gas-current in question is such as not to give rise to capricious modifications of the temperature of the experimental space; *f*) the heat-capacity of the walls of the experimental space is sufficient to efface the rapidly alternating deviations from the mean value of the temperature of the gas-current in question, which are due to the changes in the heat-development in the heating-wire, the consequence being that the walls only follow the changes of the mean value; *g*) the gas in the experimental space owing to its low temperature has a very much higher heat-capacity than under normal circumstances and finally *h*) the gas-current emerging from the heat-exchange tube in the experimental chamber keeps the gas in continual motion [1]) along the walls and the apparatus.

In the experiments which have been made with the cryostat so far, it was noticed that capricious disturbances from time to time interrupted the periods of constant temperature [2]). But when the measurements were continued for a long time, generally periods of more than half an hour or longer were repeatedly found in which the temperature of the experimental apparatus and thermometers remained constant to .01 of a degree, whereas these periods are preceded by even longer ones during which the temperature did not vary by more than .02 of a degree, so that the measuring apparatus during this time were able to assume the desired temperature with very near approximation.

Physics. — "*Isothermals of mon-atomic substances and their binary mixtures.* XVIII. *A preliminary determination of the critical point of neon.*" By H. KAMERLINGH ONNES, C. A. CROMMELIN and P. G. CATH. (Communication N°. 151 *b* from the Physical Laboratory at Leiden).

(Communicated in the meeting of June 24, 1916).

1. *Introduction.* The chief reason why the critical data of neon are not known yet with any degree of accuracy — notwithstanding their great importance for the comparison of its thermal properties with those of other, especially monatomic substances — is doubtlessly the fact, that so far it had been impossible to obtain temperatures

[1]) In cryostats with baths of liquefied gas strong stirring is necessary on other grounds.

[2]) Each time after a fresh adjustment of temperature it is necessary to wait some time for the experimental space and the measuring apparatus to arrive at the new temperature.

in the neighbourhood of 45° K. sufficiently constant to make reliable measurements of the critical temperature. Since in the hydrogen-vapour cryostat [1]) we have obtained an apparatus by which it is possible to govern the temperatures in the range between the melting point of oxygen and the boiling point of hydrogen, this difficulty has disappeared and we could now attempt the long-desired determination of the critical condition of neon with every chance of success. The reason why our results must still be looked upon as preliminary ones is not due to a want of constancy in the temperature of observation or to other defects in the method adopted, but to the fact that the neon on which we have experimented was not absolutely pure. Small as the admixtures were, their influence showed itself very clearly in a gradual increase of pressure during condensation. [2]) The difference between initial and final pressures in the vapour-pressure measurements immediately below the critical point amounted to .2 of an atmosphere. [3]) In the determination of the vapour-pressure of hydrogen in the immediate vicinity of the critical point which was carried out with the same apparatus (comp. the next Communication N°. 151*c*) where, on account of the purification of hydrogen by distillation, the purity of the experimental gas was completely guaranteed, differences of that kind did not occur.

If the pressure rises during condensation, the determination of the critical data becomes uncertain. [4]) Our result for the critical temperature may therefore differ from the true value by a few tenths of a degree; a similar uncertainty applies to the critical pressure. The circumstance, that observations on the critical temperature of neon are so far completely lacking and that it will take some time before the more accurate measurements [5]) aimed at will be completed, justify sufficiently the publication of our present results.

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[1]) Comp. the preceding Comm. N°. 151*a*.

[2]) Previous investigations, in the first place by KUENEN (Comm. N°. 8 Meeting of Oct. 1893 and Comm. N°. 11 Meeting of May and June 1894), have sufficiently shown the great influence which even very small admixtures produce on the phenomena in the critical region.

[3]) In the table the pressure at the beginning of condensation is given as the vapour pressure.

[4]) Instead of the critical temperature of the pure substance the experiment gives the plaitpoint temperature of the mixture.

[5]) In these determinations we hope to be able to utilize a visual method by a modification of the hydrogen vapour cryostat (comp. Comm. N°. 151*a*) which will allow us to follow the phenomena inside the experimental chamber by eye.

2. *Apparatus and method.* The measurements were carried out with a vapour-pressure apparatus which will be described in a future paper on the vapour-pressures of neon and hydrogen. The small bulb in which the gas is liquefied is shown at A in fig. 1 of the preceding communication. It is placed in the experimental chamber E of the hydrogen-vapour cryostat half way between bottom and top side by side with a helium-thermometer Th_1 and a resistance-thermometer Ω. The vapour-pressure apparatus is so arranged, that the quantities of gas which were liquefied at a given temperature between the beginning and the end of condensation could be measured.

Using the values obtained in that manner at different temperatures in the neighbourhood of the critical temperature it was possible in connection with temperature and pressure by means of an extrapolation over a small range to derive the critical temperature and pressure within the limits of accuracy given above.

