكل (١) حول محور المسادات (ص) ، اى من الأشكال (٢ ـ ٥) يمثل التركيب بعد عملية الدوران .

الجواب ٢

الجواب ٥

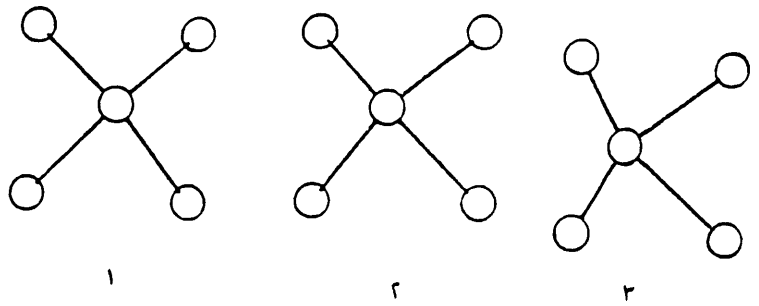


٨

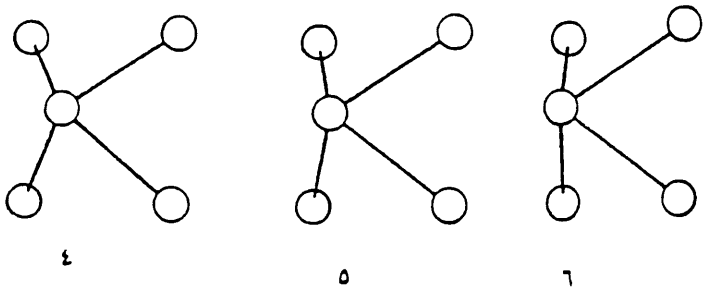


عند دوران التركيب المبين في شكل (١) حول محور المادات (ص) ، اى من الأشكال (٢ ـ ٥) يمثل التركيب بعد عملية الدوران .

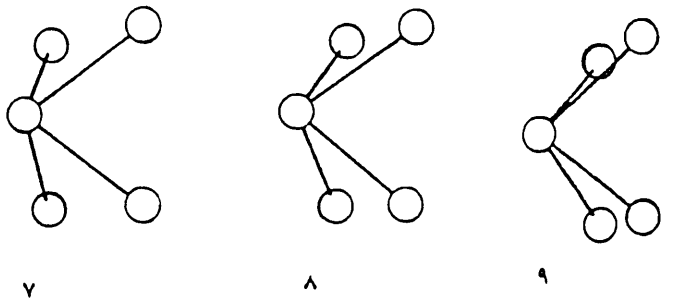
الجواب ٤



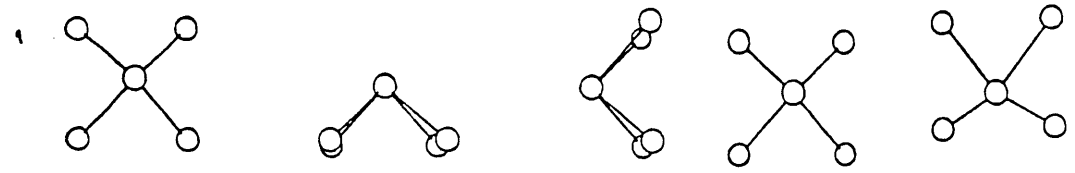
١ ٢ ٣



٤ ٥ ٦



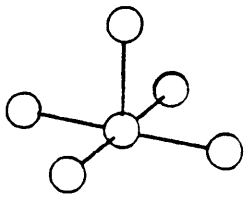
٧ ٨ ٩



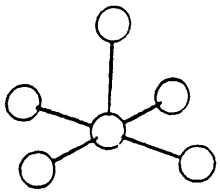
(١) (٢) (٣) (٤) (٥)

عند دوران التركيب المبين في شكل (١) حول محور الصادات (ص) ، اى من الأشكال (٢ ـ ٥) يمثل التركيب بعد عملية الدوران .

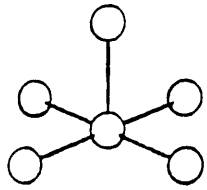
الجواب ٣



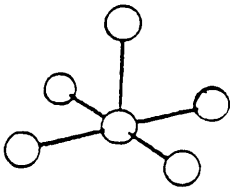
١



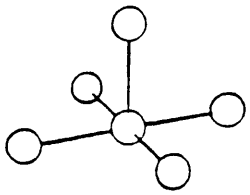
٢



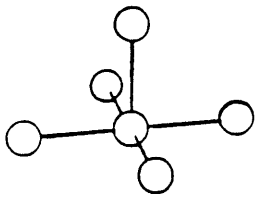
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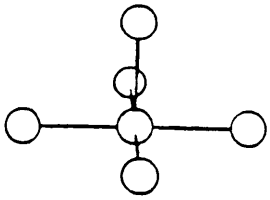
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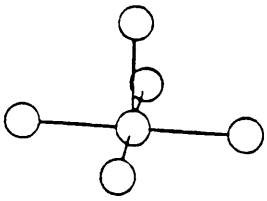
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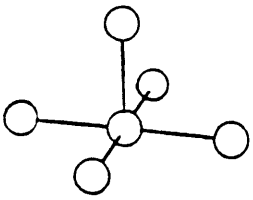
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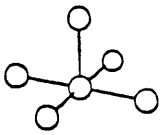


