their symmetry, and at least in conformity with each other, with rational proportions of their linear distances; and they must also remain so, if their aggregation shall be crystallographically a possible one. For that reason the changes in symmetry of one of these space-lattices, must be connected with the same changes in the other ones; it can hardly be hazardous, to conclude from the changes in the Röntgenogram of one of them, with regard to the changes of the other space-lattices. Besides it will seem somewhat improbable with respect to the relatively slight change in molecular arrangement, that at the same time no further change should accompany it, which takes place within the domain of the composing molecules themselves. For the birefringence is, even just a little below the inversion-temperature, again very strong, but disappears at 266° C. quite suddenly. It is difficult to believe, that so great a change could only be attributed to the apparently not very great change in the molecular arrangement. The conception, that the optical properties partly, if not greatly, must be caused by the anisotropy of the composing molecules themselves, more than by the structure of their molecular aggregation, is often defended, just because it is able to give a clear idea of the nature of optically-anomalous crystals. It is true, our experiments have once more proved, that doubtlessly the influence of the molecular arrangement is present; but perhaps it is in this direction of research, that the cases are to be found, which will allow a definitive conclusion with respect to the one or the other of those views.

Experiments with *leucite*, in which the difficulties will be even greater, because of the higher inversion-temperature and the much slower transformation, are at present being made in our laboratories.

Groningen, January 1914.

Mineralogy. — *"On temperature-measurements of anisotropous bodies by means of radiation-pyrometers."* By Prof. Dr. F. M. JAEGER and Dr. ANT. ŠIMEK. (Communicated by Prof. HAGA).

(Communicated in the meeting of January 31, 1914).

§ 1. In the study of the optical behaviour of white-hot silicates, it accidentally happens that the temperature of the investigated objects is measured by means of the now generally used radiation-pyrometers of WANNER or of HOLBORN—KURLBAUM.

The temperature of the body, as determined in this way, generally cannot coincide with its real temperature; for the mentioned pyrometers will indicate only that temperature, which an absolutely black body should possess, to show the same emission, that really is observed by means of the pyrometer. Just because different objects differ from the absolutely black state in an unequal degree, they will seem to possess different radiation-temperatures, when heated to the same temperature of t° C.

If the radiating object, as in the case of birefringent crystals, is anisotropous with respect to its absorption for radiant energy, it must be also anisotropous with respect to its emission, in accordance with KIRCHHOFF's fundamental law. Such a radiant anisotropous body will behave therefore as if it had different temperatures in different directions of vibration; its apparent radiation-temperature will not be the same for different vibration-directions of its emitted radiation.

§ 2. Although this conclusion from KIRCHHOFF's law of radiation, has been tested already occasionally by means of experiment[1]), — as we learned however just after this investigation was finished, — all those experiments were made at a time, when the construction of radiationpyrometers, founded on the law of KIRCHHOFF, and on those of WIEN and PLANCK formulated since that date, had not yet taken place: We thought it interesting, to demonstrate the said phenomenon once more by means of a radiationpyrometer, as it is used now in a very perfectly develloped form in all laboratories for high temperature work, and thus to show at the same time again the validity of KIRCHHOFF's law, in qualitative respects, by means of a striking experiment.

§ 3. Our experiments were made in the following way.

From a crystal of dark green turmaline of *Brasil,* two small flat cylinders of about 1 mm. thickness were prepared; one of them had its axis parallel to the crystallographical axis of the trigonal mineral, the other one perpendicular to it. The form of a cylinder was chosen,

1) KIRCHHOFF himself (Pogg. Ann. **109**, 299. (1860)), has already drawn this conclusion from his theory, and tried to demonstrate it by experimenting with a heated turmaline crystal. The same experiment was repeated later on by BALFOUR STEWART (Phil. Mag. (4). **2**, 391. (1861)). Although both experiments can be considered as proving the fact, they are not adapted to make a strong impression. In 1902 however the law of KIRCHHOFF for this case was demonstrated in a convincing and quantitative manner by PFLÜGER (Ann. d. Physik (4). **7**, 106 (1902)), who measured by means of a spectrophotometer, as well the difference in absorption for the ordinary and extraordinary lightwaves, as the difference in emission of white-hot turmaline for vibrations in the direction of the crystallographical axis, and for those perpendicular to it.

