at the University of London in 1879 he was nominated C.B.

It is impossible to do justice to Dr. Carpenter's character as a scientific man in a few lines: here no attempt has been made to do more than indicate in something like chronological order and connection of subjects the vast amount of work which he accomplished.

Upon the present writer, whose father was his fellow-student at University College, and who has enjoyed since boyhood the privilege of his friendship, Dr. Carpenter always produced the most vivid impression of a man of indomitable energy, who had accepted as the highest duty and keenest delight of his life, the promotion, whether by advocacy or by research, of true knowledge. The tenacity and vigour with which he was wont to expound his views on such matters of research as at the time occupied his thoughts, and the importance and respect which he assigned to all genuine research, were evidences of an earnest and just nature which evoked sympathy and esteem in all men of kindred pursuits.

In reference to Dr. Carpenter's private life and tastes, the following extract from a weekly contemporary states, with the authority of a member of his own family, what might, in its absence, have been here less completely indicated. The journal to which we are thus indebted is an organ of the Unitarian Church, of which body Dr. Carpenter was, throughout life, an active and orthodox member, a fact which may or may not be brought into connection with the fact of his incomplete acceptance of the leading doctrines of Darwinism, though the latter would by no means necessarily follow from the former.

"He was well versed in literature, and turned for refreshment in hours of weariness to his favourite Scott. Political memoirs of his own time were read with the keenest relish, for he had early learned from his father, Dr. Lant Carpenter, to take a high view of a citizen's obligations, and the Bristol riots, which he had witnessed, made a life-long impression upon him. A brief sojourn in Italy called forth a susceptibility to the enjoyment of art, which was a surprise even to himself; and in music, from the time that he had taught himself as a young man to play on the organ, he found unalloyed recreation. Nature, likewise, in her vaster as well as her microscopic forms, was for him full of charm and delight, and from every excursion he carried back memories which remained singularly vivid and distinct. In society his immense stores of information, his sympathetic interest in others, his thorough enjoyment of humour though he felt unable to originate it, made him a genial and ever-welcome companion, while his friends learned how strong a confidence might be placed in his faithfulness. Many young men found unexpected help and encouragement in him, and he rejoiced when he could open a way to those who were involved in the struggles through which he had himself once passed. The dominant conception of his life—as was fitting in one of Puritan descent—was that of duty. And if this sometimes took austere forms, and led him to frame expectations which others could not always satisfy, an enlarging experience mellowed his judgment and enabled him to apprehend their position from their point as well as his own. Released from the pressure and strain of earlier life, he was able to give freer play to his rich affections; and in his own family they only know what they have lost who will never again on earth feel his support as husband and father, brother, and friend."

E. RAY LANKESTER

WALTER FLIGHT, D.Sc., F.R.S.

THE close of this year has witnessed the termination of another bright and promising life, ended all too soon for the hopes and expectations of his many friends.

Walter Flight was the son of William P. Flight, of

Winchester, in which city he was born on January 21, 1841. He was sent, after a period of pupillage at home, to Queenwood College, Hampshire, in the days when George Edmondson was head master, and Tyndall and Debus were the teachers of science. From Queenwood he went to the University of Halle, where, in the laboratory of Prof. Heintz, he pursued his chemical studies during the winter session of 1863-64. During 1864 and 1865 he entered the University of Heidelberg, where, in the laboratories of the celebrated Profs. Bunsen, Kopp, and Kirchhoff, he applied himself early to acquire that thorough knowledge of the various branches of theoretical and practical chemistry, and that marked facility for overcoming experimental difficulties which characterise the practised and careful worker. From Heidelberg Flight passed to the University of Berlin, where he remained until 1867, studying and working in Prof. Hofmann's laboratory, and for a time filling the office of his Secretary and Chemical Assistant.

Returning to England in 1867, he graduated D.Sc. in the University of London, and in the following year was appointed by the Senate to the office of Assistant Examiner under Prof. Debus (his former teacher at Queenwood). On September 5, 1867, Dr. Flight was appointed an Assistant in the Mineralogical Department of the British Museum. Here, under the direction of Prof. Maskelyne, the Keeper of Mineralogy, he commenced a series of researches into the chemical composition of the mineral constituents of meteorites and the occluded gases they contain. Many of the methods by which he carried out these investigations were originated by him in the course of the research, and displayed in a remarkable degree his skill and ingenuity in chemical manipulation.