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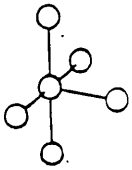


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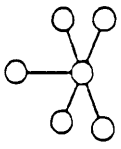
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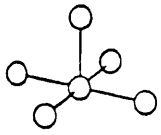
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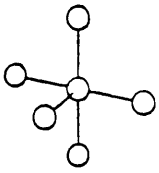
(٢)



(٣)



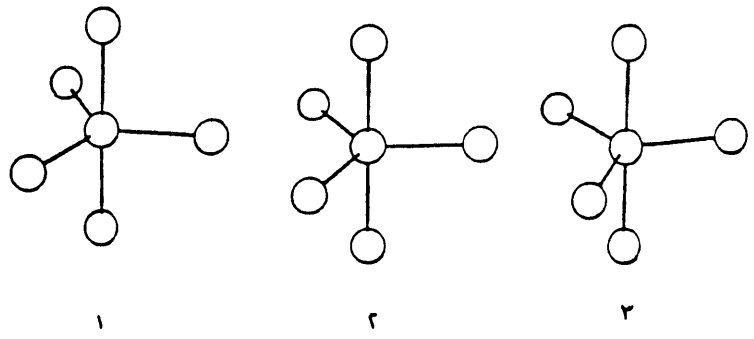
(٤)



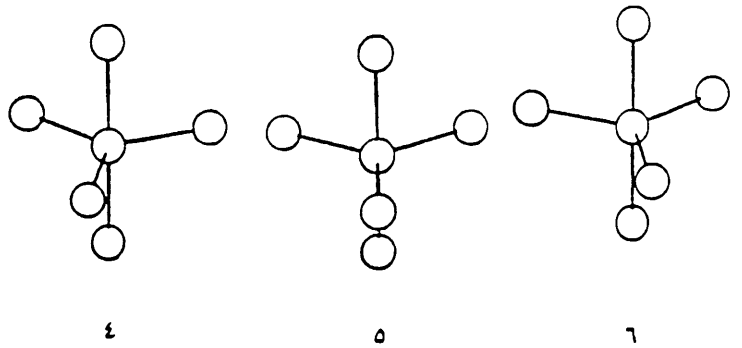
(٥)

عند دوران التركيب المبين في شكل (١) حول محور الصادات (ص) ، اى من الأشكال (٢ ـ ٥) يمثل التركيب بعد عملية الدوران .

