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Molecular Forces

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chemistry, in which he made some notable discoveries. These prepared him for his biological and medical contributions, resulting later in the great Pasteur Institute in France.

It would not be difficult to prepare a program on the life and works of Sir Isaac Newton. His mathematical achievements and investigations in the field of physics offer many possibilities for papers.

Among others that would make an interesting program would be Galileo, John Dalton, Louis Agassiz, and Blaise Pascol.

Should the reader care to follow out the ideas suggested above, the following brief bibliography will be of service. (1) For reference work for all of them we would recommend the standard encyclopedias, such as "Britannica" and "The New International." (2) Archimedes (about 287-212 B.C.) "Library of Historic Characters," Vol. 6, by A. R. Spafford and others; "History of Science" by H. S. Williams. (3) Joseph Priestly (1733-1804) "A History of the Sciences, Chemistry," Vol. 1, by Edward Thorpe; "History of Chemistry" by F. P. Venable. (4) Charles Darwin (1809-1882) "Library of Historic Characters," Vol. 10, by A. R. Spafford and others; "Charles Darwin and Other English Thinkers" by S. P. Cadman; "The Evolution of Charles Darwin" by George Amos Dorsey; "Biographies of Eminent Persons," Vol. 3; "Darwin" by Gamaliel Bradford. (5) Asa Gray (1810-1888) "Leading American Men of Science," by D. S. Jordan. (6) Louis Pasteur (1822-1895) "Library of Historic Characters," Vol. 10, by A. B. Spafford and others; "Life of Pasteur" by Rene Vallery-Radot; "Pasteur and His Works" by L. Descour. (7) Sir Isaac Newton (1642-1727) "Library of Historic Characters," Vol. 10, by A. R. Spafford and others; "Book of Days, Sir Issac Newton and the Apple," Vol. 2, by R. Chambers; "Dictionary of National Biography," Vol. 14; "A History of Science," Vol. 2, by H. S. Williams. (8) Galileo (1564-1642) "Radiant Suns" by Agnes Gilbern; "Beacon Lights of History," Vol. 3, by J. Lord; "Encyclopedia of Universal History," Vol. 2, by J. C. Ridpath.

O. B. READ

MOLECULAR FORCES

Physics

(Continued from April issue)

The three states of matter denoted as solids, liquids and gases are different phenomena of matter arising from a change in the intensity of molecular attractions.

By the application of heat iron can be made to change from a solid to a liquid and finally into a gaseous state. In changing from a solid to a liquid, the molecules of a substance are forced by heat from a fixed vibratory condition into a mobile vibratory state. Hence it is evident that in the liquid state the molecular attractions are much less intense than in the solid state. Then, as the liquid state gives place to the gaseous state, the molecular attractions must become exceedingly small, as evidenced by the high speeds of the molecules of gases.

The three most prominent phenomena arising from molecular attractions and discussed in elementary physics are those of surface tension, capillarity and crystallization. These phenomena are exceedingly interesting and play a very important role in the processes of nature and in the inventions of man.

In discussing surface tension the instructor should emphasize particularly its practical side. The term itself is quite abstract to the beginning pupil and hence its discussion should be placed on a commonplace basis. The phenomenon is most strikingly illustrated in the free surface of a liquid, as the free surface of water in a tumbler. The impression should not be created, however, that water has a monopoly on this property. It pertains to all kinds of fluids.

How surface tension arises out of the molecular attraction in the surface layer of a liquid is quite clearly presented in most high school texts and need not be discussed here. The important task for the instructor is to bring the pupil to see that there is a tension—a contractile force—acting in the surface film of a liquid as of water in a tumbler. He should first be shown by experimental demonstration that the surface of a liquid is in quite a different physical condition from its interior. A heavy cambric needle, when carefully placed in a horizontal position upon the surface of water, will float, even though its density is seven or eight times that of water. A Gillette razor blade can be floated in the same way. A glass tumbler can be filled with water above its brim. In this case the upper surface of the water will take a convex form, the surface film acting as a cover to keep the water from running over. In nature we can observe water beetles scampering around upon the surface of water in sloughs, ponds and running streams without breaking through. All such phenomena convince us that there must be a virtual film at the surface of water strong enough to support these objects. This is actually the case. In the home the dishes used for pouring liquids are equipped with spouts. The spout is for the purpose of breaking the film at the surface of the pouring liquid so that it will flow out smoothly and steadily.

In the next place, point out that there is a stress in this surface film responsible for its existence, and resulting from the unbalanced molecular attractions. This fact is illustrated by placing two matches close together upon the surface of water in a dish and then dropping some alcohol between them by means of a pipette or a glass tube. As a result, the matches are pulled apart with a suddenness that is quite striking. Dropping fresh water between the two matches so placed causes no such effect. It is clear that the alcohol must weaken the surface tension between the matches so that the tension of the water film acting on their outer sides can pull them apart. It might also be said that the alcohol cuts the film between the matches while the water does not. The effect in this experiment is not unlike that of a stretched rubber band when cut in the middle, the free ends flying violently in opposite directions.

