less desultory in our observations if we knew that we were a part of a great organized system for the education and for the mental and bodily health of the community. The master mind will come in due time which will be able to generalize on our isolated facts and observations, if the facts are true and the records of the observations are intelligible and honest. We could tell the medical inspector of schools a great deal about the peculiarities and the risks of the children of the insane, the children of criminals, and the children of the degenerate and feeble in mind. We could tell him also a good deal about the children of the drunkard. We need ourselves to know much about the real origin and the preliminary symptoms of the mental diseases we have to treat, which we only see when fully developed. I believe the school inspector, if he is the right sort of man, will be able to help us in regard to this momentous point. To prevent and even to diminish mental disease would be an enormous gain to the community. To do this I believe we need to begin almost from the birth of the child who is predisposed to it. If the medical school inspector can help society in this way he will become the most effective of practical psychiatrists.

THE CRITICAL SOLUTION POINT OF URINE: A NEW PHYSICO-CHEMICAL METHOD OF EXAMINATION.

By W. R. GELSTON ATKINS.

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In order to determine the efficiency of a kidney as an excretory organ, the most exact method is the determination of the total solid content of the urine as shown by the depression of its freezing-point below that of pure water. This lowering of freezing-point was first fully investigated by Raoult, who showed that for moderate concentrations the depression was strictly proportional to the molecular concentration—namely, the number of gram molecules per litre—for non-electrolytes.

Its application to the examination of urine and blood has proved very useful and reliable, but the time required for carrying it out constitutes a serious drawback when only one or two specimens are to be examined. The following method is brought forward in the hope that it may prove to be of service in cases where great accuracy is not essential and saving of time an advantage. The method is capable of giving very accurate results, but this requires a tedious operation, involving the plotting of a curve from temperatures taken in a bath cooling very slowly.

OUTLINE OF CRITICAL SOLUTION POINT THEORY.

Consider two liquids not completely miscible at room temperatures, such as phenol (m.p. 40°C .) and water. If small quantities of these two substances are shaken together a white emulsion is obtained; this on standing separates into two layers, a lower one, consisting of phenol with some dissolved water, and an upper one of water with some phenol dissolved in it. If the temperature be now raised, the quantity of each dissolved in the other increases till a temperature is reached at which the two dissolve completely in one another, or, in other words, become completely miscible; on cooling even a tenth of a degree a separation again occurs, a white foggy emulsion is formed, and on standing the two layers separate out as before. The temperature at which the two layers become homogeneous depends upon the proportions of water and phenol initially present, and rises in the case of water as the amount of phenol is increased until a mixture is reached which remains in the two separate phases at a higher temperature than any other mixture of the two components.

The composition of this mixture is known as the "critical concentration," and the temperature at which the liquid becomes homogeneous is called the "critical solution temperature." The "critical solution temperature" is the temperature at which the two phases have the same composition and same properties. Accordingly it is the highest temperature at which any particular mixture of the two substances can exist as two separate phases. At the critical concentration and critical solution temperature the volumes of the two phases, water in phenol and phenol in water, are seen to be equal in the test tube.

At the critical temperature the two phases have the same surface tension, and are therefore completely miscible; at a temperature very slightly below the critical temperature the surface tensions of the two phases are almost equal, consequently the meniscus between them is flat. As the homogeneous mixture cools, at a temperature very little above the critical temperature a beautiful opalescence, blue by reflection, brown by transmission, is seen.

If now a series of mixtures of water and phenol be taken and the temperatures at which the two phases, of which each mixture consists, become one homogeneous phase, be determined, and the values thus obtained be plotted on squared paper as ordinates, while the corresponding percentage compositions of the mixtures be taken as abscissae, a curve is obtained, the highest point of which gives the critical solution point (Fig. 1). This curve is somewhat flat at the top, which means that the composition of the mixture may be slightly altered to one side or the other of the critical concentration without altering the temperature of miscibility much—about 1°C . The blue opalescence is still obtained, but it is not as beautiful as at the critical point itself.

Fig. 1.—C, Critical solution point.