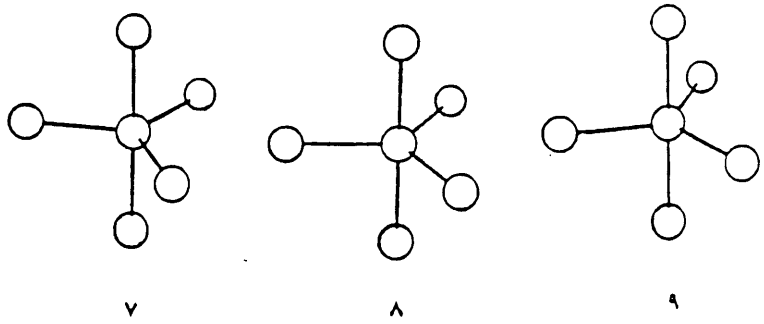
الجواب ٤



١ ٢ ٣

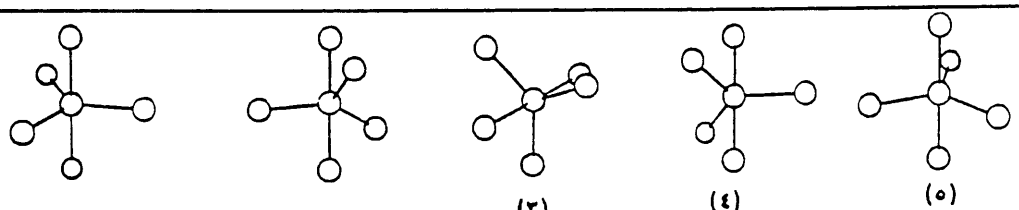


٤ ٥ ٦



٧ ٨ ٩

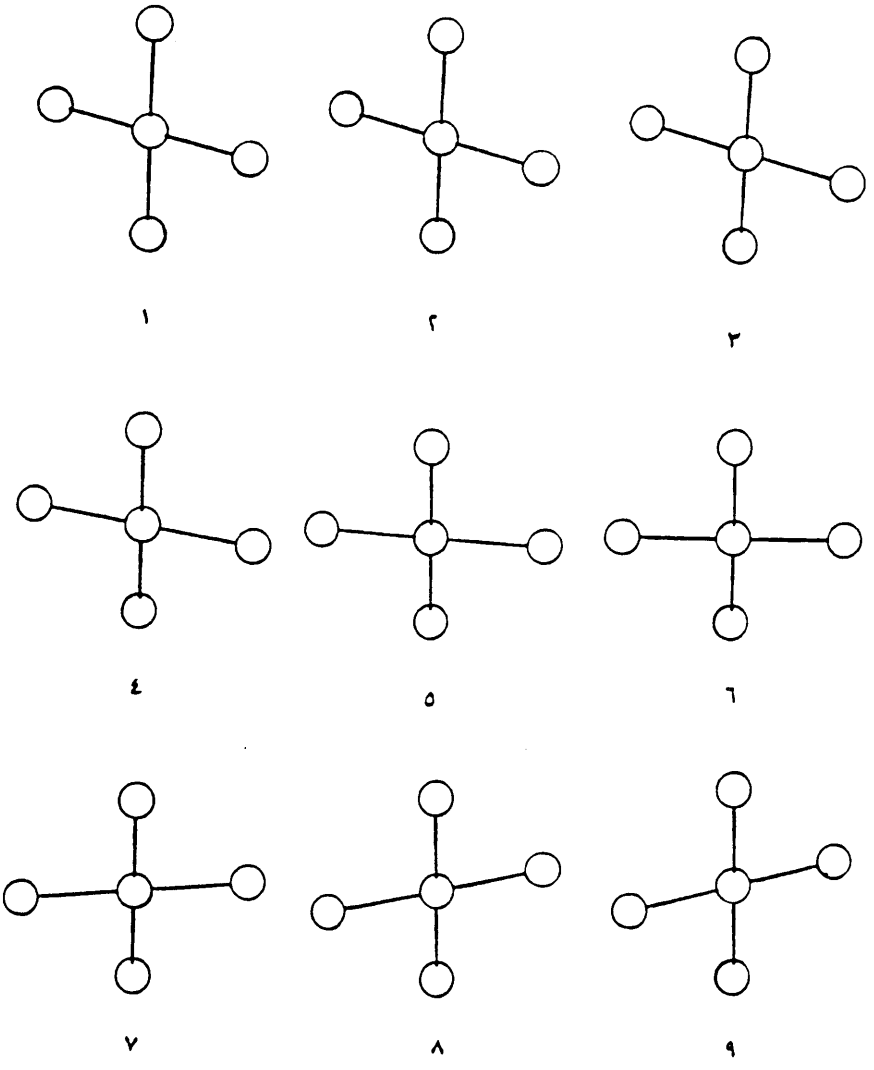
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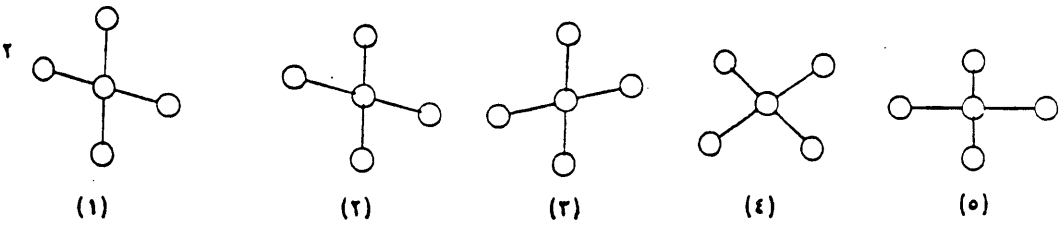


(١) (٢) (٣) (٤) (٥)

عند دوران التركيب المبين في شكل (١) حول محور الصادات (ص) ، اى من الأشكال (٢ – ٥) يمثل التركيب بعد عملية الدوران .

الجواب ٥

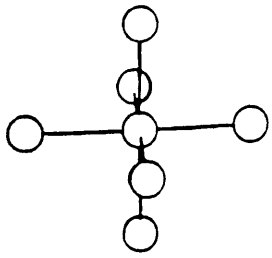




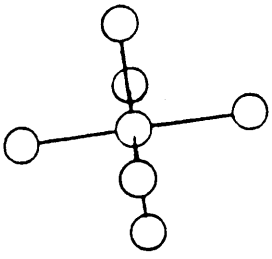
عند دوران التركيب المبين في شكل (١) حول محور الصادات (ص) ، اى من الأشكال (٢ – ٥) يمثل التركيب بعد عملية الدوران .

