striations, and V_s the additional potential for each additional striation.

Pressure.	V_m .	V_s .
1.26	66.3	9
0.31	90.1	14.8
0.14	120	16.2

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Critical Potentials of Light Elements for Simultaneous Transitions.

INVESTIGATIONS have been made by various workers to determine the energy levels of the outer shells of the atom by bombarding it with cathode particles of definite velocity and measuring the photoelectric current due to the radiation impinging on a metallic plate. Keeping the cathode current constant through the tube, the voltage is gradually increased, and it is found that at certain voltages kinks appear in the voltage-photoelectric curve. These kinks are attributed to the sudden appearance of 'new types of radiation' and the corresponding voltages are called 'critical potentials.'

Numerous observers (Richardson and Chahklin, Rollefson, Horton, Thomas, Compton, and others) have measured the critical potentials for the elements chromium to copper in the region from 40 to 200 volts, and in spite of certain disagreements between some of these values, due chiefly to the different values taken for W (the work necessary to remove the electron out of the metal) by different observers, it is found that there is a good agreement between them for about ten of these critical potentials, though these numbers are very much more than what is to be expected from the Bohr atomic model. For example, Andrews, Davies, and Horton (*Proc. Roy. Soc.*, vol. 117) have obtained critical voltages for copper in this region corresponding to 56, 67, 75, 85, 116, 131, 153, 196, 212 volts, whereas from the Bohr model one would expect critical voltages at 76.9 (M_2 , $M_{II} - M_{III}$) and 119.7 (M_1 , M_I) only.

Attempts have been made to explain the origin of the critical potentials by different observers, but none of them has been able to get the right result even qualitatively, though Richardson and Thomas have suggested the possibility of double ionisation in the atom.

In a previous communication to NATURE (Nov. 17, p. 771) one of us (B. B. R.) tried to account for the existence of secondary absorption edges by supposing that the same quantum of radiation can successively knock out two electrons occupying the same or different energy levels in an atom. In a similar way we can explain the appearance of these critical potentials by assuming that in certain circumstances the same cathode particle can simultaneously eject two electrons either from the same or from different energy levels of the atom, and radiation is emitted due to simultaneous jumps of two electrons to fill up these two vacancies. The frequency of the radiation then emitted is equal to the sum of the frequencies due to the individual jumps. The idea of the emission of single quanta, as the result of the simultaneous transitions of more than one electron, has been already established in the field of optics (see Andrade, "The Structure of the Atom," pp. 563-564).

With this idea we have plotted Moseley curves with $\sqrt{\nu/R}$ as ordinate against Z in the region from iron to copper for such transitions as $2M_1$, $2M_2$, $M_1 + M_3$, $M_2 + M_3$, $M_1 + (M_1 - M_3)$, $M_2 + (M_2 - M_3)$, and so on. The values for M_1 and M_2 in this region are taken

from X-ray, and N_1 from the optical data, whereas M_3 is obtained by extrapolation. On comparing the common values of different observers with those from the curve in these regions, we find that out of ten critical voltages, eight can be explained in this way; the error in any case is not more than 5 per cent. The values for chromium and manganese can also be deduced with success from these curves by interpolation. As for the other values, we are not sure if these are due to tungsten or to other impurities present in the metal. We also wish to point out that a large number of lines would accompany each of the transitions considered here in accordance with the Pauli-Hund rule as applied in the optical spectra.

This hypothesis of simultaneous transitions thus appears able to explain satisfactorily a large mass of hitherto unexplained experimental determinations of critical voltages.

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The Electromotive Behaviour of Single Metal Crystals.

ALTHOUGH the results of crystal analysis indicate that the electromotive characteristics of a metal, in common with other properties conditioned by interparticle electrostatic forces, presumably vary with the orientation of the surface measured, no attempt seems to have been made to relate electrode potential measurements to a structure definitely describable in the crystallographic sense. The study of this structure-potential relation seems particularly desirable if electromotive data are to be correlated with photoelectric and electron condensation measurements. The measurement of a definite cleavage plane of a typical single metal crystal suggests itself as a suitable starting-point for such a study.

Measurements in oxygen-free solutions carried out at Yenching University, Peking, between June 1927 and June 1928 on three single zinc crystals, one of which was furnished by Prof. Bridgman, indicate that the primary cleavage face (basal pinacoid) of a zinc crystal is capable of yielding potentials constant to within 0.0001 volt and reproducible to well within one millivolt. The potential, further, was identical to that of the electrolytically deposited crystal conglomerate within the range of variation of duplicate conglomerate electrodes, a result which would be predicted if, as Bozorth (*Phys. Rev.*, **26**, 390; 1925) has shown, the electrolytic crystals are deposited with a random orientation and if the potential of the primary cleavage is a unique maximum. This second condition is rendered probable by the fact that the interplanar lattice distance is a maximum at the basal cleavage, but would depend upon any variation of the photoelectric work function with orientation. Attempts to prepare zinc crystals with naturally developed secondary faces sufficiently large for measurement have so far failed. Measurements on artificially prepared surfaces annealed and lightly etched have seemed to indicate a qualitatively regular decrease of potential with increase of inclination to the primary cleavage plane. This result is being checked by further work.

It may be pointed out that the use of the single crystal electrode offers a possible solution of the problem of obtaining satisfactorily reproducible electrodes of the high melting-point, rigid lattice metals.

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