He was shortly after this date appointed Examiner in Chemistry and Physics at the Royal Military Academy, Woolwich, and in 1876 Examiner to the Royal Military Academy, Cheltenham.

For several years Dr. Flight served on the Luminous Meteors Committee of the British Association, to which he lent much valuable assistance.

Between the years 1864 and 1883 he was author of twenty-one original papers, including "A Chapter in the History of Meteorites," which appeared in a succession of twenty-three articles in the *Geological Magazine* in 1875, 1882, and 1883. He was also joint author or contributor of results to many other papers, chiefly on the chemical composition of minerals. His important memoir on the Cranbourne, Rowton, and Middlesbrough meteorites was read before the Royal Society in 1882, and he was elected a Fellow in the following year.

In 1884 he was seized by illness which prostrated his mental powers, and rendered it needful for him to resign his appointment in the British Museum in June last, and notwithstanding every care which medical skill or affection of friends could devise, he succumbed on November 4, leaving a wife and three young children to deplore his early loss.

ON RADIATION OF HEAT FROM THE SAME SURFACE AT DIFFERENT TEMPERATURES

FOR some time past I have been engaged in experimenting on the radiation of heat from the surfaces of wires in air and in vacuum, and I have obtained results which have been partially communicated in papers to the Royal Society (1884) and to the British Association at its last two meetings. I am at present preparing to publish further determinations of emissivities in absolute measure. In the meantime, however, I have obtained a result of some importance which may be of interest to the readers of NATURE.

Stefan has given a law, which is well known, as to the

dependence on temperature of radiation of heat from the same surface—namely, that the radiation is in proportion to the fourth power of the absolute temperature. This law was deduced originally from certain experiments of Prof. Tyndall on radiation from a heated platinum spiral (*Pogg. Ann.*, Bd. cxxiv., quoted by Wüllner, "Exp. Physik," Bd. iii. 1885). The law has been also considered by other writers, including Christiansen (*Ann. der Physik und Chemie*, Bd. xix. 1883), and they have adduced experiments which seemed to them to confirm it.

The method of experimenting which I employ makes it easy to test the truth of such a law, and in fact to find the law, and I have accordingly made the necessary calculations for the former purpose.

In my experiments a current of known strength is passed through the wire under examination, and the increase in the resistance of the wire due to heating by the current is determined while the current is passing through it. When the temperature of the wire has become constant, the heat generated by the current (which can be calculated in absolute measure) must be equal to that emitted by the surface of the wire *plus* that lost at the ends of the wire by conduction. The temperature of the wire at the moment is also ascertained from its resistance (as was done by Siemens in his experiments on resistance of platinum wire at different temperatures, *Proc. R.S.*, vol. xix. p. 443). I have recently been experimenting on platinum wires in a high vacuum down to about $1/20$ M. (one twenty-millionth of an atmosphere), as was described to the British Association at its meeting at Aberdeen.

The results quoted in Table I. below were obtained with a straight platinum wire about half a metre long, 0.04 cm. in diameter. It was contained in a glass tube about 0.6 cm. in internal diameter, and was sealed into the tube at the two ends, the exhaustion being made by a small side tube. The exhaustion at the time of the experiment, as measured by a McLeod gauge, was $1/15$ M. The temperature of the room during the experiment was 15° C.