The addition of a very small quantity of a third substance to any mixture of water and phenol raises the temperature at which the two phases become homogeneous, provided the added substance be freely soluble in water and almost or quite insoluble in phenol, or vice versa. If the added substance be freely soluble in both, then the temperature at which a homogeneous mixture is obtained is lowered. Thus, by adding a small quantity of sodium oleate to a mixture of phenol and water, it is possible to obtain a very strong solution of phenol, homogeneous at room temperatures. Lysol, the disinfectant, is prepared in this way.

In the case of a third substance much more soluble in water than in phenol, if curves constructed as described be plotted when one of the pure liquids is replaced by a dilute solution of the third substance in that liquid, the general outline of the original curve is followed, the ordinates of temperature being everywhere longer and markedly so in the crest region. In each of these curves there is a critical point, but it is no longer the highest temperature, as in the case of pure water and phenol; accordingly it must be recognized by the beautiful opalescence and equality of volume of the layers (Fig. 2).

The rise of critical temperature for dilute solutions, say 1 per cent., is roughly proportional to the number of gram molecules of the substance added with regard to its own solvent. Thus in the curves the concentration of the third compound is constant, proportionally to the amount of its own solvent, but is necessarily quite variable to the total amount of the two liquids taken together.

This rise in the critical solution temperature is very great, an amount of solid sufficient to depress the freezing point of water 0.5°C . will raise the critical temperature of a mixture of water and phenol about 4°C . This rise, therefore, which can be readily determined to one-tenth of a degree, gives the same accuracy as the freezing point.

measured to one-eightieth of a degree with greater facility and simple manipulation.

Fig. 2.—C, Critical solution point; K, maximum temperature. From Schreinemakers.

APPLICATION OF THE METHOD TO URINE.

If in the preceding experiments urine, which is an aqueous solution of certain compounds, be substituted for water, a considerable rise in the critical solution temperature is found to occur. This rise varies with the concentration of the urine.

A specimen of normal urine was examined throughout the whole curve, in order completely to establish the analogy, though such a tedious operation is quite unnecessary in determining the critical temperature. This curve was found to be similar to that given by a single substance added to a water and phenol mixture (Fig. 3). The method of procedure was as follows:

Weighed quantities of phenol and urine were mixed in test tubes, and the temperatures at which they became homogeneous were noted. An ordinary thermometer graduated in degrees from 0°—100° C. was used, and tenths were estimated, the object being to devise a rapid method of examination. It is not as rough a measurement as it may appear to those accustomed to Beckmann thermometers, for the temperature differences to be measured are nearly ten times as great. The data from which Fig. 3 was constructed are given below.

Percentage Weight Phenol.	Percentage Weight Urine.	Homogeneous Temperature.	Notes.
22.42	77.58	73.4° C.	
31.31	68.69	78.0	
33.99	66.01	78.3	Opalescence.
34.28	65.72	78.7	Good opalescence.
35.93	64.07	79.7	Best opalescence.
36.48	63.52	80.0	Good opalescence.
39.78	60.22	81.2	No opalescence.
48.45	51.55	84.3	
54.22	45.78	84.7	Maximum temperature.
60.06	39.94	82.2	

Inspection of the data from which Fig. 3 was constructed shows that the critical solution point for phenol

and the specimen of urine examined was 79.7°C., the critical concentration being 36 per cent. phenol and 64 per cent. urine. The critical solution point is by no means at the crest of the curve, 84.7° C., but is recognized by the beauty of the opalescence. The critical solution temperature of the phenol-water mixture determined similarly was 66.5° C. Thus the rise produced by the solids dissolved in the urine was $(79.7 - 66.5) = 13.2^{\circ} \text{C.}$

Fig. 3.—C, Critical solution point; K, crest point, maximum temperature.

The data from which the phenol-water curve (Fig. 1) was constructed are given below (Alexejeff, *Wiedemann's Annalen der Physik*, 1886).

Percentage Phenol.	Percentage Water.	Homogeneous Temperature.
7.12	92.88	1° C.
10.20	89.80	45
15.31	84.69	60
28.55	71.45	67
26.70	63.30	67
48.66	51.14	65
61.15	38.85	53
71.97	28.03	20

A number of other determinations were made as follows, the critical solution temperature only being required, no weighings were wanted.

