Aug. 25, 1936. S. J. FRENCH 2,052,457

EDUCATIONAL DEVICE FOR TEACHING THE ATOMIC AND MOLECULAR THEORY OF CHEMICAL SUBSTANCES

Filed May 25, 1933

FIG. 1.

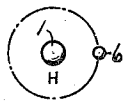


FIG. 2.

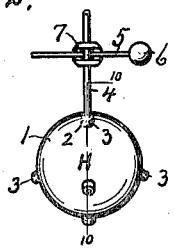


FIG. 3.

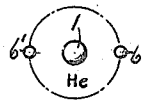


FIG. 4.

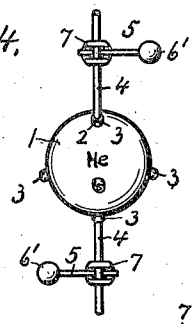


FIG. 5.

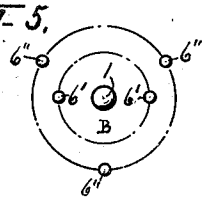


FIG. 6.

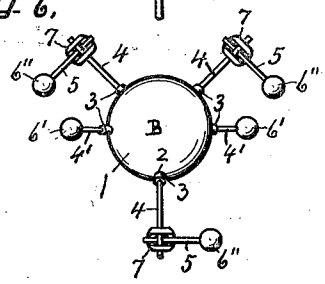


FIG. 7.

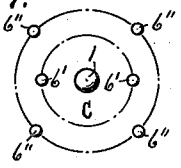


FIG. 8.

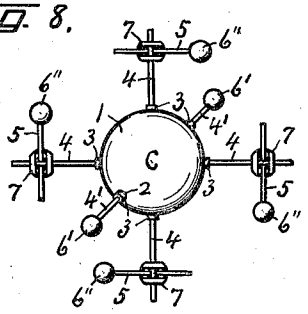


FIG. 9.

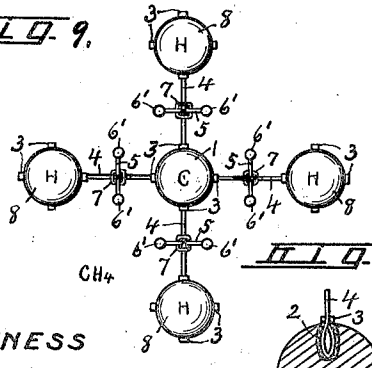
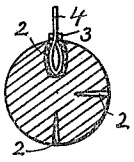


FIG. 10.



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EDUCATIONAL DEVICE FOR TEACHING THE ATOMIC AND MOLECULAR THEORY OF CHEMICAL SUBSTANCES

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Application May 25, 1933, Serial No. 672,825

6 Claims. (Cl. 35—18)

This invention relates to an educational apparatus for illustrating the atomic and molecular structure of matter, according to the electronic theory of matter, which theory assumes that all atoms are aggregates of protons and electrons, and that in any given species of elements all the protons and about half of the electrons constitute what is known as the nucleus of the atom while the remaining or planetary electrons arrange themselves in one or more shells or valence layers outside of the nucleus.

The electronic theory of matter assumes that in each successive-element of Mendeleef's chart, in which chart the elements are arranged in the order of increasing atomic weights, the number of planetary electrons increases by one. This theory further assumes that in most elements two of the planetary electrons of the system are stable with reference to the nucleus, while the other planetary electrons are more or less unstable and constitute one or more valences according to the nature of the atom.

It is further assumed that in certain orders of different elements, the outer valence layer or shell of planetary electrons continues to build up until the electrons reach a predetermined number, namely, eight, commonly known as an octet, in a stable condition, after which it is assumed that another octet valence layer is started outside of the previously formed octet.

For example, hydrogen has one planetary electron associated with its nucleus, helium two planetary electrons in stable relation to the nucleus, while lithium, beryllium, boron, carbon, nitrogen, oxygen, fluorine, and neon, each have the stabilized pair of planetary electrons as in helium, but in addition lithium, beryllium, boron, carbon, nitrogen, oxygen, fluorine, and neon have respectively one (1), two (2), three (3), four (4), five (5), six (6), seven (7), and eight (8) valence electrons in an outer shell.

