an entirely different standpoint, arrived at exactly the same conclusion. They recognised two gases, one represented by D^3, the other by 667, and further they showed that the lines might be arranged into six similar and beautifully rhythmic series, a principal and first and second series for each gas. These are indicated in the diagram of Bellatrix on p. 345, and in Fig. 14; He = helium is the gas which contains D^3, the other gas I so far call "gas X."[1]

This result is, however, more important from the chemical than from the astronomical point of view *at present*.

A word in conclusion referring to the occurrence of this gas in terrestrial minerals.

We are brought face to face with one question, which ought to influence many lines of work for many years to come. I have already suggested to you that we really now can talk with something like certainty and definiteness about hot stars and cooler stars, and that in the hottest stars we know of, the atmospheres of those stars consist almost entirely of hydrogen and helium.

But see what a little trace of helium we have in this small planet of ours, which undoubtedly was once a sun, which undoubtedly once had an atmosphere just as glorious in its hydrogen and its helium as any of the other stars are now glorious.

What has become of that helium? This question will have to be very carefully considered in the next few years.

We appear to be in presence of the *vera causa*, not of two or three, but of many of the lines which so far have been classed as "unknown" by students both of solar and stellar chemistry, and we are also apparently in the presence of a new order of gases of the highest importance to celestial chemistry, though perhaps they may be of small practical value to chemists, because their compounds and associated elements are for the most part hidden deep in the earth's interior. Why do I suggest a *new* order of gases? Look at the facts.

All the old terrestrial gases, with the exception of hydrogen, are spectroscopically invisible in the sun and stars—though they doubtless exist there—and these new gases, scarcely yet glimpsed, have already supplied us with many points of contact between our own planet and the hottest part of our central luminary that we can get at, and stars like Bellatrix.

The work certainly is full of hope for the future, not only in relation to the possibility of more closely correlating celestial and terrestrial phenomena, but since it indicates that terrestrial chemistry, founded on low density surface products in which non-solar gases largely enter, is capable of almost infinite expansion when the actions and reactions of the new order of gases, almost, it may be said, of paramount importance in certain stages of stellar evolution, shall have been completely studied.

I have some other results to refer to, but it is quite sufficient, I think, to leave my story as I have told it to you without going back on any of the characters, or without dealing in any greater detail with the *dénouement* of the plot.

[1] In the many comparisons I had to make, I soon found the inconvenience of not having a name for the gas which gave 667, 501, and other lines. When, therefore, Profs. Runge and Paschen, who had endorsed my results, and had extended them, called upon me, I thought it right to suggest to them that, sinking the priority of my own results, we should all three combine in suggesting a name. Prof. Runge (under date October 20) wrote me, "the inference that there are two gases is a spectroscopical one, being based on the investigation of the 'series.' Now, though we think this basis quite sound, we must own that the conclusion rests on induction. . . . For this reason we do not want to give a name to 'gas X.'" I have so far suggested no name, though Orionium and Asterium have been in my mind.

But the story has a moral. The more we can study the different branches of science in their relation to each other, the better for the progress of all the sciences. Another point is, that in the study of nature we behave in a very foolish way if we think there is anything unimportant which comes under our eyes. *If it had so happened* that Dr. Hillebrand had seen the line spectrum of nitrogen in 1888, we should have saved all these seven years of waiting for this terrestrial source of helium; and I may add, further, that argon would have been discovered as well in the first hour's work. In science, results of the first importance depend upon the minute examination of so-called residual phenomena; it is too much the general tendency, of scientific work on a large scale, to think too much of those results which may have a practical importance.

Geologists, natural philosophers generally, have been familiar with the mineral world for a considerable number of years. What have they been doing all the time? They have confined their attention too exclusively to the contained metals, and have neglected the gases; whereas it now seems that if they had been less careful of the metals, and had studied the gases, it would have been very much better for our nineteenth century knowledge. And that is the moral of my simple story.