to make the heat-transport between it and the walls of the furnace as symmetrical as possible. The cylinders, which had a diameter of about 2 or 3 mm., were carefully polished, and they were fixed in the small resistance-furnace B (Fig. 1) by means of a fine platinum-wire, wrapped round their curved surfaces; the furnace was of the type, used in this laboratory for microscopical purposes, and described more in detail by one of us on another occasion [1]).

By means of the fine platinum-wire the small cylinder was fixed just above the junction of the thermoelement E, made of platinum-platinumrhodium, and used in this furnace as the crystalsupport;

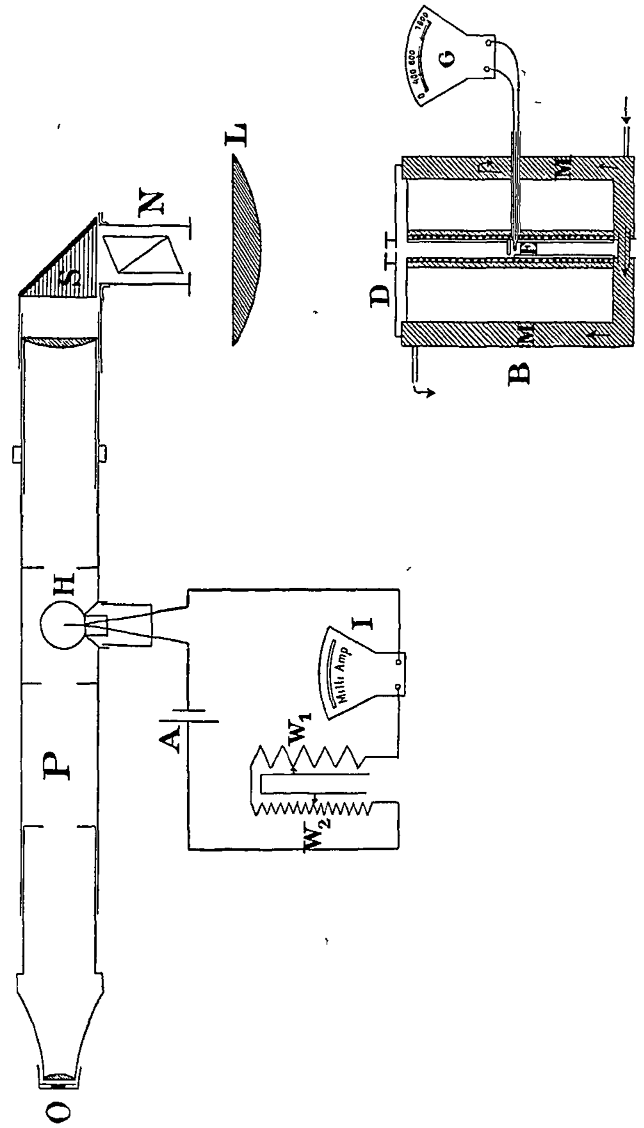

Fig. 1.

[1]) F. M. JAEGER, Eine Anleitung zur Ausführung exakter physiko-chemischer Messungen bei höheren Temperaturen; Groningen (1913), pag. 102, 103.

this thermoelement was connected with a sensitive direct-reading galvanometer G. The furnace had an inside-winding of platinum-wire; it was surrounded by a hollow mantle M, in which continually a stream of cold water was circulating. It was heated with direct current of 220 Volt and 3—5 Ampères; the temperature was regulated by means of a rheostate in such a way, as to be kept constant at will at every height. The cylinder was fixed in such position, that it remained at all sides equidistant from the furnace-walls, and that it was situated in the very short part of the furnace, where no considerable fall of temperature along its axis, could be detected. Above the furnace a movable diaphragm D was present, to make an entrance to the measuring-apparatus possible only for the rays, coming from a very small part of the surface of the glowing cylinder; a plane-convex lense L, arranged above the furnace, allowed to observe a sharp image of every chosen part of the glowing cylinder-surface, by means of the telescope of the radiationpyrometer P.