By way of further illustration, it is assumed that in sodium the nucleus of the atom has associated therewith two stable planetary electrons and also a valence octet system of electrons, together with one additional electron in another outer valence layer. In other elements succeeding sodium in the table, the number of electrons in the outer valence layer increases until another octet system is formed.

This explanation, however, is only theoretical in showing the relation of the planetary electron systems of atoms of different species relatively to their respective nuclei and is intended merely to indicate wherein my apparatus may be used in illustrating chemical relations.

In chemical reactions, it is thought that an element tends to give up its valence electrons (donor atom) if it has less than four (4) or to take on electrons (acceptor atom) if it has more than four (4) to complete an octet of valence electrons and that the atoms which have thus reacted, commonly known as positive ions and negative ions, are left electrically unbalanced, and that in other reactions electrons may not be completely transferred from one atom to the other but may remain shared equally between the two atoms and commonly known as bonding electrons in molecules which under some conditions are polar or semi-polar, or, if the electrons are equally shared, the molecule is non-polar.

It is also assumed that the valence of an atom is related as follows to the number of its valence electrons. That is, if the atom has one (1) electron, it gives up one (1), thereby exhibiting a positive valence of one (1). If the atom has two (2) electrons it gives up two (2), exhibiting a positive valence of two (2), and so on through the successive species of atoms. If the atom has four (4) electrons it may either give up four (4) or take on four (4), or if it has six (6), it will take on two (2) or give up six (6), exhibiting a negative valence of two (2) or positive valence of six (6). For example, one (1) oxygen atom takes on two (2) electrons, while each hydrogen atom can give up only one (1), this ratio being required to form H_2O.

The theories heretofore advanced are probably well-known to those skilled in this art, but it is quite difficult for the student to understand the structure of the atoms and molecules of different species and their relations to each other and particularly the relation of the valence electrons to the nucleus of the atom of any given species.

The main object, therefore, of the present invention is to provide a simple and comparatively inexpensive mechanical device which may be manipulated in such manner as to permit a more practicable illustration of the chemical properties of atoms and molecules than has heretofore been practised and thereby to enable the student more easily and quickly to understand the various phases of chemical activity.

It would, of course, be impracticable to show all of the positions to which the device may be adjusted to illustrate the different relations of the constituent parts of atoms and molecules of all of the widely varying specimens and, therefore, I have limited the illustrations in the drawing to

a comparatively small number of settings of the device for a limited number of, in this instance four, species of atoms, viz:—hydrogen, helium, boron, carbon and the methane molecule, but obviously the same device may be set to illustrate the theory of many other atoms and molecules.

Another object is to enable certain elements of the models to be removed or built up to represent the electronic structure of any type of atom or molecule.

Other objects and uses relating to specific steps in the process of illustration and to the mechanism for making such illustrations will be brought out in the following description.

In the drawing:—

Figure 1 is a diagrammatic view representing the theoretical structure of the hydrogen atom including its positive or proton nucleus and its negative electron.

Figure 2 represents a mechanical model adapted to illustrate the theory of the relation of the electron to the nucleus of the hydrogen atom.

Figure 3 is a diagrammatic view representing the theoretical structure of a helium atom including its nucleus and the two electrons associated therewith.

Figure 4 represents a mechanical model for demonstrating the theory of the helium atom including its nucleus and two electrons associated therewith.

Figure 5 is a diagrammatic view of the theoretical structure of an atom of boron including its nucleus, inner electronic shell containing two electrons, and outer valence shell containing three electrons.

Figure 6 represents a mechanical model for demonstrating the atomic theory of the boron atom shown in Figure 5.

Figure 7 is a diagrammatic view of a carbon atom according to the electronic theory, representing the nucleus and inner and outer electronic shells with two electrons in the inner shell and four electrons in the outer valence shell.

Figure 8 represents a mechanical device for demonstrating the theory of the carbon atom shown in Figure 7.

Figure 9 represents a mechanical device for illustrating the theoretical structure of a methane molecule.

Figure 10 is a sectional view of a device for representing the nucleus of an atom with which the electrons are associated including a portion of one of the bond members and sockets for receiving the same.

The models illustrated are particularly adapted to show the planetary and valence electrons of an atom, the electronic changes when atoms unite to form molecules, the electronic structure of the various types of molecules including polar, semi-polar and non-polar types, and may be built up to represent the electronic structure of any type of atom or molecule.

