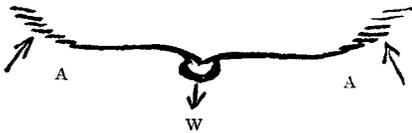


fish, &c., I cannot help thinking that Lilienthal's central and superposed aeroplanes were a mistake; and that instead of that type, while the weight must be central, the sustaining aeroplanes should, like the birds, have great lateral extension.

You will observe in the diagram that the wing planes can each be divided into two portions, having quite distinct functions. The outer extremities are the sustaining aeroplanes, marked by the arrows, while the inner portion of each wing, A to W, is that which assists the bird when it is alighting, by offering a fixed passive resistance to a fall when the speed is slackened down. W is the central weight.



Observe also that in the bird, the sustaining mechanism is so far structurally subdivided that the loss of a primary feather is not fatal to flight; each primary lies, and acts, in a distinct plane, and has its attachment distinct from the others.

Now, it seems to me that Mr. Maxim's central aeroplane and twin screws, situated so far apart, are hardly a safe plan, for if accident happen to one screw, the other must at once stop, and the whole thing, *nolens volens*, come down.

It is not like the twin-screw steamer, where the water sustains the hull, and progress by one screw is still possible. In the aerial ship translation is the support, and it only.

In the bird, when sailing, we see no screw at work; the aeroplanes are there plain enough, lifting the 16-pound bird higher and higher as we watch it; but propeller there is none.

This propulsion, as I before stated, must be got from an outside source. The bird can only soar *in a wind*, and then, to rise, must go in spirals, passing to leeward a little at each lap. Of course the wing planes are not horizontal, but inclined thus in



passing round the centre of spiral C; and there is necessarily great centripetal reaction at such a high speed of translation as fifty or sixty miles per hour.

I think Mr. Maxim will find the bird arrangement of aeroplanes to weight, and a central screw, the best and safest. If a large central overhead aeroplane is needed, it would be for safety in alighting only.

S. E. PEAL.

Sibsagar, Asam, December 13, 1896.

OSMOTIC PRESSURE.

IN last week's NATURE, Lord Rayleigh gave, for an *involatile liquid*, a rigorous and clear proof of "the Central Theorem" of osmotics. But this theorem, though highly interesting in itself, is not, so far as I can see, useful as a guide for experiment. Consider for example the typical cases of sugar, and of common salt, dissolved in water.

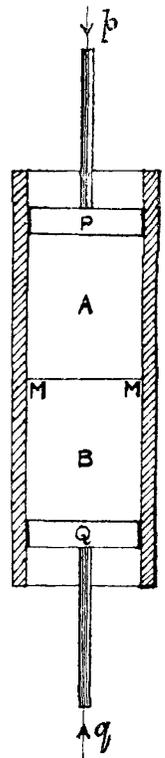
If water were absolutely non-volatile, the osmotic pressure of each solution against an ideal semi-permeable membrane separating it from pure water, would, according to the theorem, be equal to the calculable pressure of the ideal gas of the dissolved substance supposed alone in the space occupied by the solution. *This would be true whatever be the molecular grouping of the sugar or of the salt in the solution.* It is believed that experiment has verified the theorem, extended to volatile solvents, as approximately true for sugar and several other substances of organic origin, and of highly complex atomic

structure; but has proved it to vastly under-estimate the osmotic pressure for common salt and many other substances of similarly simple composition. KELVIN.

Belfast, January 19.

ON OSMOTIC PRESSURE AGAINST AN IDEAL SEMI-PERMEABLE MEMBRANE.¹

To approach the subject of osmotic pressure against an ideal impermeable membrane by the easiest way, consider first a vessel filled with any particular fluid divided into two parts, A and B, by an ideal surface, MM. Let a certain number of individual molecules of the fluid in A, any one of which we shall call D (the dissolved substance), be endowed with the property that they cannot cross the surface MM (the semi-permeable membrane); but let them continue to be in other respects exactly similar to every other molecule of the fluid in A, and to all the molecules of the fluid in B, any one of which we shall call S (the solvent), each of which can freely cross the membrane. Suppose now the containing vessel and the dividing membrane all perfectly rigid.² Let the apparatus be left to itself for so long time that no further change is perceptible in the progress towards final equilibrium of temperature and pressure. The pressures in A and B will be exactly the same as they would be with the same densities of the fluid if MM were perfectly impermeable, and all the molecules of the fluid were homogeneous in all qualities; and MM will be pressed on one side only, the side next A, with a force equal to the excess of the pressure in A above the pressure in B, and due solely to the impacts of D molecules striking it and rebounding from it.



If now, for a moment, we suppose the fluid to be "perfect gas," we should find the pressure on MM to be equal to that which would be produced by the D molecules if they were alone in the space A; and this is, in fact, very approximately what the osmotic pressure would be with two ordinary gases at moderate pressures, one of which is confined to the space A by a membrane freely permeable by the other. On this supposition the number of the S molecules per unit bulk would be the same on the two sides of the membrane. And if, for example, there are 1000 S molecules to one D molecule in the space A, the pressure on the piston P would be 1001 times the osmotic pressure, and on Q 1000 times the osmotic pressure. But if the fluid be "liquid" on both sides of the membrane, we may annul the pressure on Q and reduce the pressure on P to equality with the osmotic pressure, by placing the apparatus under the receiver of an air-pump, or by pulling Q outwards with a force equal and opposite to the atmospheric pressure on it. When we do this, the annulment of the integral pressure of the liquid on the piston Q is effected through balancing by attraction, of pressure due

¹ Communicated to the Royal Society of Edinburgh, January 18, by Lord Kelvin.