الجواب ٣

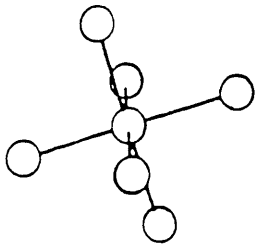
قسم-ع



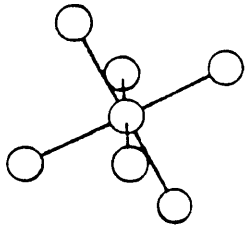
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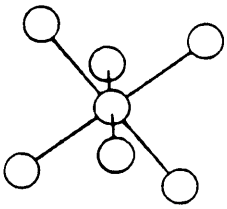
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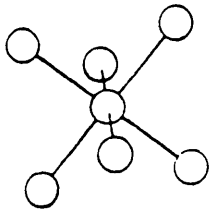
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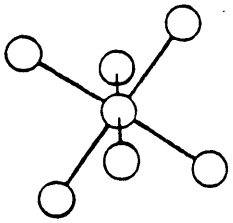
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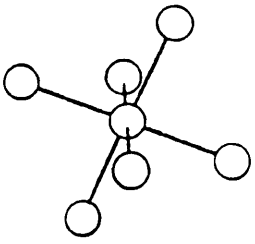
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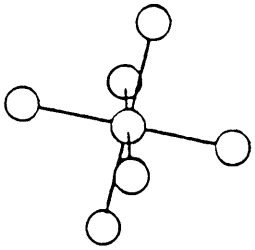
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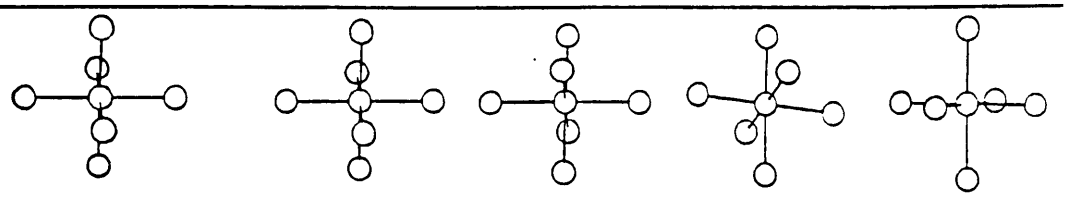


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٩

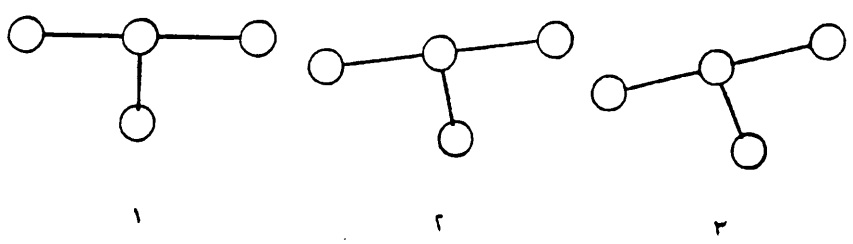
١٣



(١) (٢) (٣) (٤) (٥)

عند دوران التركيب المبين في شكل (١) حول محور العينات (ع) ، اى من الأشكال (٢ - ٥) يمثل التركيب بعد عملية الدوران .

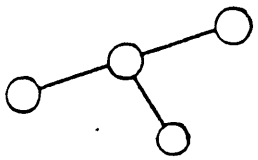
الجواب ٢



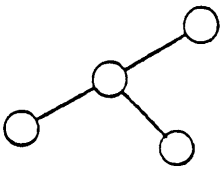
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٢

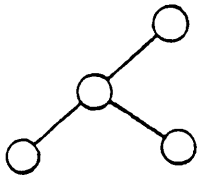
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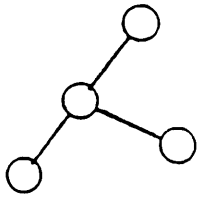
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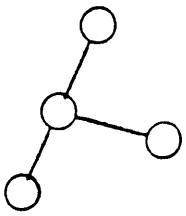
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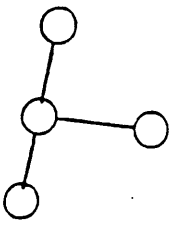
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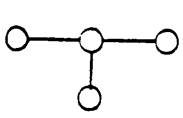
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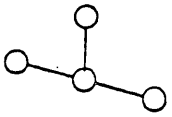
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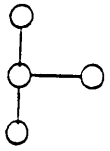


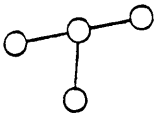
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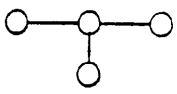


