in very small quantities, so that it is practically certain that the chemical atomic weight 87·63 at present in use is too low.

Cobalt also appears to be a simple element of mass-number 59, as was to be expected from its atomic weight, which has been determined with great care by a number of observers.

Scandium was successfully attacked by the use of material kindly supplied by Prof. Urbain, of Paris. The only line obtained was at 45. It may be taken provisionally to be a simple element, but the effects are not strong enough to disprove the presence of small quantities of another constituent.

Manganese behaved surprisingly well, and yielded unequivocal results indicating that it is a simple element of mass-number 55. This result is in good agreement with the chemical atomic weight, and is particularly interesting, for 55 is a term in the numerical series 2, 3, 5, 8, 13—all of which had previously corresponded to gaps in the list of weights of known species of atoms.

Gallium fluoride made from a specimen of the hydrate kindly provided by Prof. Richards, of Harvard University, also gave satisfactory results. Gallium consists of two isotopes, 69 and 71. The intensity relation between the lines agrees much better with the atomic weight 69·72 recently published by Richards than that previously in use, 70·1.

Vanadium and chromium give single mass-lines at positions expected from their atomic weights 51 and 52.

Titanium gives a strong line at 48. On one of the spectra obtained there is a faint and doubtful indication of a line at 50. Should this latter be confirmed it would tend to support Honigschmid's value 48·1 for the atomic weight rather than the lower figure 47·85 more recently obtained by Baxter.

Silver in the form of the chloride worked unexpectedly well, and gave two nearly equally intense lines at 107, 109.

Yttrium gives a single strong line at 89, another term of the numerical series already referred to, and completes the analysis of the first 39 elements.

A specimen of potassium hafnifluoride sent from Copenhagen by Dr. Hevesy was experimented with, but in no case were any lines visible in the region of the expected atomic weight of hafnium. This sample contained about 50 per cent. of zirconium, and an extremely faint effect at 90 shown here and on other plates taken with pure zirconium salts suggests this as the principal isotope of this element; but further work is necessary on this point.

Niobium, molybdenum, cadmium, barium, and lead have all been tried without any definite results, and it is feared that difficulties may arise in finding suitable compounds to use in the case of these and other elements not yet analysed. On the other hand, success with scandium and yttrium offers hope of obtaining the mass-spectra of all the rare-earth group.

The following is a list of the elements the composition of which has been first indicated by the use of accelerated anode rays. The mass-numbers were usually determined with reference to the lines of iron or iodine, and no outstanding divergence from the whole-number rule was observed.

Element.	Atomic Number.	Atomic Weight.	Minimum Number of Isotopes.	Mass-numbers in Order of Intensity.
Sc	21	45·1	1	45
Ti	22	48·1	1	48
V	23	51·0	1	51
Cr	24	52·0	1	52
Mn	25	54·93	1	55
Co	27	58·97	1	59
Cu	29	63·57	2	63, 65
Ga	31	69·72	2	69, 71
Ge	32	72·5	3	74, 72, 70
Sr	38	87·63	1	88
Y	39	88·9	1	89
Ag	47	107·88	2	107, 109

Obituary.

Sir Henry Hubert Hayden, F.R.S.

ALL who knew Sir Henry Hayden well enough must recall a passing thought, more than once definitely formulated, that some day his irrepressible keenness for exploring new and little-known lands would lead to accident. Those who had the inestimable privilege of knowing him with real intimacy know well that, if he had to choose a way of ending his career, it would be on a mountain side and in a fight against physical difficulties. He never revealed and probably never entertained but one fear—that the medical history of his family might repeat itself and render him unfit for further exploratory work. It is appropriate that he should be laid to rest near the foot of a great mountain, and appropriate too that it should be the mountain which he had just conquered, for as a mountaineer he was as efficient as he was daring.

To accomplish a difficult task in exploration was in itself his sufficient reward. Kindred spirits and but very few others knew of his accomplishments; for, without being reticent, he never looked to the "gallery": his photographs, maps, sketches, and collections were made readily available to specialists, but rarely, and only under pressure, were they turned into lantern slides. The end of one task was to him the beginning of the next: there never was an interval for popular demonstrations, and little even for rest.

Each geographical enterprise was invariably in a new field, and Hayden's geological work was just as varied — geotectonic problems in the Himalayas, economic mineral questions in various parts of India, pure palæontology, the application of geology to engineering problems, and the microscopic petrology of igneous rocks formed the subjects of his papers, each treated in turn with a thoroughness and sense of relativity that revealed a wide and precise acquaintance with literature, which was always surprising to those who were impressed by his restless physical activity in the field.

Since January 3, 1895, when I met Hayden on his landing at Calcutta to join the Geological Survey of India, I have been in closer and perhaps more constant touch with him than most of his friends, and during those twenty-eight years I never heard from him an ungenerous remark about a colleague, never heard him grumble about the climate, at the work, or even at the inequalities of treatment that seem to be the

inevitable characteristic of every form of official service. Two examples are worth recording, for every friend of Hayden will recognise them as typical.