² In the drawing, the vessel is represented by a cylinder closed at each end by a piston to facilitate the consideration of what will happen if, instead of supposing it rigid, any arbitrary condition as to the pressures on the two sides of the membrane be imposed.

to impacts, between the molecules of the liquid S and the molecules of the solid piston Q. We are left absolutely without theoretical guide as to the resultant force due to the impacts of S molecules and D molecules striking the other piston, P, and rebounding from it, and their attractions upon its molecules; and as to the numbers per unit volume of the S molecules on the two sides of MM, except that they are not generally equal.

No molecular theory can, for sugar or common salt or alcohol, dissolved in water, tell us what is the true osmotic pressure against a membrane permeable to water only, without taking into account laws quite unknown to us at present regarding the three sets of mutual attractions or repulsions: (1) between the molecules of the dissolved substance; (2) between the molecules of water; (3) between the molecules of the dissolved substance and the molecules of water. Hence the well-known statement, applying to solutions, Avogadro's law for gases, has manifestly no theoretical foundation at present; even though for some solutions other than mineral salts dissolved in water, it may be found somewhat approximately true, while for mineral salts dissolved in water it is wildly far from the truth. The subject is full of interest, which is increased, not diminished, by eliminating from it fallacious theoretical views. Careful consideration of how much we can really learn with certainty from theory (of which one example is the relation between osmotic pressure and vapour pressure at any one temperature) is exceedingly valuable in guiding and assisting experimental efforts for the increase of knowledge. All chemists and physicists who occupy themselves with the "theory of solutions," may well take to heart warnings, and leading views, and principles, admirably put before them by Fitzgerald in his Helmholtz Memorial Lecture (*Transactions of the Chemical Society*, 1896) of January 1896 (pages 898-909).
KELVIN.

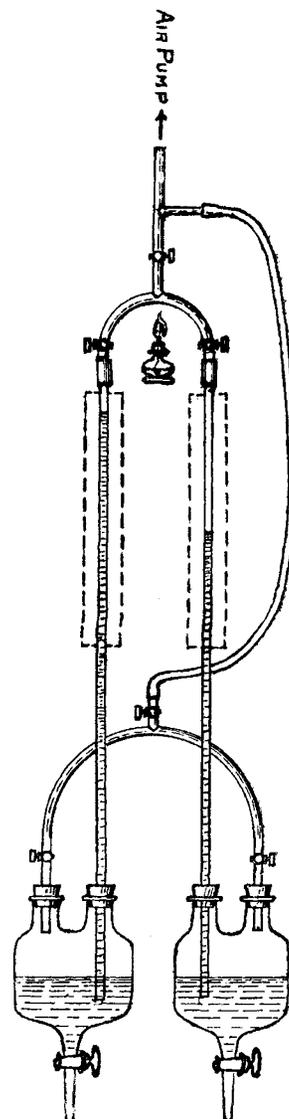
METHOD FOR MEASURING VAPOUR PRESSURES OF LIQUIDS.¹

Apparatus for realising the proposed method is represented in the accompanying diagram. Two Woolff's bottles, each having a vertical glass tube fitted airtight into one of its necks, contain the liquids the difference of whose vapour pressures is to be measured. Second necks of the two bottles are connected by a bent metal pipe, with a vertical branch for connection with an air pump, provided with three stopcocks, as indicated in the diagram. Each bottle has a third neck, projecting downwards through its bottom, stopped by a glass stopcock which can be opened for the purpose of introducing or withdrawing liquid. The upper ends of the glass tubes are also connected by short india-rubber junctions with a bent metal pipe carrying a vertical branch for connection with an air-pump. This vertical branch is provided with a metal stopcock.

To introduce the liquids, bring open vessels containing them into such positions below the bottles that the necks project downwards into them. Close the glass stopcocks of these lower necks, open all the other six stopcocks, and produce a slight exhaustion by a few strokes of the air-pump. Then, opening the glass stopcocks very slightly, allow the desired quantities of the liquids to enter, and close them again. They will not be opened again unless there is occasion to remove the whole or some part of the liquid from either bottle; and, unless explicitly mentioned, will not be included among the stopcocks referred to in what follows. It will generally be convenient to make

the quantities of the two liquids introduced such, that they stand at as nearly as may be the same levels in the two bottles, as indicated in the drawing.

Operation No. 1.—Close the stopcock on the lower passage from the bottles to the air-pump (which, for brevity, we shall call the lower air-pump stopcock); and, with the other five stopcocks all open, work the air-pump till the liquid in one of the glass tubes rises to within a centimetre of the india-rubber collar round its top.



Operation No. 2.—Open the lower air-pump stopcock till the liquids fall down the tube, nearly down to hydrostatic equilibriums in the bottles. Close it again, and work the air-pump till the liquid in one of the glass tubes rises to within a centimetre of the india-rubber collar.

Operation No. 3.—Repeat operation No. 2 over and over again until you cannot, however long you go on pumping, get the liquid in either tube to rise within a centimetre of the india-rubber collar.

Operation No. 4.—Continue Operation No. 3 until the

¹ "On a Differential Method for Measuring Differences of Vapour Pressures of Liquids at One Temperature and at Different Temperatures." (Communicated to the Royal Society of Edinburgh, January 18.) By Lord Kelvin, G.C.V.O.I.