This pyrometer P was of the Holborn-Kurlbaum-type, which is to be preferred to the about equally accurate pyrometer of Wanner, because of its giving an opportunity to observe the objects themselves in the hot furnace sufficiently well. Before the objective of the pyrometer, a total-reflecting prism (45°) S was fixed, whose hypothenuse-side was heavily coated with silver; it was fixed in an innerly blackened tube, which at the same time bore the rotating Nicol-prism N. This prism N could eventually be removed in an easy way, and, if necessary, be substituted by another prism N', to be fixed this time however at the opposite end of the telescope, before the ocular. The telescope contained the accurately calibrated incandescent-lamp H, which was lighted by the current of two storage-cells A. In the same circuit were present two easily adjustable rheostates W_1 and W_2, and a milliampère-meter I, provided with pointer and scale.

The calibration of the incandescent-lamp H between 600° and 1000° C. gave the following results:

Temperature in ° C.:	Intensity of current in milli-ampères:	Number of milli-ampères, corresponding with a temperature-rise of 1° C.:
600°	318	0.38
700°	356	0.40
800°	396	0.44
900°	440	0.44
1000°	484	

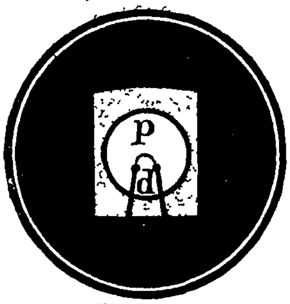

Fig. 2.

For temperatures under 800° C. it makes evidently no difference for the adjustment of the pyrometer, if a monochromatic red glass is placed before the ocular, or not. The way, in which the wire of the incandescent-lamp and the image of the heated cylinder could be observed after the diaphragm D was removed, is visible from fig. 2; the hot crystal there is indicated by p, while d represents the wire of the lamp.

§ 4. In first instance it was tried to find out, in what way this apparatus would show the properties of an isotropous radiator.

For the purpose to be as much as possible in analogous conditions as were present in the study of the expected phenomenon, these experiments were made with a turmaline-cylinder, with its flat end cut perpendicularly to the optical axis of the crystal. It could be proved easily, that this crystalsection, which was investigated at temperatures ranging from 800° to 1000° C. showed in all directions of vibration the same radiation-temperature: on rotating the nicol N, the intensity of the radiation was *the same* at every moment. This observation proves also, that no disturbing polarisation-phenomena were caused by the reflection of the light at the prism S; the observations to be described further-on are thus proved to be quite independent of the presence of this reflecting prism.

The object appeared, after removal of the nicol N, to possess considerably lower temperature, than the thermoelement indicated; the differences between 700° and 800° are about 12°—16° C., between 800° and 900° about 3°—12° C., between 900° and 1000° about 5° C. The indications of the galvanometer are therefore diminished by these amounts, to find the true temperature of the object. Those lower temperatures are probably partially caused by the fact, that the small, but relatively thick cylinder was fixed at some distance above the hot junction of the thermoelement, while a considerable heat-conduction took place along the suspension-wires. The turmaline-plate, cut perpendicularly to the optical axis, got soon opaque at a temperature of 900° or 1000° C.; the cylinder however, which was cut parallel to this axis, remained transparent at 1000° C. for a long time, so that it was possible to see the hot junction of the thermoelement through it, although only very feebly. Finally however also this section got opaque; the investigations with HAIDINGER's dichroscope e.g., are made all with such an opaque cylinder. Because of the very steep temperature-fall in these small furnaces, the parts of the furnace before and behind the radiating object were for the greater part considerably cooler than the turmaline-plate itself.

