



Eistert homologation of *cyclohexenylacetic acid*. Ring closure of β -(*cyclohexenyl*)propionic acid (IIIa) to 4 : 5 : 6 : 7-tetrahydroindanone with acetic anhydride-zinc chloride proceeded in 56 per cent yield.

Substance	Conditions	Products
γ -(<i>cyclohexenyl</i>) spirobutyrolactone (II)	Potass. bisulphate, 200° C., 45 min.	14% acid 80% lactone
	Anhydrous oxalic acid, 200° C., 1 hr.	16% acid 80% lactone
	Reagent A 4 hr. " A 8 "	2% acid 94% lactone 2% acid 93% lactone
β -(<i>cyclohexenyl</i>) propionic acid (IIIa)	Reagent A 4 hr.	30% acid 65% lactone
	" A 8 "	10% acid 82% lactone

The position of equilibrium of the lacto-enoic tautomerism $\text{II} \rightleftharpoons \text{IIIa}$ has also been established under certain conditions; our results agree with those of Johnson. The above series of reactions is being examined with substituted *cyclohexanones*, and the results will be communicated elsewhere in due course.

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¹ Johnson and Hunt, *J. Amer. Chem. Soc.*, **72**, 935 (1950).

² Haynes and Jones, *J. Chem. Soc.*, 505 (1946).

³ Cason, Adams, Bennett and Register, *J. Amer. Chem. Soc.*, **66**, 1764 (1944).

⁴ Johnson, Peterson and Sneider, *J. Amer. Chem. Soc.*, **69**, 74 (1947).

Mean Restoring Forces of Hydride Di-Atoms and their Positive Ions

I HAVE recently published¹ the periodic table of deuteride di-atoms and their positive ions, thus completing a programme initiated by the periodic classification of the elements², and of non-hydride³ and hydride⁴ di-atoms according to electron configurations. In a forthcoming communication⁵, I propose to examine in the light of these tables a suggestion made by Dadiou and Kohlrusch⁶ that the 'mean restoring force' of a linkage may be used as a measure of bonding strength. The authors found that for C—C, C=C and C≡C linkages the mean restoring forces were closely in the ratio 1 : 2 : 3.

The mean restoring force of a di-atom is measured by $K = 1,878 \sqrt{\mu\omega_e^3}$, whereas the bond constant is $k_e = 3.550 \times 10^{23} \mu\omega_e^2$ (c.g.s. units). It is thus found that K generally changes from one case to another in the same sense as k_e and D_e (dissociation energy), and is a periodic function for hydrides. I have indicated that K appears to be a suitable magnitude for comparing changes in binding force in considering the effects of formation of singly charged positive ions from

the corresponding hydride or deuteride, and as a measure of the increasing stability of di-atoms in a given period with increasing group number: for example, in the KH period from Li^+H^- to F^-H^+ .

An interesting and apparently general principle has emerged from this work, to the effect that stability increases on ionization when the hydrogen atom lies at the negative end of the dipole, that is, for hydrides near the beginning of a period, and decreases when it is at the positive end, for hydrides of elements on the right of the periodic table. In the middle groups, the changes in stability are correspondingly small. The positive and negative effects are apparently greatest in the KH period in Groups II (LiH) and VIII (FH) respectively, and least in Group V (CH). They also increase from one period to the next in the same group. The accompanying table shows the percentage change in mean restoring force of hydrides AH on ionization for cases where data are available.

Period	Group number and atom A				
	II	III	IV	VII	VIII
HH	H -62.3				
KH		Be +13.2	B +4.5	O -29.5	
LH		Mg +21.1	(Al -6.7)		Cl -15.3
MH		Zn +30.1			
NH		Cd +45.9			
OH		Hg +77.6			

In an earlier communication, Walsh⁷ noticed the drop in binding strength of OH and BrH on ionization, as judged by changes in internuclear distance. This observation is now brought into line with a general scheme. The large drop in stability in passing from $\text{HH} \rightarrow \text{HH}^+$ is doubtless connected with the setting up of a one-electron linkage. The other changes are satisfactorily explained by Walsh's polarity theory, to the effect that increasing stability accompanies decreasing polarity, and *vice versa*. The theory must be confined to changes of polarity of the same two atoms involved in a linkage. It is not applicable to account for changes of stability from CH to FH, where both stability and polarity increase. These changes may be referred instead to the increasing positivity of the hydrogen atom.

The small changes in K for BH and AlH shown in the above table suggest a still smaller value for $\text{CH} \rightarrow \text{CH}^+$. In the middle of a period, ionization may involve a slightly polar bond reversing its dipole, with only a small attendant change in stability. This possibly also happens in the CH bond from CH_4 to C_2H_4 , where only a small change in internuclear distance (1.094 to *circa* 1.087 Å.) occurs^{7,8}. A fall in internuclear distance is linked with rising mean restoring force and increasing stability.

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¹ Clark, C. H. Douglas, *Proc. Leeds Phil. Soc.*, **5**, 244 (1949).

² *Idem, ibid.*, **2**, 225 (1931); **3**, 231 (1936).

³ *Idem, ibid.*, **2**, 502 (1933); *Trans. Farad. Soc.*, **31**, 1017 (1935).

⁴ *Idem, Proc. Leeds Phil. Soc.*, **3**, 218 (1936).

⁵ *Idem, ibid.* (in the press).

⁶ Dadiou, A., and Kohlrusch, K. W. F., *J. Opt. Soc. Amer.*, **21**, 286 (1931).

⁷ Walsh, A. D., *Trans. Farad. Soc.*, **43**, 60 (1947).

⁸ *Idem, J. Amer. Chem. Soc.*, **68**, 2408 (1946).