Dry crystalline phenol (carbolic acid) was placed in a test tube to the depth of about 1 cm., and slightly more than enough urine to cover it was run in from a pipette. The mixture was warmed. If the opalescence appeared the temperature of homogeneity was noted, then a few drops more were added. If after warming and allowing to cool the opalescence was improved the temperature was again taken, the thermometer being in the test tube with its bulb just covered. In this manner we proceed from a too concentrated mixture of phenol to one of the critical concentration without the trouble of weighing quantities. By alternate warming and slow cooling the critical temperature may be accurately measured. These determinations can be very rapidly made, ten minutes sufficing for each. The rapidity depends on how nearly the critical concentration has been hit off at the first trial.

The freezing point of each sample was also found by the usual method, and against the depression Δ the rise in the critical solution temperature, R_c , has been tabulated. A third column gives the ratio $\frac{R_c}{\Delta}$.

Rc.	Δ.	$\frac{Rc.}{\Delta}$
3.2° C.	0.33° C.	9.70
4.7°	0.44°	10.70
7.6°	0.87°	8.74
7.7°	0.98°	7.86
9.4°	1.07°	8.78
11.3°	1.47°	7.68
11.9°	1.63°	7.28
12.5°	1.73°	7.21
16.3°	1.85°	8.80
*15.9°	1.87°	8.71
17.4°	2.48°	7.00
Mean of the last nine...	—	8.00

* A very highly-coloured specimen.

From this comparison it is seen that there is a great similarity between the rise of the critical solution point and the depression of freezing point. The ratio $\frac{Rc.}{\Delta}$ is nearly constant, having a mean value $\frac{Rc.}{\Delta} = 8$. With very dilute urines, namely those of low depression, the ratio has a slightly higher value, while with very concentrated specimens the ratio is slightly less than the average.

Having established this similarity, a number of specimens, many of which were pathological, were examined by both methods. The results are tabulated below:

Nature of Specimen.	Rc.	Δ.	$\frac{Rc.}{\Delta}$
Normal	9.7	1.07	9.06
" " " " " " " "	12.5	1.47	8.50
" " " " " " " "	14.0	1.71	8.19
" " " " " " " "	15.0	1.79	8.38
" " " " " " " "	15.5	1.87	8.28
" " " " " " " "	15.3	1.92	7.96
Mean	—	—	8.41
Chronic parenchymatous nephritis:			
Albumen present	9.3	1.12	8.30
Albumen precipitated by boiling	9.3	1.04	8.94
Specific gravity 1010	7.0	0.70	10.00
Alkaline, much albumen	11.0	1.27	8.66
—	16.0	1.87	8.55
From a right kidney, by catheterization...	4.5	0.47	9.58
" left " " " " " "	7.0	0.73	9.58
M. R., both kidneys, morning; no food since previous evening	5.5	0.63	8.73
M. R., 1 p. m., nothing but water since previous evening; from right kidney by catheterization; albumen present	2.5	0.24	10.42
Left kidney; no albumen	3.0	0.30	10.00
Glucose present 1.87 per cent.	8.0	1.17	6.84
" " 5.62 " " " " " "	10.0	1.56	6.41
" " " " " " " "	11.0	1.75	6.30
" " 0.19 per cent.	15.3	1.94	7.88
" " 2.34 " " " " " "	16.0	2.03	7.88
" " 3.33 " " " " " "	16.5	2.27	7.56
Mean of glucose specimens	—	—	7.14

These results make it clear that the determination of the critical solution point rise is a reliable method for getting a measure of the functional activity of a kidney. The presence of a considerable quantity of glucose gives results which are slightly lower than would be expected from the freezing-point values, the ratio $\frac{Rc.}{\Delta}$ being nearer

7 than 8. From inspection of the results the conclusion may be arrived at that a kidney which gives urine producing a critical solution point rise of 8° C. or more is functioning well, as this rise corresponds to a depression of 0.92° C., the value given by v. Koryani, and leaves a margin on the safe side for experimental error. Ordinary values of Rc are between 11° C. and 16° C. The presence of a moderate amount of albumen appears to have little effect, and in the presence of the large quantity of phenol it is not precipitated even by five minutes' boiling.

For the benefit of those who wish to try this method, the following directions are added:

Apparatus and Materials.

A few test-tubes.

A thermometer graduated from 0° to 100° C., or, better, from 50° to 100° C.