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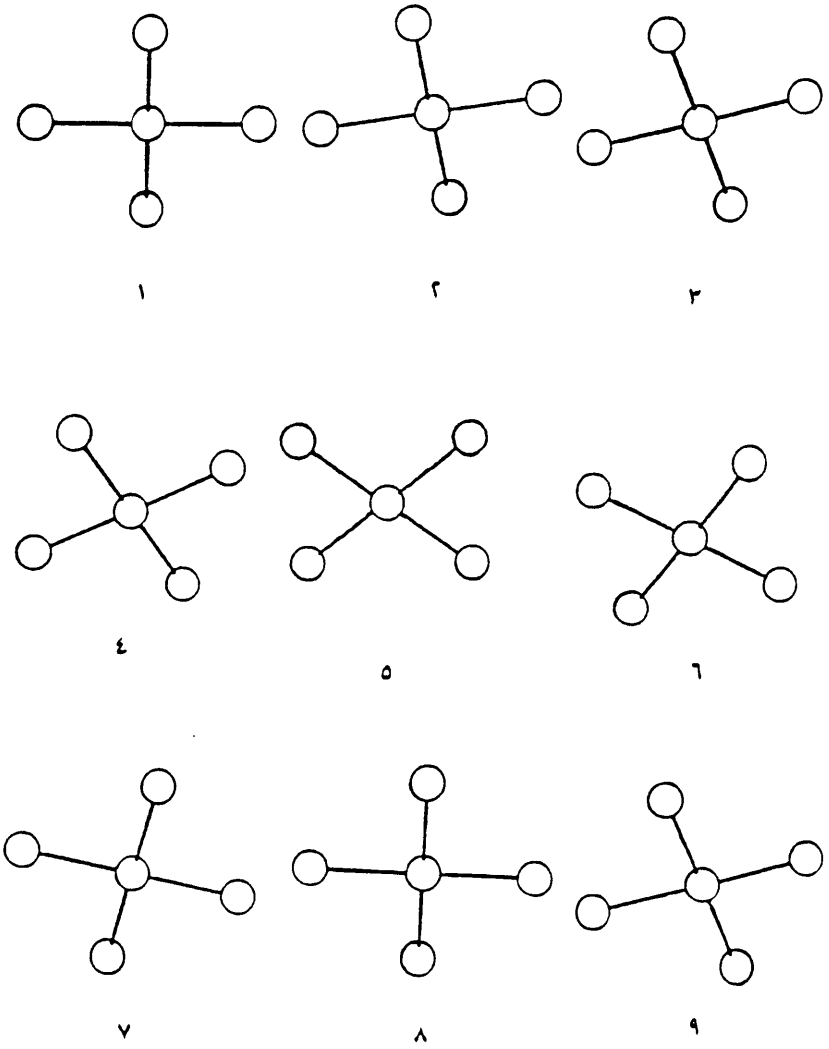




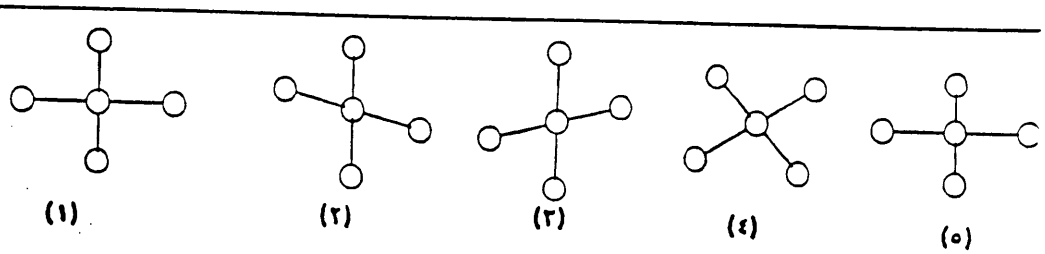
(١) (٢) (٣) (٤) (٥)

عند دوران التركيب المبين في شكل (١) حول محور العينات (ع) ، اى من الأشكال (٢ ــ ٥) يمثل التركيب بعد عملية الدوران .

