

NOTE ON CRYSTALLINE AND AMORPHOUS STATES IN THE
ALKALI METALS

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ABSTRACT

X-ray diffraction patterns obtained on a wire of metallic lithium at 20°, 80°, 110°C show a decreasing diffracting power at the higher temperatures. This is consistent with the observations of Hull and McKeehan on sodium and potassium. The obliteration of the lattice structure at the higher temperatures is correlated with changes in the thermo-electric power and resistance lines previously found by the author for all the alkali metals.

IN a previous paper¹ on the resistance and thermo-electric power of the alkali metals a modification or structural change of some sort was shown to occur in the case of each of these metals, the transition being indicated by gradual changes in the resistance and thermo-electric lines. For lithium the change began to show at about +50°C, for sodium at about -40°C, for potassium about -120°C. The thermo-electric lines are straight to the transition temperature at which a gradual change in slope occurs. The resistance lines are of the form $R = R_0(1 + at + \beta t^2)$ with different values for a and β after the transition temperatures are passed.

A careful study of the crystal structure of lithium at various temperatures by x-ray diffraction methods indicates that the change is not a change from one crystalline pattern to another but a gradual disintegration of the lattice with rise of temperature. For this study a squirted wire of lithium was sealed into a thin walled glass tube, one-half of which was filled with sodium chloride and flour as a comparison control. The specimen was mounted vertically in the x-ray beam and continuously rotated about its axis of cylinder. Heating was effected by a stream of warm air passing through a paper cylinder which was slipped down over the specimen. By adjusting the velocity of the air stream and its temperature, any desired temperature could be maintained within five degrees.

At 20°C a 72 hour exposure gave 5 lithium lines and 13 strong lines for the NaCl control. The lithium lines were consistent with a body-centered cube as found by Hull.² At 83°C a 92 hour exposure gave three lines for lithium, and again the 13 strong lines for the NaCl control. At 110°C a 76 hour exposure still showed indications of the three lithium lines but

¹ Bidwell, Phys. Rev. **23**, 357 (1924).

² Hull, Phys. Rev. **10**, 661 (1917).

very much fainter than in the 83° exposure, while the NaCl control showed 14 lines indicating certainly no diminution in the intensity of the x-ray beam. New specimens were mounted up for each of these exposures. While the films indicate some persistence of the lattice at 110° they indicate certainly that the structure is much less definite at 110° than at 83° and less definite at 83° than at 20° .

Hull found difficulty in getting a sample of sodium which was not amorphous at room temperature but finally succeeded in getting a pattern of seven lines corresponding to a body-centered cube. He says "the tendency to form this regular arrangement is however very slight, corresponding to a small difference between the potential energies of the crystalline and amorphous states." McKeehan³ was able to obtain a definite crystal pattern for potassium at -150°C and states that the observed crystalline structure does not persist when the temperature is allowed to rise again to 20°C .

It is the purpose of this note to suggest that the changes indicated by the resistance and thermo-electric lines for the alkali metals may be correlated with the gradual disintegration of the crystal lattice. The thermo-electric power is particularly affected, the slopes of these lines even changing in some cases from positive to negative. The fact that these curves are not exactly reproducible on successive runs may be explained as due to the persistence in varying degree of the crystalline forms at the higher temperatures. The change in the resistance lines is not so marked out nevertheless is definite and in entire agreement as to the temperature above which the metal tends to become amorphous.

The author wishes to express his gratitude to Dr. W. R. Whitney for offering the facilities of the Research Laboratory of the General Electric Company for this work and to Dr. W. P. Davey for the use of the special x-ray equipment.

CORNELL UNIVERSITY.
December 17, 1925.

³ McKeehan, Proc. Nat. Acad. Sci. **8**, 8 (1922).