XV. The thermal properties of isopentane compared with those of normal pentane

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the effect of moving electrified bodies still unanswered, at least satisfactorily ; for example, the motion of a dielectric in a uniform field ; also the reverse of the above experiment. These problems are also to be attacked.

It is a source of great satisfaction to me that the above investigation was practically completed before the death of Prof. Rowland. His advice and criticism throughout the work were invaluable.

To Prof. Ames also I am indebted for much valuable advice. I also take this opportunity of thanking Mr. N. E. Gilbert for his valuable assistance in the early part of the work, and Messrs. J. T. Barrett and Jas. Barnes for their help in taking the final readings.

Physical Laboratory,
Johns Hopkins University,
June 10, 1901.

XV. *The Thermal Properties of Isopentane compared with those of Normal Pentane.* By J. ROSE-INNES, M.A., B.Sc., and SYDNEY YOUNG, D.Sc., F.R.S.*

[Plate IV.]

IN a paper read before the Physical Society in December 1898, attention was drawn to the great interest attaching to the comparison of the isothermals of two isomeric substances (Phil. Mag. xlvii. p. 366). An experimental investigation of the relations between the temperatures, pressures, and volumes of isopentane had been carried out by one of us some time previously ; and in the paper above referred to the results of a similar investigation into the thermal properties of normal pentane were given. A preliminary comparison was instituted between the thermal data belonging to the two substances respectively, and the conclusions provisionally arrived at were stated (*loc. cit.* pp. 366-367). We have since undertaken a more exhaustive examination of the experimental results, and the conclusions now reached form the subject of our present paper.

If we could treat normal pentane and isopentane as perfect gases, we should be able to write $p v = RT$, where all the letters have their usual signification. In practice it is found that $p v$ changes as p diminishes along any isothermal, in such a way that the limiting value of $p v$ for $p = 0$ is equal to RT ; but any actual value of $p v$ lies below RT within the limits of temperature of the experiments. The quantity $RT - p v$, which

* Communicated by the Physical Society : read May 10, 1901.

should be zero if Boyle's law were correct, may be considered as measuring the error of Boyle's law, and we may term it "the departure from Boyle's law" for the particular volume and temperature in question. It then appears that the departure from Boyle's law in the case of isopentane bears a constant ratio to the departure for normal pentane at the same volume and temperature*. This simple law is found to yield numerical results so nearly in accordance with the experimental facts that the error incurred by assuming the law as entirely correct is comparable with the errors of experiment.

We will next proceed to describe our method of testing the law. Take any volume and temperature, v and T say; and let p_n and p_i denote the pressures of normal pentane and of isopentane respectively at the said volume and temperature. Then the departure from Boyle's law for normal pentane is $RT - p_nv$, while the departure from Boyle's law for isopentane is $RT - p_iv$. The proposed law tells us that

$$\frac{RT - p_iv}{RT - p_nv} = \text{a constant} \\ = \lambda, \text{ say.}$$

Hence we easily obtain

$$p_iv = \lambda p_nv + (1 - \lambda)RT.$$

By examining the experimental data in the neighbourhood of the critical point of normal pentane, it was concluded that λ might conveniently be put equal to .9463. By the last formula it was then possible to calculate p_iv for any volume and temperature whenever p_nv for the same volume and temperature was known. In this way a large number of values of p_iv were found for the isothermals 280°C. , 240°C. , 200°C. , 160°C. , 120°C. These were plotted in a diagram against $v^{-\frac{1}{3}}$, and the dots so drawn distinguished by means of a cross. The values of p_iv found by direct experiment for the same temperatures were also plotted against $v^{-\frac{1}{3}}$, and the resulting dots distinguished by means of a small circle. As both sets of dots were very numerous, and occurred at small intervals of $v^{-\frac{1}{3}}$, we were well able to judge by the eye whether the curve determined by the one set might be considered as

* The connexion between chemical problems and the departure from Boyle's law has also been investigated by M. Daniel Berthelot. (See *Comptes Rendus*, 1898, cxxvi. pp. 954, 1030, & 1415.) His immediate object, however, was different from ours. He confined himself to studying how the departures from Boyle's law might be allowed for in deducing the true molecular weights of substances by physical methods; and he nowhere pays special attention to isomeric bodies.

coinciding with the curve determined by the second set. The diagram is reproduced on Pl. IV. Only the volumes above 3.4 were taken into consideration, for reasons stated in our former paper (*loc. cit.* p. 364).

It will be seen that on the whole the two sets of dots agree very well. In places, however, there is a discrepancy between the two sets: *e.g.*, at small volumes on the isothermal of 240° C. the calculated values of p_v differ from the experimental values by slightly over 1 per cent. This error is partly to be accounted for by our not having chosen the most suitable value of λ ; by choosing a rather smaller value we could easily diminish the error spoken of. But we cannot diminish the error indefinitely in this way, since we are hampered by the condition that we must not introduce more serious error into fresh places by our changes in λ . Hence there will necessarily be some small outstanding differences between the two sets of dots whatever value of λ be chosen. We have not thought it worth while to draw a fresh diagram with a more suitable value of λ , as a slight correction in the diagram corresponding to a slight change in λ is easily allowed for by the eye.

As to whether the outstanding differences referred to above indicate the necessity for a correction in the law we have proposed, or whether they can be considered as due to errors of experiment, we are unable to decide with any confidence at present. But it seems certain that by far the greatest part of the difference in the behaviour of normal pentane and of isopentane can be attributed to the action of the law we have mentioned. We are therefore confirmed in the conclusion stated by us in a former paper "that the difference of pressure between two isomeric substances at the same temperature and volume involves the same power of the density as the first deviation from Boyle's law, *i.e.* the second power" (*Phil. Mag.* xlviii. p. 214).

XVI. *Dependence of the Current through Conducting Gases on the Direction of the Electric Field.* By E. RUTHERFORD, M.A., Macdonald Professor of Physics, McGill University, Montreal*.

IN the conduction of gases under the influence of Röntgen and Becquerel rays, it has generally been considered that the magnitude of the current between the electrodes is independent of the direction of the electric field, except in

* Communicated by Prof. J. J. Thomson.