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A handbook of chemical manipulation

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Section I. The Experimental Laboratory

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CHEMICAL MANIPULATION.

SECTION I.

THE EXPERIMENTAL LABORATORY.

1. **I**T is not often that a building is to be specially erected for the purposes of chemical research: it will be necessary, therefore, in most instances, to alter one already existing; but it is essential for the completeness of the plan about to be detailed, to presuppose the laboratory built purposely. The matter contained in this section must be understood as applying solely to a laboratory of research, unconnected with any School of Medicine, University, or other place where the science is taught. In order that the following descriptions may be more easily apprehended, a plan of a laboratory, and an elevation of a student's working-bench, will be inserted at the end of the volume.

2. It is more convenient for the laboratories to be on a ground floor than on several storeys, as will be readily seen when we consider the facility with which furnaces can be built without the necessity of springing arches for their support, the much greater safety in the event of fire or other accident, and the ease with which heavy or large articles can be brought in or removed. Nevertheless it is the opinion of many that the dryness of an upper floor more than compensates for any slight trouble of access. Balances, air-pumps, and other apparatus of metal soon become injured by the damp frequently found in rooms level with the ground.

3. Unless it is intended for several persons to work together, it is better not to have an experimental laboratory too large, for it

will generally be found that one of moderate size is kept in better order than a very large one; the fact of there being plenty of room frequently inducing carelessness in putting things away, a procedure which cannot be too strongly reprobated, whereas, on the other hand, if there be not too much space, it becomes absolutely necessary to the operator's comfort and progress that everything which may be no longer in use should be restored to its proper place.

4. Those who have not been accustomed to experimental pursuits, can scarcely conceive how frequently an operation is dependent for success upon the readiness with which the hand can be placed upon an instrument, while a careless person is constantly exposed to the mortification of finding an experiment which has perhaps cost much labour, entirely spoiled from the impossibility of adding an ingredient, or performing some apparently trifling operation, at the exact instant required.

5. The apparatus required in an experimental laboratory of the present day is very different, and in general far less bulky than in those of even a few years ago. The furnaces especially have been modified, while the greatly increased facilities for the use of gas have to a certain extent rendered chemists independent of them. Every laboratory ought to have three or four gas-furnaces of different sizes and patterns, as will be described in the section on Lamps. Several yards of vulcanized india-rubber tubing will also be required, to enable them to be arranged upon any part of the tables or floor. They can be attached to any of the gas-pipes, and when not in use may be kept in a special place out of the way of injury.

6. The laboratory, as will be seen by a glance at the Plan and explanation, is lighted by windows all down one side; and at one end there is another large window, in front of which is placed a glass case fitting very tight and containing three balances, each being also in its own lantern, so that they are doubly protected from the corrosive vapours which float about the laboratory. No chemical laboratory can, however, be considered as at all approaching completeness, unless another room is especially

appropriated to the balances, air-pumps, and other delicate instruments.

7. All down one side is placed the chief working bench, at one end of which is a desk in which will be contained paper, the note book, and various *et ceteras* which are necessarily kept free from dirt; it is advisable to allot one of the drawers of the desk to the various test papers, cut into slips, and kept in well-corked tubes ready for use. Above the desk will be two or three shelves, for those works of reference which are constantly in use in the laboratory; and above these may be placed a shelf for containing some of the less bulky and more valuable reagents. The books for reference may perhaps with greater propriety be kept in a cupboard in the balance room.

8. At the extremity of the long bench, next the desk, should be fixed a small vice, which will be in everyday use during the construction or repair of apparatus. A few pairs of scissors or shears should be suspended against the wall near this spot, which should also be close to the drawers containing the tools. At the other extremity of the bench to the vice, is placed a four- or six-gallon stone barrel with a tap of the same material, containing distilled water, and beneath it a pan to contain the droppings. This will, from its proximity to the operator during his work, be found far more convenient than having it over the sink, which would involve passing to the extremity of the laboratory frequently. The presence of the barrel will not prevent the necessity of having one or two Gmelin's washing-bottles, of about a pint capacity, within easy reach, they being constantly in use for washing precipitates and applying small quantities of water.

9. At intervals of every few feet down the working benches, are gas-pipes projecting a few inches above the surface; they afford great facilities for the performance of several operations simultaneously, and as each is terminated by a screw or "thread," they may have attached any of the gas-jets mentioned in the section on Lamps.