J. NORMAN LOCKYER.

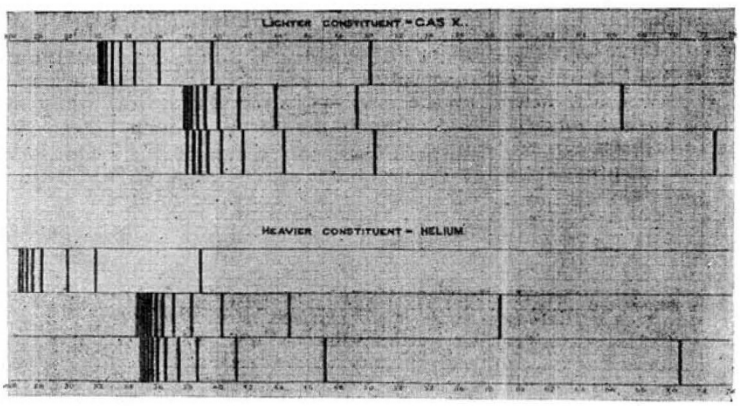

FIG. 14.—Runge and Paschen's results suggesting that cleveite gives off two gases, each with three series of lines.

SCIENCE TEACHING IN SECONDARY SCHOOLS.

THE School Syllabus of Chemistry and Physics, which has just been put forward by a Committee of the Incorporated Association of Headmasters, is an attempt to indicate to those who are dissatisfied with the ordinary course of qualitative analysis, the lines on which the practical study of science may be made more profitable.

It is a great misfortune that in constructing a syllabus for use in schools, one has constantly to keep in mind its relation to the examination fiend. A short notice upon this syllabus, in this journal on Jan. 16 (p. 262), contained the observation that the teaching in schools is governed entirely by the examinations; and nothing could be more sadly true, nor a greater hindrance to a more rational system of teaching.

A syllabus may be perfect of its kind, but school authorities do not ask "How will it develop certain powers?" but "How will it examine?" and they base their estimation of it upon the answer to this question; while the relative value of the two in the eyes of parents

may be judged from the fact that many a parent who grumbles at having to pay £6, £7, or £8 a year for his son's education, willingly pays a 30*s.* or 40*s.* fee for the examination which tests it. As a matter of fact, if £7 be a fair sum to pay annually for a boy's education, an examination at the same rate would be rather overpaid with half-a-crown.

Our whole system of examinations rests upon a wrong basis; it assumes that the value of a boy's education depends upon how much he has learnt, whereas the true criterion is how he has learnt it. The climax of absurdity is reached in those examinations which test the knowledge of a language, as French or German, by the knowledge a pupil has of one specified book; it is true that some of our examining bodies have attempted to meet this difficulty by setting books of an extremely uninteresting character, in order that the pupil's attention, not being able to find interest in the subject-matter, may be solely occupied with the language, but that is a digression.

Those who have taught science in schools have long been dissatisfied with the ordinary course, and have felt the necessity of a change; but the question, "What change?" has hitherto been asked in vain. In answering this question, it is important to bear in mind that we do not want to train boys to be chemists or physicists; that is the part of the technical institute, and a system of instruction which may be excellent for producing trained chemists may be extremely unsuitable for developing the latent powers of children.

The chief principles which it is hoped to introduce by means of this syllabus are as follows.

The insistance at the outset of *measurement* as the chief factor in scientific work, and as the basis of reasoning. It is not too much to say that all scientific reasoning is the outcome of measurement, but measurement has been conspicuously absent hitherto from our school courses, and the balance, which is often stated to be the instrument of precision of chemistry, has never yet had its due place in the chemical teaching. The mental realisation of the value of numbers, and what a theologian would call an "experimental faith" in arithmetic, are important results from this kind of work. The figures in an arithmetic book, however they may profess to deal with concrete substances, represent to a boy's mind only abstract ideas, which, by means of skilful juggling, may be made to produce certain "answers," but the answers convey to him no meaning. A good instance of this is found in his view of decimals; any average boy will tell you that a mistake in the first or second decimal place causes his sum to be wrong, but the misplacement of a decimal point is not worth considering; in practice the former error is a trifle, the latter causes a grotesque absurdity.

Another point of value in the syllabus is that it teaches a boy to perform experiments with a definite purpose, and to suggest experiments himself—to put, in fact, questions to nature. Herein lies its great superiority to qualitative analysis, which, as practised in most schools, is scarcely superior to the setting of puzzles. Any boy who has worked intelligently through this course can scarcely fail to have a much better idea of the problems which natural science has to attack, and of the reasoning which is brought to bear upon them, than one who has obtained a greater amount of knowledge from text-books and lectures.

A valuable lesson which may be learnt from this syllabus is that of writing down in good English prose a systematic account of any experiment done, and of the conclusions to be drawn from it. The lesson, in fact, becomes largely a literary one. The faculty of doing this is extremely rare amongst boys leaving school, because it has hitherto never been cultivated, and the ordinary courses of analysis, whether quantitative or qualitative, rather discourage it than otherwise. Professors who continue our boys' education in higher colleges complain, with reason, of its absence, and, once acquired, it cannot fail to be of great advantage in every walk of life.