الجواب ٣

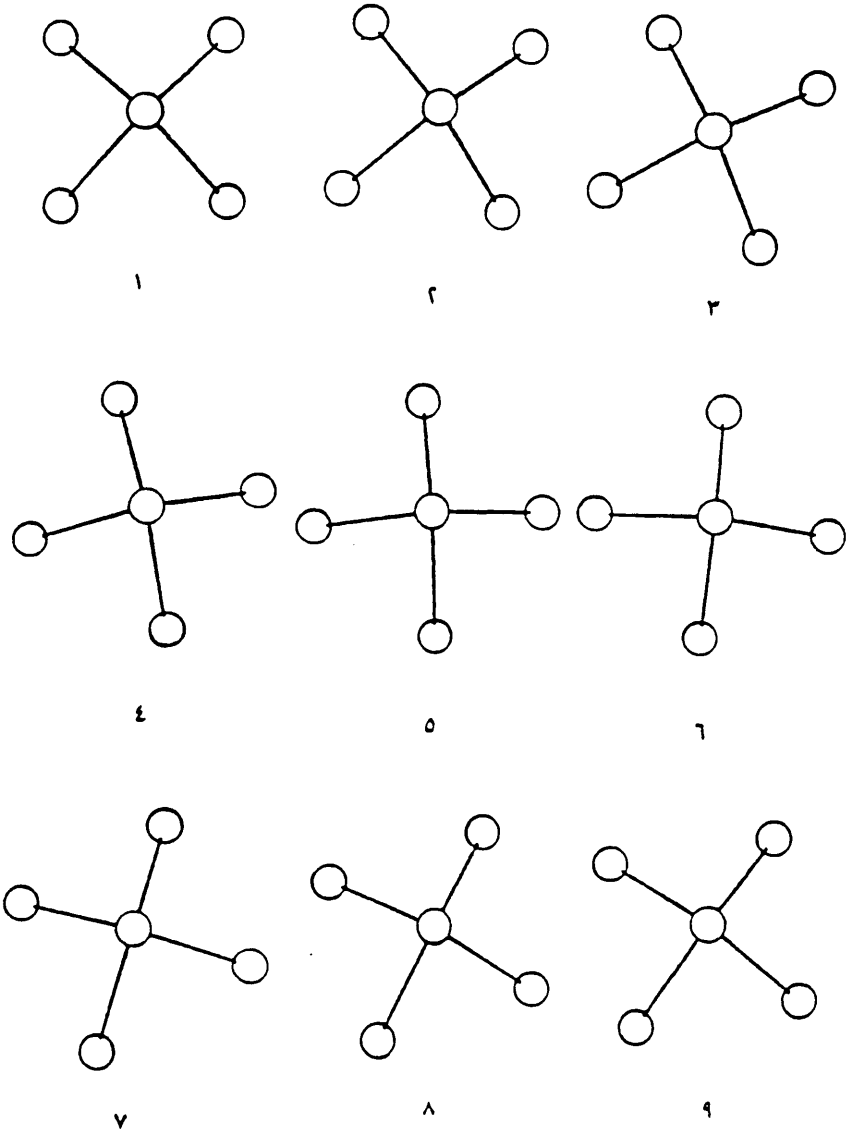


١٥

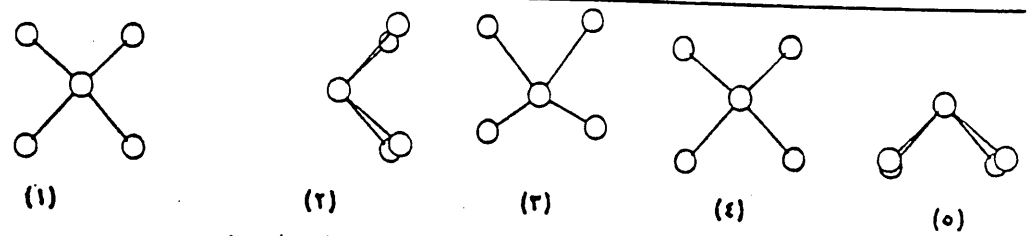


عند دوران التركيب المبين في شكل (١) حول محور العينات (٤) ، اى من الأشكال (٢ ـ ٥) يمثل التركيب بعد عملية الدوران .

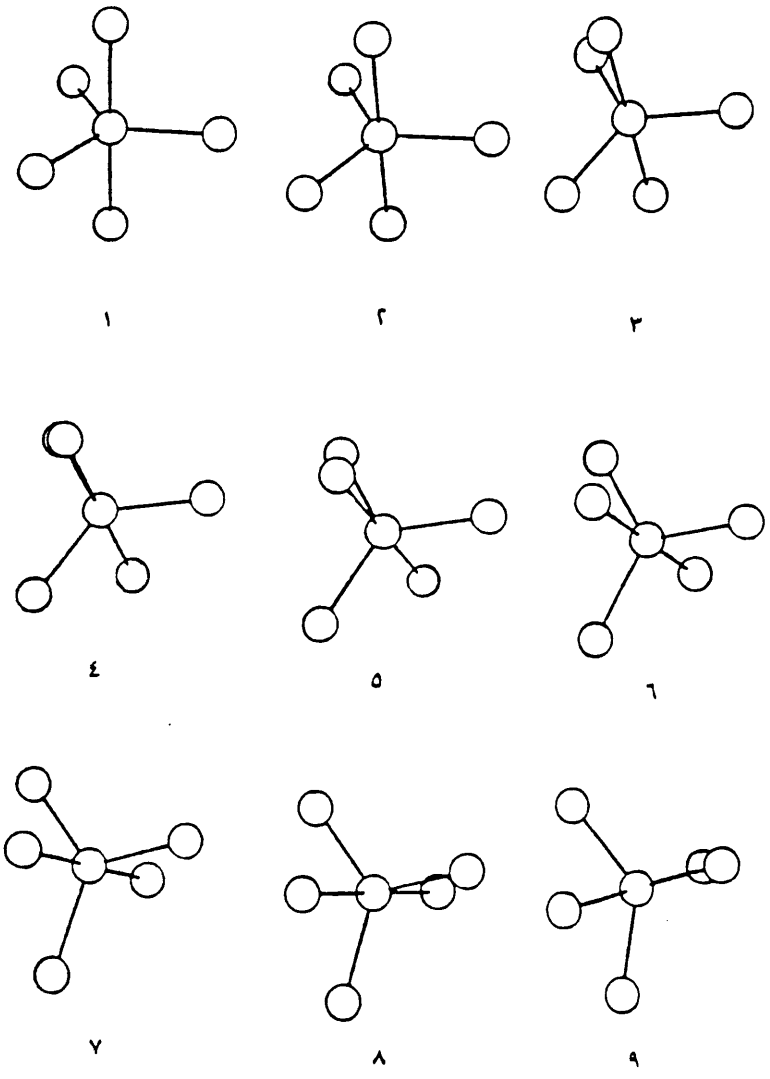
الجواب ٤



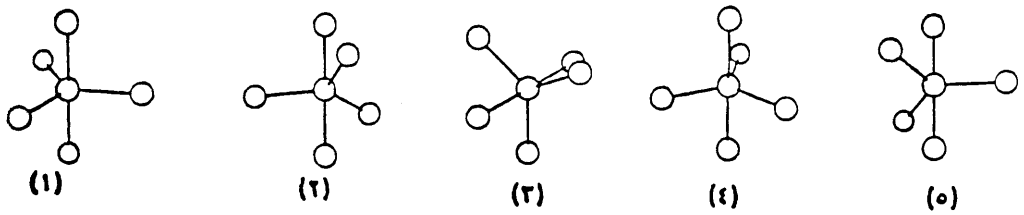
١٦



عند دوران التركيب المبين في شكل (١) حول محور العينات (ع) ، اى من الأشكال (٢ ـ ٥) يمثل التركيب بعد عملية الدوران .