We were moving camp to a new field where there was a probability that the fast-coming hot weather would soon make work difficult. The hot, west winds, laden with fine dust, had significantly started as a warning that life in tents would soon be impossible. Every day was important, when, through the negligence of a local subordinate official, transport facilities broke down absolutely within twenty miles of our new field. I was annoyed especially because my mail having been directed from headquarters to the new camp, the enforced halt could not be utilised even for office work. There seemed to be no escape from a wasted day of useless grumbling. On rising next morning Hayden was missing, but by noon he turned up loaded with heavy postal packets, and then I found that he had been to fetch my mail, and, as I afterwards discovered, had cycled nearly forty miles over what only an Indian District Board would be content to call a road. Few but Hayden would have thought of it; none but Hayden would have done it silently, as if it were only the usual thing.

Four years later Sir Francis Younghusband was starting on his mission to Lhassa. The remarks in the Director's Annual Report for 1902–3 (Rec. Geol. Surv. Ind., vol. xxxii. pp. 153-156) show why at that time we were anxious to know whether on the northern side of the snow-covered, crystalline range of the Eastern Himalaya there had been an extension of the Mesozoic fossiliferous basin which had been surveyed in Spiti and other parts of the north-western Himalaya. I hurried to Darjeeling to intercept Younghusband, who was then on his way to join the expedition that had already started into Sikkim. He realised the value of the problem and readily offered to give facilities for a geologist to join the party, but warned me that unless an officer could move at once he might be too late. I returned immediately to Calcutta and put the question before Hayden, who promptly volunteered to cancel his local engagements, and although he knew the meaning of winter on the inhospitable plateau of Tibet, did not wait to discuss conditions or settle his local affairs, but moved off within twenty-four hours, trusting to pick up transport and equipment on the way. Within a fortnight there came back a parcel of Spiti shale fossils and a letter that opened a new chapter in Himalayan geology. Hayden was away for more than a year, and how he covered so much ground with such excellent results was known only to him and to his kindred spirit, Sir Francis Younghusband.

Always moving rapidly, but never too hurried to help a colleague; always doing something, but mentally as well as physically, Hayden piled up a record of solid results which would have been the envy in turn of the sportsman, the explorer, the scientific worker and the most orthodox official. After graduating at Trinity College, Dublin, in engineering as well as arts, he made a journey round the world before joining the Geological Survey of India in 1895. He was appointed Director of the Department in 1910 and held office for eleven years. Meanwhile, as a junior officer his work touched most of the provinces of India, but his Himalayan and trans-frontier stratigraphical work naturally attracted most attention, the chief scientific results being included in his memoirs on Spiti and Bashahr (Mem. Geol. Surv. Ind., vol. xxxvi., part 1), on the provinces of Tsang and U in Central Tibet (vol. xxxvi., part 2), and on Northern Afghanistan (vol. xxxix., part 1). Just before leaving for Switzerland he completed and sent to the press in French his account of the journey through northern Tibet during 1922, that is, after he had retired from the Indian Government service.

In 1915 the Geological Society awarded Hayden the Bigsby medal, and he was elected a fellow of the Royal Society in the same year, whilst Calcutta University conferred on him the honorary degree of D.Sc. He served successively as president of the Mining and Geological Institute of India and of the Asiatic Society of Bengal. In 1911 his official service was recognised by the C.I.E.; in 1919 he received the senior order of C.S.I., and on the day of his embarkation at Bombay in June 1920, preparatory to retirement from the office of Director of the Geological Survey, his knighthood was gazetted.

The accident which led to Hayden's death with his two guides must have occurred soon after August 12, on his return from an ascent of the Finsteraarhorn, but his body was not found until August 28. The details of his death will never be known, but if the final and determining incident was not a definite attempt to save his companions, it was not Hayden's fault. He was buried by friends on September 1 at Lauterbrunnen, and the selection of the spot would almost certainly be in accordance with his own wish. Perhaps of all the many incidents that one can recall as illustrations of his generous nature, my last glimpse of him was the most characteristic: it was just a few days before he started on his tour in Switzerland; he was busy with his preparations, but looked in to say farewell on his way to see the sick relative of a friend who was away from home. One frequently came across instances of his generosity to the poor and sick, but not even the most intimate of his friends knew them all; as in his work, each act of kindness followed too closely on its predecessor to allow of time for talking about it.

T. H. HOLLAND.

THE issue of the *Physikalische Zeitschrift* for July 15 contains an obituary notice of Prof. O. Lehmann by Drs. A. Schleiermacher and K. Schachenmeier. He was born on January 13, 1855, at Constance, where his father, F. X. Lehmann, was director of the training college. As an only child he spent much time in his father's laboratory and was interested in his search for mathematical law in organic life. He studied under Kundt and Groth at Strasbourg, and after graduating taught in schools in Baden and Alsace until 1883, when he became lecturer and afterwards extra professor at the polytechnic at Aix-la-Chapelle. After a year as extra professor at Dresden he succeeded Hertz as director of the physics department of the technical school at Carlsruhe in 1889. He took a prominent part in the meetings of the scientific society of Carlsruhe and was noted for the experiments with which he illustrated his lectures. He is best known in Great Britain for his work on liquid crystals and for the improvements he made to the microscope to facilitate that work. His death occurred on June 17, 1922, some time after his retirement.