A great advantage to which I, as a schoolmaster, can bear witness, is the influence of this teaching upon the other work of the school; it has caused masters who teach other subjects to appreciate the value of teaching practically, and of reducing text-books to a secondary place. No consummation could be more devoutly to be wished especially in view of the present colossal output of worthless text-books, which boil down every difficulty and compress all knowledge into a few pages; and the general value of which is well instanced by the advertisement of a French grammar now before me, which states that several school masters and mistresses have given very successful lessons out of this book, *without any previous knowledge of the language.*

I have omitted some of the more obvious advantages of this syllabus, the importance of a definite connection between lectures and laboratory work, the training in manipulation, and the development of step-by-step reasoning, and I pass on to consider some of the objections which have been urged against this syllabus.

Although there have not been wanting objectors to the syllabus, especially the chemistry part of it, I have found it difficult to induce them to formulate objections definitely; and when they have done so, many of the objections raised appear to me to be positive advantages Amongst these I class the following statements.

That it requires closer attention and more work on the part of the teacher, that it necessitates small classes, that it is unsuitable for examination.

The only objections I have ever heard which appear to me to require answering are the three following:

(1) That many of the experiments are unsuitable for boys; one experiment which has been specially mentioned in this connection, and which, I own, startled me before I tried it, is the production on burning hydrogen of sufficient water to estimate its physical constants. The best answer to this is, "Try it." If a boy can be taught to burn a jet of hydrogen at all, nothing is easier than that he should burn it under a retort kept cool by a stream of water running in at the tubulure and out at the neck; and if eight or ten couples are doing this, it is surprising what a large amount of water can be collected in half an hour. A little experience will enable any teacher to simplify the experiments to the capacity of his class.

(2) That the results of experiments are often so far from accurate as to be worthless. This objection proceeds from an insufficient appreciation of the aims of the work. It is true that a schoolboy will not obtain Stas's numbers, but he will obtain numbers which show a remarkable concordance when the average of all the experiments done by various members of the class are taken, and which will enforce upon his mind the law of definite proportions.

A boy may find that H and O combine in the proportion of 1 : 7·3, that chalk contains 42·8 per cent. of CO_2, or that phosphorus and oxygen combine in the proportion of 100 : 113; but when eight or ten couples have obtained similar figures, the lessons of the definiteness of the reaction, and the importance of careful quantitative work, may be learnt as thoroughly as from more accurate results.

(3) Is it not a waste of time for a boy to laboriously work out a fictitious discovery when he could learn it in five minutes by being told it, or by reading a book? *Yes*, if committing facts to memory be the desired end; but *No*, if the end be to form habits of inquiry and of thought, to understand scientific reasoning, and to prepare the mind for dealing with problems where the text-book is not available.

If I may be allowed to speak of my own experience as a teacher, I have now taught on these principles for some time, and I can positively say that I believe this system

to be infinitely superior to the ordinary method of lecturing on the non-metallic elements and on physics, and setting qualitative analyses as practical work. The only examination of which I had experience lately is the London University Matriculation, which has recently introduced practical questions; my boys have always gone up with confidence, and found these distinctly easy, a matter in which others with whom they compared notes have not agreed with them. I have never had a failure in chemistry.

At the same time, I must insist upon the point that I do not believe that this kind of knowledge can be properly tested by examination; the true criterion of the success of this syllabus must be the opinion of those professors who carry on the scientific education of our boys after they have left us. I have received a large number of letters from various professors, in which they complain bitterly of the present preparation of most of their students, and state that they believe such changes as those contemplated by this syllabus would be of the greatest value. One of these I feel justified in quoting.

"I am a very strong advocate for change in the method of teaching science in schools. The method that usually prevails is, in my opinion, worse than barren. Not only is no satisfactory foundation laid for future teaching, but bad and slovenly habits of mind and manipulation are formed, with the result that a large portion of my work and that of my colleagues consists in the attempt (too often futile) to eradicate these habits."

The syllabus, if it has a fault, is that it is too long for an elementary course. Several of the Committee were of opinion that a course on mechanics, to lead up to the construction and use of a balance, would be sufficient; but it was pointed out that the Science and Art Department would not accept any syllabus which did not include a complete course of statics. This will explain why the syllabus includes an amount of statics out of all proportion to the other subjects; it is a sacrifice to the examination fiend; personally I should leave this work for a more advanced course.