§ 5. After it was demonstrated in this way, that the chosen apparatus was really suitable, to make accurate temperature-readings. the other cylinder, cut parallel to the crystallographical axis, was fixed into the furnace in quite the same way. By a preliminary optical investigation the direction of maximum light-absorption was fixed, which direction we will discern as R_m. The emitted light is elliptically polarised; the intensity of the radiation for vibrations in the two principal directions could be studied easily by rotating the nicol N.

a) In the field of the telescope, R_m may be in a vertical position. The polarisator had its plane of vibration parallel to R_m; reading at 739° C. : 350 M.A. If the polarisator N is rotated over 90°, the intensity of the current in the incandescent-lamp is only 344 M.A. at 739° C. When the nicol is rotated over 360°, the following readings were made in the four principal situations: 350 M A.; 344 M.A.; 351M.A.; 346 M. A.; finally once more: 351 M. A.

The apparent temperature of the small cylinder with respect to vibrations in the direction of maximum absorption thus seems to be clearly higher for 14° or 15° C., than in a direction perpendicular to the first.

b) Now R_m was in a horizontal position; the plane of vibration of the prism N is vertical. At 751° C. the readings were now: 351M.A., and after N being rotated over 90°, —356 M. A.

c) R_m is replaced as in *a*); the polarisator has its plane of vibration parallel with R_m. Readings: at 756° C., first 358 M.A., and after rotating N over 90°: 352 M. A.

d) R_m is again horizontal. At 815° C. the readings of the milliamperemeter are: 376 M.A. and 381 M.A., according to the plane of vibration of N being perpendicular to, or parallel with R_m.

e) R_m is now in a vertical position. Readings at 826° C. : 388 M.A. and 383 M.A. If the nicol is removed, then the reading is in all directions: 402 M.A.; the apparent increase of temperature is of course explained by the light-absorption of nicol-, and prism-system. Therefore all numbers of M.A., as they are found, need to be augmented with 20 M.A., to get the true radiation-temperatures (Table).

f) The experiments mentioned *d* and *e* were now repeated, with the use of a red, almost monochromatic glass on the ocular. As the same readings were made as before, there seems to be no difference of any appreciable amount between the two modes of observation.

g) If all nicols are removed, as well before as behind the pyrometer, the readings remain the same, if the furnace is turned over some angle by means of the table of the microscope. Once more thus the reflection at the prism S is demonstrated to have no real effect on the results.

h) A nicol N' is adjusted behind the pyrometer, and while R_m has a fixed position, it is turned over 0°, 45°, and 90° respectively. The readings at 850° C. were:

Rotation of N' over:	*Milli-Ampères:*
0°	415
45°	413
90°	409

i). Finally the nicol N was placed again before the pyrometer and of course the other one was removed. At 898° C. the readings were now: 418 M. A. and 410 M. A.; at 963° C in the same way: 441 M.A. and 447 M. A.

We can thus conclude from it:

True temperature of the body in °C:	Readings in M. A. as they would be without the absorption by the nicol:	Radiation-temperatures for vibrations in the two principal directions:	Differences:
	R_m : $\perp R_m$:	R_m : $\perp R_m$:	
739°	370 en 364	735° en 720°	15°
751	376 „ 371	750 „ 737	13
756	378 „ 372	755 „ 740	15
815	401 „ 396	811 „ 800	11
826	408 „ 403	824 „ 816	8
850	415 „ 409	846 „ 831	15
890	435 „ 429	889 „ 875	14
898	438 „ 430	895 „ 878	17
969	467 „ 461	961 „ 948	13
			Mean: 13°.5 C.