The value to be ascribed to the critical pressure can be checked by means of the pressure at the point of inflexion of an isothermal immediately above the critical temperature, which was determined specially for this purpose.

The manner in which the extrapolation was carried out will be elucidated by means of a diagram in the next communication dealing with the critical point of hydrogen.

We mention in this connection that owing to the impurity of the neon referred to, small though it was, the heterogeneous isothermals in a pressure-density diagram did not run exactly parallel to the density-axis, whereas they did with hydrogen.

Owing to these pressure-differences along the heterogeneous isothermal it was more difficult than in the case of hydrogen to arrive at an exact calculation of the critical constants.

As regards the preparation of neon it may be mentioned that the impure gas forming our stock was first freed from hydrogen after the addition of oxygen by explosion, it was then frozen a number of times at the air pump and ultimately repeatedly distilled over carbon cooled in liquid air. Although often repeated and carefully carried out these operations have evidently not been sufficient to free the neon completely from admixtures.

The pressure measurements were made by the aid of the closed hydrogen-manometer M_{60} which has been often mentioned in previous communications of this series (see for instance Comm. N°. 146c). The temperatures were measured with the constant-volume helium gas-thermometer Th_1 referred to above; the bulb had a volume of 110 cc., the "waste space" was .7 % of the volume of the bulb;

the zero-point pressure was 1000 mm. and the temperatures were calculated using .0036614 as the pressure-coefficient. For the calculation of the temperatures we may refer to a previous communication [1]).

3. *Results.*

The results of our observations are contained in the following table:

T	θ	$p_{coëx}$ (intern. atm.)	quantity of gas (cc)
43°.83 K	—229°.26 C	24.305	670
44°.43	—228°.66	26.049	416

Above t_k the following point was established:

T	θ	p (intern. atm.)
44°.94 K	—228°.15 C	27.462

From these data we have derived:

Critical constants		
T_k	θ_k	p_k
44°.74 K	—228°.35 C	26.86

We are glad to record our thanks to Mr. J. M. BURGERS phil. cand., assistant in the Physical Laboratory, for his assistance in checking the automatic temperature-regulation during the experiments by means of the resistance-thermometer Ω and the thermometers θ_1 and θ_2 (cf. fig. 1 of the previous communication).

4. *Discussion.*

In a previous communication [2]) two of us had drawn some preliminary conclusions as to the critical temperature of neon from

[1]) H. KAMERLINGH ONNES and G. HOLST, Proc. XVII, 1, p. 501. Comm. N°. 141*a*.
[2]) H. KAMERLINGH ONNES and C. A. CROMMELIN, Proc. XVIII, p. 515. Comm. N°. 147*d*.

a comparison of the net of isothermals of neon with that of argon.

The values then found by a comparison with argon viz. — 228°.2 C. and — 227°.9 C. were, however, obtained using the result of a somewhat rough determination of the critical pressure of neon, viz. 29 atm. [1]). Repeating these calculations utilising the value now found for the critical pressure, the results come out a little lower, namely —228°.9 C and —228.°6 C, which values appear to agree very satisfactorily with the experimental value. Our supposition expressed at the time, which was rendered probable by the course of the vapour-pressures in connection with that of the isothermals, that argon and neon, looked upon from the point of view of the law of corresponding states, differed but little from each other, is thereby confirmed in a very satisfactory manner.

The estimate of the critical temperature of neon obtained at the time by a comparison with hydrogen (—231°.2 C) deviated much more from the observed value. In this comparison use was made, however, of the critical temperature of hydrogen, as determined by BULLE [2]), —241°.14 C and, moreover, of our rough determination of the critical pressure of neon above referred to: these values have now to be replaced by those found by ourselves (for hydrogen as will be shown in Comm. N°. 151*c* we have found $T_k = 33°.18$ K, $\theta_k = -239°.91$ C, $p_k = 12.80$ atm.).

The calculation when corrected in this way gives — 230°.2 C for the critical temperature of neon, a value which deviates much less from the result of direct experiment than before.

Physics. — "*The viscosity of liquefied gases.* VI. *Observations on the torsional oscillatory movement of a sphere in a viscous liquid with finite angles of deviation and application of the results obtained to the determination of viscosities.*" By J. E. VERSCHAFFELT. (Communication N°. 151*d* from the Physical Laboratory at Leiden). (Communicated by Prof. H. KAMERLINGH ONNES).

(Communicated in the meeting of February 24, 1917).

1. In a previous communication [3]) the theory of the oscillatory rotation of a sphere in a viscous liquid was developed on the supposition of the rotation taking place with such small angular velocities,

[1]) H. KAMERLINGH ONNES, Proc. XII, 1, p. 175. Comm. N°. 112.

[2]) F. BULLE, Phys. Zeitschr. 14, p. 860. 1913.

[3]) Comm. N°. 148*b*. Proc. XVIII 2. p. 840.