This mechanical device or model, as shown in Figures 2, 4, 6, and 10, comprises a main body section **1**, which preferably consists of a spherical ball of soft or pliable rubber representing the nucleus or kernel of the atom, said body being provided with a series of, in this instance five, slits or openings **2**, Figure 10, in which are releasably but tightly fitted a corresponding number of elastic rubber or equivalent tubes **3**, four (4) of which are preferably arranged in tetrahedral relation and radial to the center of the ball.

Each of the tubes **3** is adapted to receive a wire or equivalent arm member **4** representing the valence bonds between the nucleus and the planetary electrons of the atom and having one end releasably and adjustably inserted in its corresponding opening **2**, but firmly held in operative position therein through friction therewith and of sufficient length to extend or protrude radially some distance beyond the periphery of the nuclear body for receiving and supporting one or more cross arms **5** having one or more relatively small objects **6**, **6'** or **6''** mounted thereon to represent a corresponding number of electrons in one or more outer shells or valence layers. The electrons **6**, **6'**, etc., are presumed to have a planetary motion about the nuclear body **1**.

The electron arms **5** are coupled to the bond members **4** by means of a rubber or equivalent band **7** which permits adjustment of the arm **5** along the bond member **4** and serves to hold the former in its adjusted position.

This radial adjustment of the electron arms **5** toward and from the nucleus member **1** serves to represent the position of the electrons in different shells or valence layers according to the requirement of the illustration for atoms of different species.

For example, in Figure 2 the electron **6** is set to represent the relation of the electronic shell of a hydrogen atom to its nucleus and to indicate that when brought into proper relation to the electronic shell of another atom, such as oxygen, the latter may take on the electron of the hydrogen atom to chemically unite with the electrons of the oxygen atom in proper ratio to form another substance H_2O.

If the theory of the helium atom is to be demonstrated, as shown in Figure 4, an additional bonding arm **4** may be inserted in the nuclear body **1**, in which case the supporting arms **5** and their electrons **6'** will be set to represent the stable relation of the electron shell to the nucleus.

When demonstrating the theory of the boron atom, as in Figure 6, the two stable electrons of the helium type may be placed upon relatively short arms **4'** which, together with three of the bonding arms **4** carrying a corresponding number of electrons **6''**, are then inserted into the nucleus **1** in suitable relation thereto and to each other to represent respectively the stable electronic shell and the active outer electronic valence layer.

In Figure 8, the device is set to demonstrate the theory of the carbon atom in which the supporting arms **4'** for the electrons **6'** representing the stable electronic shell of the helium type shown in Figure 6 remain in place upon the nuclear body and four of the bonding arms **4**, carrying a corresponding number of electrons **6''**, are inserted in said body in suitable relation thereto and to each other to represent the active electronic shell or valence layer of that atom.

In this figure, the nuclear body C is shown as provided with six (6) slits or openings, two of which are adapted to receive the pair of stabilized-electron bonding arms **4'** while the remaining four openings may be tetrahedrally arranged to receive a corresponding number of the bonding arms **4** for supporting the same number of electron cross arms **5**, the latter being adjusted along their respective arms **4** to the proper position to represent the position of the valence layer.

In Figure 9, the device is shown to represent a methane molecule and comprises a nuclear body **1**, of a carbon atom, to which are releasably attached the inner ends of a plurality of, in this instance four, bonding arms **4**, carrying releas-

ably a corresponding number of objects 8 representing the nucleii of hydrogen atoms.

Upon the bonding arms 4 are mounted a corresponding number of cross arms 5 each carrying a pair of electrons 6', the cross arms 5 and their electrons 6' being arranged normally midway between the nuclear body 1 and atom bodies 8 and are connected to their respective bonding arms 4 by couplings 7 similar to those previously described. It will be understood that the couplings 7 enable the cross arms to be adjusted toward and from the nuclear body or toward and from the corresponding atoms 8 as may be necessary to illustrate the difference in polarity between the nuclear body 1 and corresponding atomic bodies 8.

For example, in case the atomic bodies 8 as in chlorine should be more negative than the nuclear body, the electrons on the cross arms 5 would be drawn toward the negative bodies and consequently the cross arms 5 carrying the electrons 6' would be correspondingly adjusted toward the negative bodies, the reverse being true in case the nuclear body should be more negative than the outer bodies.

