Letters to the Editor.

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Constitution of Molybdenum.

FOLLOWING the successful analysis of chromium announced in NATURE of Aug. 9, I have now been able to apply similar methods to molybdenum. The mass-spectrum of this element is a remarkable one, and the credit of its discovery rests with Dr. A. v. Grosse, who prepared the specimen of molybdenum carbonyl with which the work was done.

In contrast to the theoretical prediction of Russell (NATURE, Oct. 20, 1923) molybdenum has no less than seven isotopes, and the group indicates relative abundance relations far closer than those of any other multiple element so far investigated. Owing to incidental difficulties, which I need not enumerate here, measurements could not be made so accurately as usual. The following are the mass numbers and their approximate percentage abundance:

By comparison with the doubly charged mercury group the packing fractions of Mo^{98} and Mo^{100} were provisionally estimated. Both appear to be about -5.5, a considerably smaller negative value than that expected from the curve. From these values, correcting to the chemical scale we get :

Atomic weight of $Mo = 95.97 \pm 0.05$

in good agreement with the figure 96.0 obtained by chemical methods.

Two of the isotopes are isobaric with the wellestablished isotopes of zirconium 92 and 94, and a third with the doubtful one 96.

F. W. Aston.

Cavendish Laboratory, Cambridge, Aug. 21.

The Period of 'Actino-uranium' and its Bearing on the Ages of Radioactive Minerals.

FROM the mass-spectrum of the mixture of lead isotopes isolated from Norwegian bröggerite Dr. F. W. Aston (NATURE, Mar. 2, 1929, p. 313) estimated the relative proportions of the individual isotopes to be approximately

Pb206	Pb207	Pb208
86.8	9.3	3.9

The line 207 is referred to the end-product of the actinium series, and the latter is regarded as having its origin in an isotope of uranium (actino-wanium). In the course of a discussion of the significance of Aston's results, Sir Ernest Rutherford tentatively estimated the half-value period of the hypothetical isotope (NATURE, Mar. 2, p. 314; 1929). Taking the period of uranium I as 4.5×10^9 years, he found a probable value of 4.2×10^8 years for the period of actino-uranium. If this estimate (based on the unexpectedly high amount of Pb²⁰⁷ found by Aston in the bröggerite lead) be of the right order, then it follows that Pb²⁰⁷ has been generated in minerals more rapidly from the actinium series than Pb²⁰⁶ from

No. 3175, Vol. 126]

the uranium series. In calculating the ages of radioactive minerals it would therefore be necessary to allow for this difference. The object of this letter is to direct attention to another line of evidence from which it can be inferred that the periods of uranium I and actino-uranium are probably more nearly equal, and that no correction to the calculated ages of minerals is required in the present state of our knowledge.

From the approximate constancy of the ratio of actinium or protoactinium to uranium in minerals, it has generally been accepted that the percentages of atoms disintegrating via actinium and radium respectively are about 3 and 97. This ratio has recently been investigated afresh by J. E. Wildish (Jour. Am. Chem. Soc., 52, Jan., 1930, p. 163), who finds that the number of atoms of protoactinium disintegrating per 100 atoms of uranium I ranges in five different minerals from 1.47 to 5.16. Incidentally, this departure from constancy strengthens the growing belief that the actinium series is not a branch of the uranium series; it also raises a doubt whether the actinium parent can be an isotope of uranium. The immediate point of importance, however, assuming that actinium produces Pb207, is that the number of atoms of Pb²⁰⁷ produced in radioactive minerals at the present time is 3 ± 2 for every 100 atoms of Pb²⁰⁶ produced from uranium I. If both uranium I and actino-uranium disintegrate at about equal rates, then in Pre-Cambrian minerals the percentage of accumu-lated Pb²⁰⁷ to accumulated Pb²⁰⁶ should also fall within this range. If, on the other hand, Rutherford's suggestion is true, that actino-uranium disintegrates more rapidly than uranium I, then the proportion of accumulated Pb²⁰⁷ should be definitely higher. For a few minerals data are available which permit a test of these alternatives.

Let A =atomic weight of the mixture of lead isotopes isolated from a mineral;

$$a = \text{percentage of Pb}^{207}$$
 in the mixture
 $b = \text{percentage of Pb}^{206}$ of lead

 $c = \text{percentage of Pb}^{208}$ isotopes.

Then we have

$$207a + 206b + 208c = 100A$$

$$a + b + c = 100$$

$$\frac{a + b}{c} = \frac{U}{0.38 \text{ Th}}$$

where U and Th represent the respective percentages of uranium and thorium in the mineral. The third equation is based on the fact that the lead-producing capacity of thorium is only 0.38 times that of uranium which, as chemically determined, includes actinouranium as well as uranium I.

From the three equations we find

100

$$c = \frac{100}{\left(\frac{\text{U}}{0.38 \text{ Th}} + 1\right)}$$
$$a = 100(A - 206) - \frac{200}{(-\text{U})}$$

The packing-effect is clearly important here, for if the atomic weight of Pb²⁰⁶ be 206.016 (as suggested by Aston), then the value of a will be diminished by 1.6, which is a considerable part of its total value. In the following table a is therefore calculated from the expression

$$a = 100(A - 206.016) - rac{200}{\left(rac{\mathrm{U}}{0.38 \mathrm{~Th}} + 1
ight)}$$

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