A bottle of pure dry crystalline phenol (m. p. 40° C.).

A small pipette.

Some distilled water and urine.

To Determine the Critical Solution Point of Phenol and Water.—Shake out some phenol into a clean dry tube to the depth of 1 cm., roughly. Run in from a pipette enough distilled water to more than completely cover the phenol. Warm the test-tube till the contents become homogeneous. If no opalescence appears on allowing it to cool, add a little more water till an opalescence is got on cooling after warming. Note the temperature at which the white fog, followed by two layers on standing, appears in the homogeneous liquid. Keep on adding a little water till a beautiful opalescence is obtained; the appearance of fog in this mixture must be noted accurately, as this is the real and only reliable critical solution point. By alternately warming up and allowing to cool two or three times this temperature can be accurately ascertained. The further addition of water will be found to mar and finally prevent the appearance of the opalescence. Thus the temperature in which the fog appears in the mixture having the best opalescence may be taken as giving the critical solution point. This is a constant for each bottle of phenol, but, owing to the delicacy of the method, the presence of a slight amount of an impurity produces a considerable alteration in the critical temperature; accordingly it must be determined again for each sample of phenol of new origin.

To Determine the Critical Solution Point of Phenol and Urine.—Proceed exactly as in the case of water, substituting urine for distilled water. The opalescence is most readily seen by looking at the test tube against a black coat-sleeve background. It is most distinct with urines of light colour and low concentration, but can be seen even with strongly-coloured specimens. The urine should be examined without admixture of any substance whatever, phenol excepted, and, if possible, before any precipitate has formed by standing. The difference in the temperatures found, using distilled water and urine, is the rise in critical solution point required.

Fig. 4.—C, Critical solution point; K, crest point, maximum temperature.

Experiments were also made, using isobutyric acid instead of phenol, with water and urine. The curve obtained (Fig. 4) was quite similar to that given by urine and phenol. The freezing point of the specimen of urine employed was — 0.92° C., the critical solution temperature was found to be 31.2° C., giving a rise of 5.2° C. The critical concentration was 42 per cent. isobutyric acid.

The data from which the curve was constructed are given below, but, as the use of isobutyric acid was discontinued, they have no direct bearing on the subject, but afford a further illustration of the method, and serve to show that it is quite general, not resting upon any peculiar property of phenol. From the practical point of view phenol was found to be the most suitable substance.

Percentage by Weight Isobutyric Acid.	Percentage Urine.	Homogeneous Temperature.	Notes.
23.44	76.56	25° C.	
31.75	68.25	28.7°	
41.43	58.57	31.1°	Slight opalescence.
42.15	57.85	31.2°	Good opalescence.
47.25	52.75	32.2°	No opalescence.
48.19	51.81	32.3°	
48.50	51.50	32.3°	
50.56	49.45	22.7°	Maximum temperature.
56.36	43.64	32.5°	
61.93	38.07	31°	
69.68	30.32	27°	
78.85	21.15	18°	

SUMMARY AND CONCLUSIONS.

The examination of urine by the critical solution point method gives a reliable measure of the functional activity of the kidney producing it, and may be employed in all cases where cryoscopy can be.

The difficulty of obtaining a clear solution with blood or blood serum has so far prevented the application of this method to their examination. The rise in critical solution point should not be less than 8° C. for the urine from a healthy kidney; ordinarily the rise is from 11° to 16° C. Each determination can be made in ten minutes, without weighing and without any special or costly apparatus.

Only a small quantity of urine is required, not more than 5 c.cm. for each determination; when specimens have to be collected by catheterization of the ureters this is a saving of time and occasions less inconvenience.

I have to thank Dr. J. Timmermans (Brussels) for placing his extensive knowledge of critical solution point determinations entirely at my disposal, for much assistance in the experimental work, and for carefully revising this paper. My thanks are also due to Professor S. Young and Professor E. A. Werner for valuable advice, and to the Clinical Research Association, Dr. T. Gelston Atkins and Dr. Moorhead for supplying specimens.

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MEMORANDA:

MEDICAL, SURGICAL, OBSTETRICAL.

NOTE ON THE BARNESLEY DISASTER, 1908.

THIS sad accident, whereby some 16 children lost their lives by suffocation due to forcible compression of the chest, presents some features in common with the one at Sunderland in 1883, when nearly 200 lost their lives.

