

banded. It was shown by me in 1928<sup>1</sup> that certain strained and annealed alpha iron crystals contained twins lying along (112) planes, and furthermore I cited evidence suggesting that twinning in alpha iron might sometimes be associated with twinned gamma iron from which it had cooled. It has also been observed<sup>2,3</sup> that on annealing a deformed single crystal of alpha iron the polygonal aggregate obtained gives pressure figures indicating uniform orientation, and it seems likely that this may also be associated with twinning.

The general importance of annealing twins to the metallurgist has hitherto been the evidence which they afford of the previous history (cold-working and annealing) of the specimen. Unfortunately only X-ray methods can be relied upon to detect them with certainty in alpha iron, and now apparently some method of distinguishing between the two processes of origin is required.

An interesting practical point may be connected with this twinning behaviour. Mild steel tinplate is said to be more ductile and to have better Erichsen values when cold-rolled and annealed than when hot-rolled and normalised. The former process probably produces a more highly twinned structure, which for crystallographic reasons would tend to deform more easily.

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<sup>1</sup> *J. Iron and Steel Inst.*, **117**, 689.

<sup>2</sup> H. O'Neill, *T.A.I.M.E.* (Iron and Steel Div.), 229; 1928.

<sup>3</sup> L. B. Pfeil, *Carnegie Mems.*, *J. Iron and Steel Inst.*, 153; 1927.

### Dissociation Energy of the CO Molecule and the Sublimation Heat of Carbon

THE direct experimental values of the sublimation heat  $L$  of carbon obtained by several authors<sup>1</sup> lie between 139 and 177 kcal. An accurate value can be deduced from the energy of dissociation  $D_{CO}$  of CO into normal atoms, since the well-known relations (at 0°K.):

$$\begin{aligned} C_{diam.} + \frac{1}{2}O_2 &= CO + 27.6 \text{ kcal.} \\ CO &= C(^3P) + O(^3P) - D_{CO} \\ C(^3P)_{gas} &= C_{diam.} + L \\ O(^3P) &= \frac{1}{2}O_2 + 58.7 \text{ kcal.} \end{aligned}$$

lead to

$$L = D_{CO} - 86.3 \pm 0.2 \text{ kcal. (86.3 kcal. = 3.74 v.e.)} \quad (1)$$

The value of  $D_{CO}$  was hitherto not exactly known. However, the predissociation in the  $CO(B^1\Sigma)$  level<sup>2</sup> gives the upper limit:  $D_{CO} \leq 11.07$  v.e. We obtain the lower limit in the following way: for the upper level ( $A^1\Pi$ ) of the fourth positive CO bands, which lies 7.99 v.e. above the ground ( $X^1\Sigma$ ) state, 16 vibration levels (2.41 v.e.) are observed, corresponding to  $7.99 + 2.41 = 10.40$  v.e. above the ( $X^1\Sigma$ ) state. This value is a lower limit for  $D_{CO}$ , if CO ( $A^1\Pi$ ) dissociates into normal atoms. By linear extrapolation (which gives in many cases values which are too high) of vibration levels of the ( $A^1\Pi$ ) state we obtain about 4 v.e. ( $v'_{max.} = 43$ ), that is 12 v.e. above the ( $X^1\Sigma$ ) state. The ( $A^1\Pi$ ) state could be formed only from atoms of equal multiplicity: (a)  $C(^3P) + O(^3P)$  or (b)  $C(^1D) + O(^1D)$  or (c)  $C(^1S) + O(^1D)$ , etc. Already the interpretation (b) leads to  $D_{CO} \leq 8.79$  v.e. =  $12 - 3.21$  v.e. (3.21 v.e. being the sum of excitation energies of  $C(^1D)$  and  $O(^1D)$ ). According to (1), then  $L \leq 5.05$  v.e. (116 kcal.); this

value must be excluded as being beyond the errors of determinations of  $L$  (it seems also too near to  $L = 113$  kcal. for Fe). Consequently, we must assume that  $CO(A^1\Pi)$  dissociates into non-excited atoms (if it is really a singlet state) and  $D_{CO}$  lies between 10.4 v.e. and 11.07 v.e.  $D_{CO}$  is certainly much nearer to the upper limit, since at the 16th vibration level the convergence is still not sufficiently advanced.  $D_{CO} = 11$  v.e. = 253.6 kcal. is probably not in error by more than 0.1 v.e. Therefore we obtain  $L = 7.26$  v.e. = 167 kcal. The restriction of the error limits to 0.1 v.e. = 2.3 kcal. eliminates one of the most important uncertainties inherent at calculations of formation energies of carbon compounds<sup>3</sup>.

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<sup>1</sup> H. Kohn and M. Guckel, *Z. Phys.*, **27**, 305; 1924. A. L. Marshall, and F. J. Norton, *J. Amer. Chem. Soc.*, **55**, 431; 1933.

<sup>2</sup> D. Coster and F. Brons, *Physica*, **1**, 155; **1**, 634; 1934. D. N. Read, *Phys. Rev.*, **45**, 752; 1934. R. Schmid and L. Gerö, *Z. Phys.*, **93**, 656; 1935.

<sup>3</sup> L. Pauling and J. Sherman, *J. Chem. Phys.*, **1**, 606; 1933. C. T. Zahn, *J. Chem. Phys.*, **2**, 671; 1934. W. Lasareff, *J. Phys. Chem.* (in the press) and *Physica* (in the press). P. Goldfinger, W. Lasareff and M. Letort, *C.R.*, **200**, 1593; 1935.

IN the letter above, which I had the opportunity of reading in manuscript form, Goldfinger and Lasareff calculate the heat of dissociation of CO on the basis of thermochemical and spectroscopical data and give as the most probable value 11 v.e. with a possible error of not more than 0.1 v.e. I want to direct attention to the fact that this may be independently checked by the results of the investigation by Schmid and Gerö<sup>1</sup>, who observed in addition to the known predissociation in the  $v = 0$  level of  $B^1\Sigma$ , occurring at  $J = 38$ , another predissociation (breakdown of rotational structure) occurring at  $J = 18$  of the  $v = 1$  level. The application of the reasoning of Herzberg<sup>2</sup> to this case shows that the lower limit of the asymptote of the perturbing electronic level is situated only 40  $cm^{-1}$  below the upper limit, equivalent to 11.062 v.e., and that its real position therefore is  $11.06 \pm 0.005$  v.e. This would represent the dissociation energy of CO if the asymptote really corresponds to the dissociation in  $C(^3P) + O(^3P)$ . The alternative possibility that it would correspond to dissociation into  $C(^1D) + O(^3P)$  and that therefore  $D_{CO} = 1.105$  v.e. will be discussed in detail elsewhere.

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<sup>1</sup> Schmid and Gerö, *Z. Phys.*, **93**, 656; 1935.

<sup>2</sup> Herzberg, *Ann. Phys.*, **15**, 677; 1932. **21**, 577; 1935.

### Research and the Library

WE are in substantial agreement with the views expressed by Mr. G. E. H. Foxon in NATURE of June 8, except that he has misinterpreted the penultimate paragraph of our original article<sup>1</sup>, as reference to it will show that it was not our intention to burke scientific debates. The inclusion of these would not be overlooked by an editorial board of the calibre envisaged by us. Our point was that votes