I can, in conclusion, heartily recommend to all science teachers to try this syllabus with their classes of beginners, not following it slavishly, but adopting those points which appeal to their experience.

CHARLES M. STUART.

NOTES.

LORD KELVIN reaches this year his jubilee as Professor of Natural Philosophy in the University of Glasgow. The event will be recognised by a joint celebration, in which the City, University, and students will take part, on June 15 and 16. It is anticipated that delegates and addresses will be sent from numerous home and foreign Universities to express the esteem in which the distinguished investigator is held.

THE date fixed for the next "meeting for discussion" at the Royal Society is April 23, when the subject will be "Colour Photography," and the discussion will be opened by Prof. Lippmann.

THE Bakerian Lecture will be delivered before the Royal Society on the 20th inst., the lecturer for the year being Prof. Roberts-Austen, and the subject, "The Diffusion of Metals." The Croonian Lecture will be given, probably on March 12, by Dr. A. D. Waller, who has chosen for his subject, "Electrical Changes in Isolated Nerve."

THE Odessa correspondent of the *Times* says that the Russian Government will send a special scientific expedition to observe the total eclipse of the sun on August 9. The expedition will be in charge of three astronomers from the Nikolas Observatory at Pulkova, and leaves Odessa in May, by one of the cruisers belonging to the Russian Volunteer Fleet Committee, for Vladivostok, whence it will go near the mouth of the river Amour for observations. The Committee has agreed with the Government to convey the party from Odessa to Vladivostok and back again to Odessa free of charge.

A COMMITTEE was formed in Paris, in December last, to obtain the means for erecting a monument to Pasteur, by international subscriptions. In the furtherance of this resolution a circular has been widely distributed, appealing for funds, and asking for the organisation of local committees, so that the monument in Paris shall be worthy of the man whose labours against disease and death it will commemorate. The French Comité de Patronage includes the President of the Republic, many of the Ministry, and a large number of distinguished scientific men; while the Commission which is organising the memorial is composed of members of the Council of the Pasteur Institute. It is to be hoped that a generous response will be made to the committee's appeal for subscriptions and assistance.

A CIRCULAR has recently been issued to draw the attention of biological professors and lecturers to a course of instruction in Marine Biology which has been organised in connection with the Plymouth Laboratory of the Marine Biological Association. This course, which is intended to be supplementary to the ordinary academical courses in Comparative Anatomy, will be conducted during the forthcoming Easter vacation between March 23 and April 24, and will be superintended by Mr. W. Garstang, Fellow and Lecturer of Lincoln College, Oxford, and formerly naturalist on the staff of the Plymouth Laboratory. England has undoubtedly been behind the times in the lack of any organised arrangements by which biological students could be enabled to enjoy the various advantages which a well-equipped marine laboratory affords for the study of some of the more fascinating aspects of animal life; and it is to be hoped that this new departure in biological education in England will meet with the success and encouragement which it deserves.

JUDGING from a Reuter's telegram, a meteorite which fell at Madrid on Monday produced exceptionally striking effects. Reports of remarkable meteoritic falls are comparatively rare, so we give a fairly full transcription of the telegram:—"At half-past nine this morning an aerolite of considerable size exploded in the atmosphere above Madrid. The phenomenon was accompanied by a vivid glare of blinding light, followed by a loud report, which caused a general panic among the people. All the buildings in the city were shaken, and many windows were smashed by the concussion. The sky was clear and the sun was shining brightly at the time of the explosion, all that was visible in the heavens being a white cloud bordered with red, which was travelling eastward at a great rate, leaving behind it a train of fine, light dust. The panic was general throughout the city. Many shopkeepers closed their establishments. Not only were buildings shaken, but at least one house is known to have collapsed. At the United States Legation a partition wall fell in, and many of the windows were shattered, but no other damage was done to the building. A great many houses throughout the city sustained similar damage, partition walls being shaken down by the force of the explosion. The excitement in the city, and especially in the suburbs, has not yet calmed down. The explosion was heard over a distance of several kilometres from Madrid. At Guadalajara, a town about forty-six miles from the capital, the explosion was very strongly felt." The following official communication has been issued from the Madrid Observatory:—"At 9.29 this morning a strong light was observed proceeding from a small cloud moving from the south-west to the north-east. A minute and a half later a terrific report, followed by several others of less intensity,