In the present instance a large number of children were endeavouring to force their way into the gallery of the Public Hall to witness a cinematographic entertainment. On the gallery being completely filled the children on the stairs were turned back by the attendant, and told to make their way to other parts of the house. A stampede then occurred on the stairs, several of the little ones fell, and others fell upon them, the whole being kept from regaining their footing by the pressure of the children behind. Before they could be extricated 14 children, of an average age of 6 years, lost their lives, and 2 more died very shortly afterwards in hospital. Those who recovered seemed to have sustained surprisingly little injury. Out of the 16 killed and 17 slightly injured attended at the Beckett Hospital, only 1 sustained a fracture (fractured humerus). This, of course, may be

accounted for by the greater flexibility of children's bones, especially the ribs.

The children, seen immediately after death, presented practically the same features as described by Dr. Lambert in 1883 in his report on the disaster at Sunderland.¹ In varying degree their faces were congested and puffy, the vessels of the neck much swollen, the eyelids closed, eyeballs protruding, pupils widely dilated, and froth surrounding the mouth and nostrils. In nearly all the cases urine had been voided, and in a few cases faeces expelled.

By order of the coroner, a careful and individual examination of the whole of the bodies was made twenty-four hours after death, and in the case of two bodies *post-mortem* examinations were made by us. Rigor mortis (probably influenced by the cold) and *post-mortem* staining were well-marked in all cases. With one or two exceptions the countenance was placid as if in sleep, the eyeballs were not protruding, nor the pupils widely dilated. In 3 cases the face was markedly congested, the remainder varying from slight frontal suffusion to slight general congestion. The ears in all cases were much darker and the necks more swollen than is usually seen after death. Bruising was general but not extensive in area, being more marked on the face and lower limbs, slight abrasions being seen in a few cases. There was a total absence of fractures and wounds as disclosed by external examination. In one case in which a *post-mortem* examination was made there was a trace of blood in the left ear, but no fracture of the skull was found. In 9 cases the tongue was not protruded, in 6 but slightly, and in one case well protruded. In 12 of the cases there was well-marked oedema over the front of the chest, and in 2 of these it extended over the abdomen and thighs.

The two *post-mortem* examinations presented practically the same features. Two of the most markedly congested cases were selected with a view to getting more definite results. The following are the brief particulars:

Head.—Coverings, meninges, surface, and substance of brain congested but healthy.

Chest.—No fractured ribs. Lungs congested and air passages clear. Heart: Right side contained a small quantity of dark fluid blood.

Abdomen.—Liver and kidneys, slight congestion; intestines pale; spleen not congested but pale.

It is to be noted that there were no haemorrhages in either case on the lungs or heart, as is often found in cases of death by suffocation.

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THE HOUR OF DEATH.

WHEN Resident Medical Officer at Walton Workhouse, Liverpool, I tabulated the hour of death in 2,033 cases. The times were taken from the death notices sent to relatives and friends, and their totals are shown in the following table:

In the hour ending—	In the hour ending—
1 a.m. ... 50	1 p.m. ... 94
2 " ... 74	2 " ... 77
3 " ... 76	3 " ... 79
Three hours' total ... 242	Three hours' total ... 250
4 a.m. ... 83	4 p.m. ... 91
5 " ... 76	5 " ... 78
6 " ... 90	6 " ... 100
Three hours' total ... 249	Three hours' total ... 279
7 a.m. ... 85	7 p.m. ... 89
8 " ... 85	8 " ... 84
9 " ... 98	9 " ... 79
Three hours' total ... 268	Three hours' total ... 252
10 a.m. ... 79	10 p.m. ... 86
11 " ... 85	11 " ... 83
12 " ... 83	12 " ... 71
Three hours' total ... 253	Three hours' total ... 240
Total: First 12 hours ... 1022	Total: Second 12 hours ... 1011

It will be noticed that the greatest number which occurred in any hour was between 5 and 6 p.m., or the hour following the time that Dr. H. D. Marsh found to be the hour of greatest efficiency and also that of frequency of death.

Large numbers of cases are necessary to allow of a definite conclusion being reached in this question. The

¹ BRITISH MEDICAL JOURNAL, vol. i, 1883.