The free ends of the arms 5 in Figure 8 indicate that the carbon atom can take on four more electrons to complete an octet, thus acting as a negative element with a valence of four. It may also give up the four electrons 6'' shown in Figure 8, thus acting as a positive element with a valence of four.

It will thus be seen that the same device is adapted to be used for demonstrating the electronic theory of a wide range of atoms or molecules of different species by simply changing the number and relation of the bonding arms 4 upon and relatively to the nuclear body 1 and also changing the position of the cross arms 5 upon the corresponding bonding arms 4 so as to change the relation of the electrons 6' to the nuclear body 1 in the manner previously explained.

It will be noted upon reference to Figure 10 that at least one end of each bonding arm or wire 4 is returned upon itself to form a loop 9 for the purpose of enlarging said end to increase its frictional engagement in the opening in the nuclear body 1 and also to permit the loops of different bonding members to be attached to each other in case it should be necessary to demonstrate the relation of the electrons or molecules of different correlated atoms.

It is evident, however, that the bonding arms 4 may be made of any length suitable for illustration of the theory under consideration and that both ends of one or more of said bonding arms may be provided with the loops 9, as for example, when inserted in the nuclear body and adapted to carry at their outer ends different bodies representing other atoms which latter, in turn, may become nuclear bodies for receiving additional bonding arms carrying other electron-supporting arms, as in Figure 9.

In this manner, the device may be built up from any one nuclear body to represent the relation of any reasonable number of atoms to each other and also to represent the relation of different electronic shells or valence layers to each other and to the corresponding nuclear bodies.

Although I have shown the nuclear bodies 1 of different atoms as substantially the same size in Figures 2, 4, 6, 8 and 10 and made of relatively soft or sponge rubber or equivalent elastic material for convenience of handling, and considerably larger than the bodies which represent the electrons, it is to be understood that the size, form and material entering into the structure of the device may be varied without departing from the spirit of the invention.

It is found, however, that the smaller bodies representing the electrons may also be conveniently made of soft rubber to enable them to be readily placed upon the ends of their respective supporting units which, in turn, are preferably made of wire.

It is also to be understood that the rubber sleeves 3 may be omitted in which case the ends of the bonding members will be inserted directly into the openings 2 which may be made in the bodies 1 or 8 by any pointed tool or if the nuclear body 1 is made of sponge rubber it may be possible to insert the ends of the wire directly thereinto without pre-formation of the openings 2.

It is believed that the apparatus shown in its various settings is sufficient to illustrate the numerous uses to which it may be put in illustrating and interpreting chemical phenomena and particularly the chemical relationship of the different electronic layers to each other and to the nucleus of the atom or atoms, the chemical relationship of different atoms, and the relation of the atoms to form molecules including the effect of differences in polarity of different atoms on the positions of electrons of the molecule.

What I claim is:

1. An educational apparatus for illustrating the structure of matter according to the electronic theory, comprising a member representing an atomic nucleus, a rod representing a valence bond and inserted endwise into said nuclear member, a cross-arm mounted on said bond rod for adjustment along the length thereof, and a member representing a planetary electron mounted on the end of said cross-arm.

2. The apparatus as claimed in claim 1 in which the nuclear member has a socket into which the bond rod may be inserted, said socket having elastic walls for tightly gripping the rod.

3. The apparatus as claimed in claim 1 in which the cross-arm is mounted on the bond rod by a rubber band.

4. An educational apparatus for illustrating the structure of matter according to the electronic theory, comprising members each representing an atomic nucleus and having a plurality of sockets therein, rods each representing a valence bond and inserted endwise in sockets of said nuclear members, cross-arms mounted on said bond rods for adjustment along the length thereof, members representing planetary electrons and mounted on the ends of said cross-arms, supporting rods of shorter length than said valence rods and inserted endwise in sockets of said nuclear members, and members representing stable planetary electrons and mounted on the ends of said supporting rods.

5. The apparatus as claimed in claim 4 in which the sockets of the nuclear members have elastic walls for tightly gripping the rods.

6. The apparatus as claimed in claim 4 in which the cross-arms are mounted on the bond rods by rubber bands.

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