10. The two tables in the centre are very strong and heavy, so as not to be easily vibrated; they are, however, capable of being

removed when required to make room for any particular operation. The larger of the two has an apparatus affixed, which enables it to sustain a filter-stand to hold the calico and other bags, so often required for filtering large quantities of liquid. This is accomplished by having two slips of wood sliding in mortises immediately under the top of the table, supporting a board pierced with holes to receive the bags. In addition to this contrivance, several small filter-stands should be provided, in order to prevent the unnecessary use of retort stands, which are more advantageously appropriated to operations with retorts and flasks, and to experiments requiring heat. The shape and modes of construction of the most convenient apparatus of this kind will be mentioned in its proper place. Near that portion of the laboratory where the filtrations are carried on, will be placed the receptacle for filtering-paper, which is so arranged as to show all the different sizes of ready-cut filters at a glance.

It is recommended, if possible, to appropriate some special part of the laboratory to filtrations when they are on a larger scale than usual, because being generally a long and in many cases a tedious operation, it is desirable not to occupy the space allotted to general work.

11. On the other side of the laboratory, opposite to the general working-bench, is placed a large arch or hood of masonry, under which, on a slight rise, are placed the furnaces; but where a manufactory which contains powerful furnaces is connected with the establishment, it is recommended to dispense with them altogether in the experimental room, and, instead, to have one on Lühme's or some analogous principle, and to replace the hot-air cupboard of the table-furnace by one heated with gas. Nevertheless, as this is not always a convenient arrangement, a furnace of the kind last named is represented in the Plan of the laboratory. A few chauffers will be found necessary, from the facility with which they can be moved to any part of the laboratory. The hood must have its flue quite independent of those belonging to the furnaces, which may be placed under it, or their draught would be entirely spoiled; and it is desirable to have an

arrangement in the form of a damper placed in it, so as to enable the operator to regulate the current of air, and at times to close it altogether, especially if the flue be straight, in which case inconvenience would be occasioned in wet weather by the descent of blacks and rain.

12. Where organic analyses are frequently being made, it is advisable to have the means of using two combustion-furnaces side by side, for the convenience of performing two analyses simultaneously, unless Hofmann's gas-furnace is used, when, from the rapidity with which combustions can be made, it becomes unnecessary. The large quantity of white ash and charcoal dust which attends the use of the ordinary combustion-furnace, makes it important to perform the operation under the hood or chimney shown in the Plan, unless another room can be used for the purpose, which is very desirable.

As, in many laboratories, these analyses are of everyday occurrence, it is important to afford every facility to the operator, by placing all the materials and utensils required, within reach, and always keeping a supply of combustion-tubing clean and dry.

In a convenient place at one end of the room, the square water-bath for drying precipitates, &c. must be placed; and as, in an active laboratory, this instrument is every day in use, and is often required to contain a considerable number of preparations, it can scarcely be too large.

13. At the end of the laboratory opposite the balances will be seen a vapour chamber or cupboard, having free access to the atmosphere. Beneath may be a furnace, serving to heat a small sand-bath; the chief use of this apparatus is to receive vessels emitting vapours, which, from being corrosive or unpleasant, it is desired to prevent floating about the laboratory. The sand-bath enables us to apply heat when required, as in dissolving gold or platinum, preparing chlorine, &c.

14. At the end nearest the balance-case is a moveable sky-light, which will often be in use to remove the vapours with which the laboratory is unavoidably filled in the progress of some experiments, and which renders the power of rapidly removing

the air an object of great importance. It will be seen that no special arrangement is made for carrying away the hot and vitiated air produced by combustion of the gas, for its influence is so small in comparison with the odours and other exhalations constantly emitted during the progress of experiments, that it may be altogether disregarded.

15. The laboratory should be well provided with cupboards and shelves, of which it would be difficult to have too many. In all laboratories of research there is a constant accumulation of specimens of valuable or rare products; these should be neatly arranged and labelled; one of the large cupboards will probably be the most convenient place for their retention, in the event of there being no museum attached to the establishment.

16. In most establishments there is some operation which is more frequently in requisition than any other; for instance, in one, alkalimetric analysis will probably be of almost everyday occurrence; in some laboratories metals are constantly being examined for their purity, or ores for the per-centage of their constituents; in others, on the contrary, the analyses of manures, or operations connected with organic research, are the staple occupations; whatever, therefore, the most frequently recurring source of employment may be, everything else ought to be made subservient to it, and every facility afforded for its ready and perfect performance.

17. A good store of test-solutions should always be kept ready, and the various burettes, beakers, basins, &c. should, immediately after use, be cleaned and put in convenient situations, that they may be at hand for the next series of experiments.

18. The barometer, with a good thermometer of small range but very open degrees, should be kept near the place where the gaseous nitrogen determinations are made, so as to indicate the temperature and pressure on the spot. It is advisable to note these data every day, at stated times, and to become as familiar as possible with all the peculiarities and best methods of observing the indications of the two instruments.

19. One particular part of the laboratory, preferably under one

of the benches, should be appropriated to dirty apparatus intended to be cleaned; and it must be distinctly understood that no vessels or utensils should be taken away to be washed, no matter what their appearance, unless placed here. The best arrangement, perhaps, for this purpose, is to have three trays with rather deep rims sliding upon beadings, so as to be easily capable of removal when full.