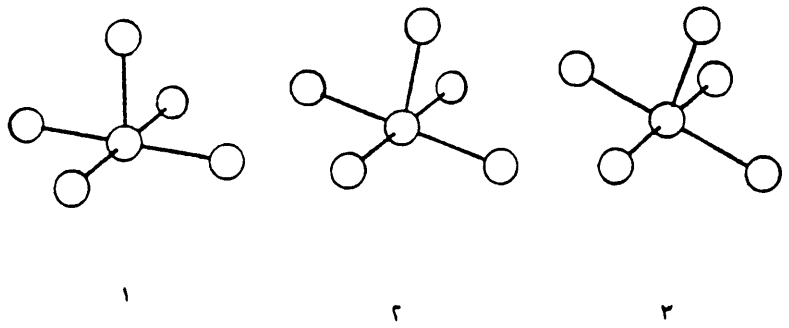


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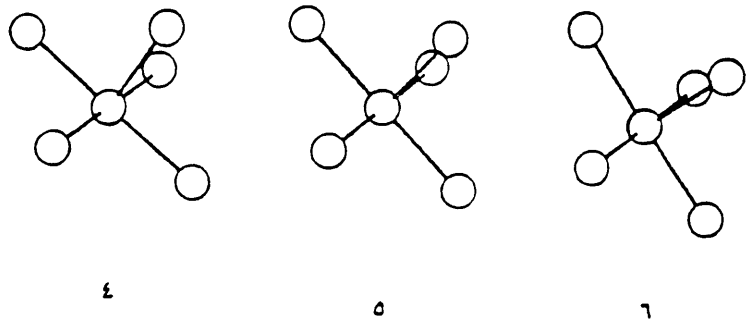


عند دوران التركيب المبين في شكل (١) حول محور العينات (ع) ، اى من الأشكال (٢ ـ ٥) يمثل التركيب بعد عملية الدوران .

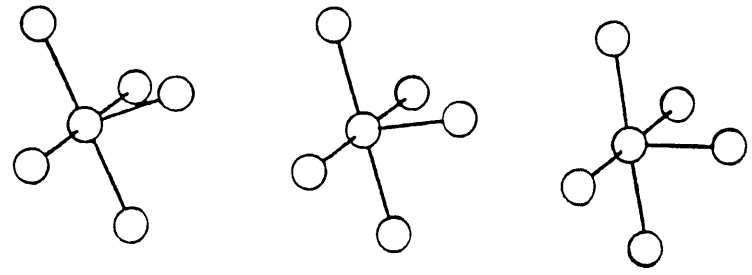
الجواب ٣



١ ٢ ٣

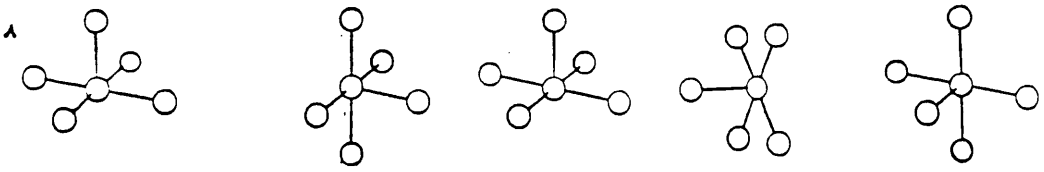


٤ ٥ ٦



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١٨

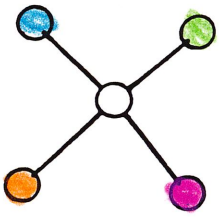


(١) (٢) (٣) (٤) (٥)

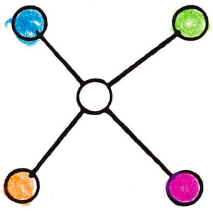
عند دوران التركيب المبين في شكل (١) حول محور العينات (ع) ، اى من الأشكال (٢ ـ ٥) يمثل التركيب بعد عملية الدوران .