§ 6. It needs to be remarked, that from the individual differences in sensitiveness of the human eye, evidently there result greater or smaller values, than those given in column 4, if different observers try to determine at the same time the apparent temperature-differences between R_m and the direction perpendicular to it. So one of us always found somewhat *greater* values, than the mean value of column 4. But the difference itself as a real phenomenon remains without any doubt.

§ 7. Finally we made also an experiment, in which the apparent colder and hotter parts of the turmaline made the impression of being in immediate contact with each other, and therefore could be compared immediately, so that the phenomenon gets in this way exceedingly striking.

The furnace was now fixed in a horizontal position, with its central axis in the direction of the optical axis of the telescope, the total reflecting prism can be removed in this case. Before the objective of the pyrometer, instead of the nicol N, a HAIDINGER dichroscope-ocular was adjusted in such a way, that two images, an ordinary and an extraordinary one, of a small part of the crystal-surface, were obtained, the object made therefore the impression of being divided into two halves.

If all the circumstances of the experiment, e g. the reversing effect of the telescope, etc, were considered, it could be demonstrated, that in the upper field only light was transmitted with a horizontal vibration-plane, in the lower one only that with a vertical plane of vibration, the last appeared to be the light of the extraordinary waves. In the fig. 3 these vibration-directions are indicated by the shadowing of the fields.

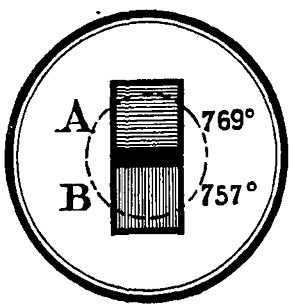

Fig. 3.

The temperature-measurements in both images, — which could be performed in an easy way, because the image of the lampwire, on moving the eye before the ocular, was seen by paralaxis now in the upper, now in the lower field, — demonstrated, that at 769° C. the lower field appeared to have a radiationtemperature of 757° C., the upper one however of 769° C. In concordance with the well-known fact, that a turmaline-plate, if parallel with the crystallographical axis, principally transmits only the light of the extraordinary waves, which are vibrating *in* the principal optical section of the crystal, — thus the direction of the horizontal vibrations (i.e. of the ordinary waves), is at the same time the direction of maximum light-absorption.

As the field A corresponds thus with that direction of vibration, wherein the maximum absorption of the radiant energy takes place, so the apparent temperature must also seem higher in that field, — quite in accordance with the law of KIRCHHOFF.

Groningen. *Laboratory for Inorganic and Physical Chemistry of the University.*

Chemistry. — *"Allotropy and electromotive Equilibrium."* By Prof. ERNST COHEN.

(Communicated in the meeting of January 31, 1914).

In the address on allotropy which I delivered on May 16th 1904 at the opening of the VAN 'T HOFF-Laboratory at Utrecht (this adress has been published as a pamphlet and also in the "Chemisch Weekblad" [1])) I called the attention of my audience to the importance of a systematic study of this phenomenon. I also gave an outline of the way to be followed in continuing the researches I had carried out with my collaborators in this direction since the year 1899.

Since that time Mr. SMITS at Amsterdam has also chosen allotropy as a field of work. Into that matter I shall not enter further at present.

However attention may be called to the form which characterizes Mr. A. SMITS' publications and which may give rise to a misunderstanding.

This is strikingly shown in his paper in these Proceedings Vol. 16, p. 708 (meeting of Dec. 27, 1913) where he says.

"In connection with the foregoing it is desirable to draw attention to this that according to these considerations *the contact with the solution of a salt of the metal must have an accelerating influence on the setting in of the internal equilibrium of the metal.*"

Mr. A. SMITS has written these words in italics; he has however forgotten to mention in the text or in a footnote that this fact was discovered and published 15 years ago by ERNST COHEN and C. VAN EYK in their researches on the allotropy of tin [2]).

Moreover he forgets to point out that an explanation of this

1) Chem. Weekbl. 1, 481 (1903/04).

2) Zeitschr. f. physik. Chem. 30, 601 (1899).