The following two tables show the results of the experiment, and also a comparison of these results with the increase of emissivity with absolute temperature calculated according to Stefan's supposed law. Four cases have been taken which are numbered in the first column of each table. For these the current, C, and the resistance of the platinum wire, R, as found by experiment, are given in the second and third columns of Table I. The energy lost by the wire, C^2R , called e in Table II., and the estimated temperature Centigrade are given in the fourth and fifth columns of Table I. The temperature of the surroundings at the time of the experiment was 15° C. In the second table, the second, third, and fourth columns show the absolute temperatures of the wire and surroundings, and the energy lost, e , or C^2R . Column 5 shows the ratios of the energy lost in the several cases to that lost in Case 1, taken as unity. According to Stefan's law the heat emitted from the wire ought to be given by

$$W = A(S^4 - T^4),$$

where S is the absolute temperature of the wire, and T that of the surroundings. Hence if S_1, T_1 denote those temperatures in Case No. 1, and if the heat emitted in this case be taken as unity, the heat emitted with any other temperatures, S and T, would be

$$\frac{S^4 - T^4}{S_1^4 - T_1^4}.$$

This ratio, for the temperatures of the several cases, is given in the sixth column of Table II.; and it will be seen by comparison with Column 5 of that table that the increase of loss of heat with increase of temperature does not follow any such exceedingly rapid law.

TABLE I.—Results of Experiment

Case	Current	Resistance	Energy emitted	Temperature, Centigrade	Condition of wire
	C	R	C^2R	$^{\circ}$	
1 ...	1×0.169	1.087	1.087	25	Wire perceptibly red in the dark Wire distinctly red hot
2 ...	$2.2 \times .169$	1.371	6.636	110	
3 ...	$6 \times .169$	2.17	78.12	525^*	
4 ...	$6.5 \times .169$	2.32	98.06	550	

* Temperature 525° taken according to Draper's estimate of temperature of a body just visible in the dark.

TABLE II.—Comparison of Experimental Results with Calculation in accordance with Stefan's Law

Case	Absolute temperature of wire (S)	Absolute temperature of surroundings (T)	Energy emitted (e)	Ratio e/e_1	Ratio $\frac{S^4 - T^4}{S_1^4 - T_1^4}$
	(S)	(T)	(e)	e/e_1	$\frac{S^4 - T^4}{S_1^4 - T_1^4}$
1 ...	298	288	1.087	1	1
2 ...	383	"	6.636	6.1	16
3 ...	798	"	78.12	71.9	438.8
4 ...	823	"	98.06	90.2	499.8

A comparison between the last two columns shows the enormous discrepancy between the results calculated from Stefan's law and those obtained by experiment.

I am now waiting for the use of a secondary battery, which I expect to have in a very short time, to determine the ratio between the energy lost at dull red heat, say 550° C., and that lost at bright white heat (1200° C. according to Draper), for the case of an incandescent lamp. Already, however, we know enough of the behaviour of incandescent lamps—for example, in the case of an eight-horse-power gas-engine, developing five-horse-power of electric energy, and feeding 50 sixteen-candle-power lamps—to be able to say that it does not require ten times as much work to keep the lamps at white heat as it does to keep them at dull red heat.

November 16

J. T. BOTTOMLEY

ELLIPTIC SPACE

ELLIPTIC geometry is more general than ordinary geometry. It refers to a three-dimensional space of a more general type than ordinary space. The ordinary mathematics supposes a more or less plausible assumption or axiom which reduces elliptic space to a special type. The present little paper is intended to illustrate the unartificial character of the elliptic geometry and to indicate the analytical nature of the axiom which the Euclidian geometry requires us to introduce. We investigate the measurement of distance on which the theory of elliptic space chiefly depends.

It is requisite to observe carefully the definitions which are made, and to refrain from the introduction of any notions not explicitly conveyed by the definition. Let us consider a "point" whose co-ordinates are x_1, x_2, x_3, x_4 . It is not necessary to think of these co-ordinates as related to any geometrical scaffolding of tetrahedra or the like. It is in fact desirable to attach no geometrical import to the words, and merely to think of the word "point" as implying the four magnitudes just written. A second "point," y , will be similarly denoted by y_1, y_2, y_3, y_4 , and we define that the point x is distinct from y , unless in the case where

$$\frac{x_1}{y_1} = \frac{x_2}{y_2} = \frac{x_3}{y_3} = \frac{x_4}{y_4}.$$

If λ be a numerical magnitude

$$x_1 + \lambda y_1, x_2 + \lambda y_2, x_3 + \lambda y_3, x_4 + \lambda y_4$$

will also denote a point, and then, it being assumed that x and y are distinct, we have a multitude of points corre-