20. The blowpipe table, so useful for the construction and repair of glass apparatus, especially the preparation of combustion-tubes, finds a place near the chief working-bench, as indicated in the Elevation. A convenient contrivance for glass-working will be found in its proper section.

21. A considerable number of retort-stands are indispensable in an active laboratory; they should vary in height from 14 inches to 4 feet; the latter are intended to stand upon the floor, and should have large and heavy bases to them. The rings should be numerous, and a few sizes will be found sufficient, varying from 2 to 9 or 10 inches diameter. It is important that only two sizes of rods should be in use, one for the large and the other for the table stands, so that the rings may be used indifferently for any one of the set of stands to which they belong. In the same manner, the threads of all the screws should, in every possible case, correspond; this will greatly facilitate the arrangement of the complicated systems of apparatus which are sometimes necessary.

22. Several small wooden hoops should be provided, some of which fit moderately tight into one another; they answer a twofold purpose, namely, as supports for hot flasks or dishes and other apparatus, which would be endangered by being put down on a rapid conductor of heat; and also as sieves, by taking two, one of which fits inside the other, stretching muslin over the smaller, and then pressing the larger one over it so as to keep the muslin tight; these sieves are the more convenient, as it is easy to wash the material, and also to have it of different degrees of fineness, without occupying so large a space as would be required by several of the ordinary kind.

23. At the end of the laboratory, over the barrel of distilled water, is placed the rack for glass tubes. Probably the most convenient form is that made on the principle of the racks used by decorators for keeping their stock of paper-hangings. It is also desirable to have a long box fastened against the wall, preferably under one of the shelves, to contain combustion-tubing. The box should be about 6 feet 6 inches long, and the cover may be attached by a leathern hinge, somewhat in the manner of a candle-box. It is made so long because the combustion-tubes are usually sold in six-foot lengths, and it is not advisable to cut them until the tubes are being made. The method of making them will be found further on. The tubes, when finished, are, from the peculiarity of their shape, extremely fragile; the smallest carelessness in moving them is almost sure to break off the long thin point. It is advisable, therefore, to keep them on two iron brackets fixed into the wall about 16 inches apart, all the tails being at the same end, and turned downwards; they should each have a cork placed in the aperture to prevent ingress of dust. As they are very quickly made, it is better to do so when required than to keep a large stock, and so run the risk of breakage.

24. Places should be provided in the drawers under the benches for the hammers, files, anvils, and other tools constantly required. One drawer should be assigned to the blowpipe apparatus, with its agate mortar, lamps, &c. The various Wedgwood mortars should have a place assigned them on a shelf near the sink. The iron mortar on a block will generally be kept in the store-room, if there be one attached, its size and weight rendering its presence inconvenient in the laboratory. The stock of porcelain crucibles will also find a place in the same cupboard with the beakers, retorts, flasks and dishes.

25. It has probably been observed, that throughout the previous descriptions it has in most cases been taken for granted that the laboratory has to be confined to one room; if, however, the operator has the use of a second or even a third, much advantage will be found to accrue from such an arrangement. The

balances, air-pumps, and other delicate instruments, will then be kept out of the danger, which they otherwise incur, of being injured by the corrosive vapours of the laboratory, which in time will find their way through even the double cases which protect them. It is therefore most desirable that whenever such fumes are flying about, every means of ventilation at hand should without delay be put in action. The close chamber previously alluded to (§ 13), will afford the means of preventing the contamination of the air of the room during the performance of experiments which will go on by themselves; but there are some operations which from their nature are necessarily carried on on the tables or benches. There are, however, few cases in which the fumes cannot be conveyed into the open air by the use of a little contrivance; when it is impossible, the only remedy is either to make the experiment under the hood (§ 11), or to open the skylight and windows, and by this means establish a current of air through the chamber.

26. In some laboratories the pneumatic trough is in very frequent request; where this is so, it is best to have it on a table near the sink, and at some distance from the fire.

The mercurial trough is best kept covered over, on a table provided with a groove and raised edge, so that any mercury spilled may be swept with a card into a receptacle for the purpose.

If it is possible for each working-bench to have a sunk basin and plug, with a tap to supply water, which can, when required, be attached to a flexible pipe so as to cool the Liebig's condensers, such an opportunity must not be neglected; if, however, the pressure is insufficient to enable it to enter the lower part of the last-mentioned instrument and escape by the upper end, it will be useless for this purpose.

Where the laboratory is attached to a public institution, the working-places for the students may be arranged in the manner shown in the Elevations. The rest of the laboratory arrangements will be best seen by reference to the engravings and accompanying descriptions.