الجواب ٢

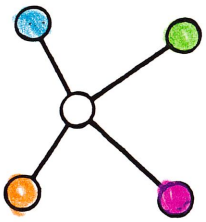
APPENDIX 8C



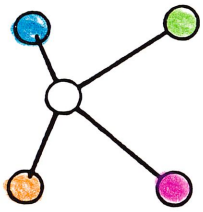
1



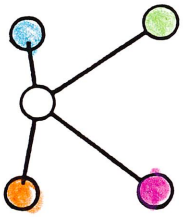
2



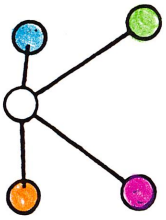
3



4

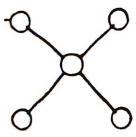


5

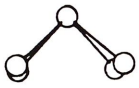


6

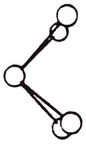
9



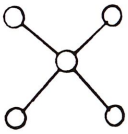
1



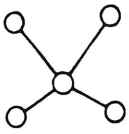
2



3



4

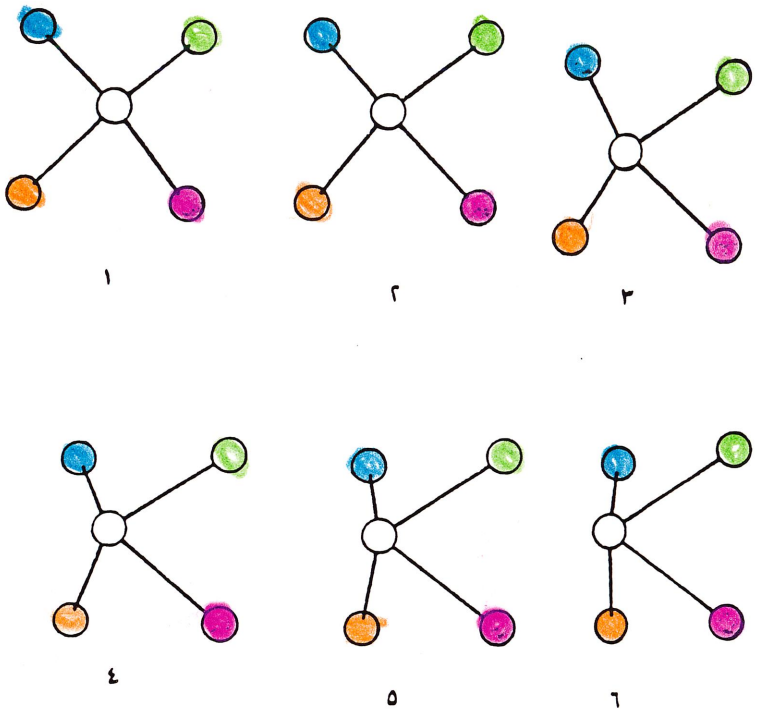


5

If the structure in diagram 1 were rotated about the Y-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

CORRECT ANSWER 3

APPENDIX 8D



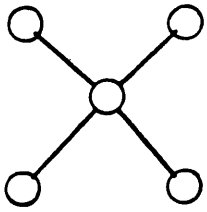
٩

(١) (٢) (٣) (٤) (٥)

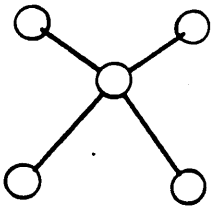
عند دوران التركيب المبين في شكل (١) حول محور المادات (ص) ، اى من الأشكال (٢ ـ ٥) يمثل التركيب بعد عملية الدوران .

الجواب ٣

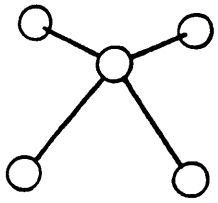
APPENDIX 8E



1

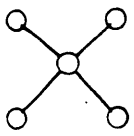


2

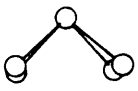


3

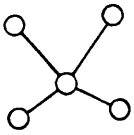
6



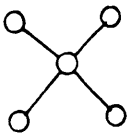
1



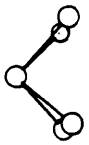
2



3



4

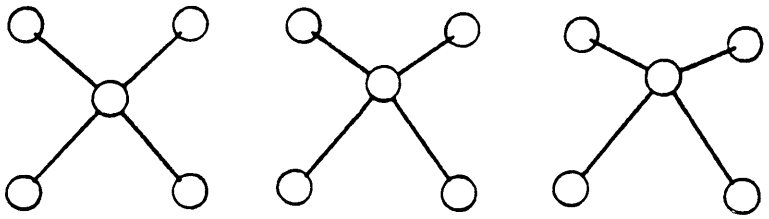


5

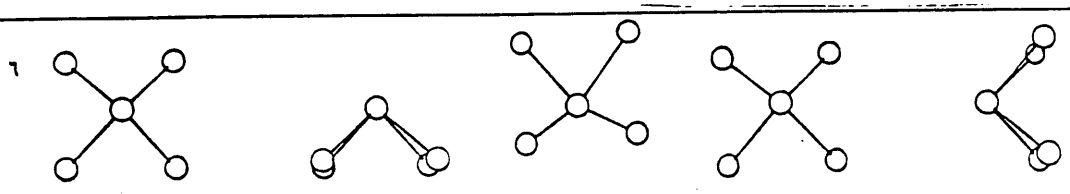
If the structure in diagram 1 were rotated about the X-axis, which of the diagrams 2-5 could represent the structure as seen after rotation?

CORRECT ANSWER 2

APPENDIX 8F



١ ٢ ٣



٦ (١) (٢) (٣) (٤) (٥)

عند دوران التركيب المبين في شكل (١) حول محور السينات (س) ، اى من الأشكال (٢ – ٥) يمثل التركيب بعد عملية الدوران .