Having introduced the idea of tension, it should be driven home by means of a number of homely illustrations. A very beautiful one is obtained by scraping a number of very small particles from some camphor gum upon the surface of clean water. The little particles will scamper around over the surface in a whirling or zig-zag fashion, like a swarm of water beetles. The camphor particles weaken the surface tension in their successive positions, thus permitting the unbalanced tensions in the water films surrounding them to pull them around in quick irregular movements.

As a second illustration we may dip a fine haired, fluffy paint brush into paint and lift it out perpendicularly, when it will be noticed that the brush is drawn to a point by the film force. Again, when one wets his hair, it is surface tension that draws the hair into pointed, compact strands. If oil is dropped upon the surface of water, it is surface tension which instantly spreads it in all directions. This last phenomenon has often been used in a practical way by seamen. A few years ago a steamer took fire off the coast of Ireland and it was not possible to take off the passengers and crew because of the rough sea. A wireless message was sent to London for a Standard Oil tanker. Upon its arrival the oil steamer sprayed the surface of the sea with oil, thus quieting the waves and permitting the use of life boats. The oil here formed a covering over the water so that the wind could not get a "bite" on it, and the waves subsided by virtue of their own friction or viscosity.

When one blows bubbles in water they immediately burst because the tension in the films is so intense. When, however, soapy water is used, the bubbles remain for a time because the soap weakens its surface tension. Lubricating oil is of good quality if its surface tension quickly spreads it over a bearing.

In nature, raindrops are molded by surface tension. As the small masses of water fall from a cloud the film which surrounds them contracts and forces them into spherical form. Electricity strengthens surface tension and after a lightning stroke we frequently observe a shower of very large drops. During a high wind, ponds are often covered with fine sticks, straw and leaves. It is surface tension which later gathers these in clusters around stumps, logs and the shore, thus gradually clearing the water surface. The stronger the surface tension the larger the drops it can mold into spherical

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EDITORIAL

Nothing will more largely contribute to the teacher's peace of mind or to the pupils' efficiency than proper foresight for the fall. A two or three day incarceration in your empty and silent laboratory and classroom some time between the closing and reopening of school should represent a good investment. During this voluntary exile, put to yourself a few questions and motorize the answers.

What equipment must be purchased to replace or supplement the present stock? Late orders to supply houses arrive at their busy season and may mean delayed shipments. Is there an alphabetical list prepared of the stock of equipment, and the quantities? This means applying business science to laboratory science. Is any of the equipment rusted or tarnished? Paint, sand paper, steel wool and polishing powders will solve the problem. Do the stock room, the bottles or the specimens need rearranging or relabelling? A little planning, a few labels and colorless shellac can work wonders.

Do some of the library books need rebinding or the files of bulletins and pamphlets extended? Reports and supplementary references from pupils can be valuable in direct proportion to the size of your library. Why not add to your displays through the courtesy of various manufacturers? Lists of houses which furnish educational displays are available. Have you planned a series of outside activities, such as science club, visits to local industries, field trips, public displays of class work, county fair exhibits and the like? These activities tend to be conspicuous by their absence but they are fully worth while.

We must close this list or the reader may decide that his task is not one of three days but of three months. Yet it pays big dividends. Don't speculate about it; invest in it.

Science Bulletin closes its first volume with this issue. We have sought ever to keep in mind the science teacher in service and to offer to these teachers only such subject matter and methods as would fill a need in the classroom, laboratory or field. That we have in some measure succeeded is indicated by the many kind and appreciative comments which have reached us. The generous co-operation of our contributors has made possible the well-filled pages and prompt publication.

Plans are going forward for the nine issues of the second volume. The present editor will spend next year at a university in chemical research, but the new staff will "carry on," and with greater efficiency. They will welcome from the readers any suggestions which will make Science Bulletin more helpful to the teacher in service. "If we have served, we have succeeded." We wish you a pleasant vacation.

TEACHERS' COURSES

Special courses for teachers of science are offered at this college. A three hour course in teaching biological sciences offers training in subject matter and methods as applied to the classroom, laboratory, and field. A physics teachers' course will be offered this summer, open to those who are actually teaching physics or who have had two years of college physics. This course deals directly with the problems of the high school classroom and laboratory.

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form. If fresh water and soapy water are dropped from the end of a tube, the fresh water drops will be much the larger. This also shows the greater intensity of the surface tension of fresh water. Ten drops of different liquids, for instance, do not represent the same bulk since each liquid has a different surface tension.

The drop-forming power of surface tension has been utilized in the manufacturing arts. Melted lead is poured through a fine sieve mounted high in a tower and the little liquid masses quickly assume a spherical shape before reaching the cooling bath of water below.

L. BEGEMAN