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Surface energy of molten metals

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In this note an attempt is made to show that a relation exists between surface energy, melting temperature and Fermi wavelength in the case of molten metals.

The relation between compressibility K, surface energy σ and Fermi wavelength K_F is given by (Brown & March 1973),

$$K\sigma = 9\pi/160\, K_F \qquad \ldots \quad (1)$$

Thus the product $K\sigma$ should be of the order of the de Broglie wavelength for an electron at the Fermi surface

In the case of alkali halides Pathak & Vasavada (1970a) have shown that

$$\frac{V}{E_f} = CK \qquad (2)$$

where V is the volume per mole, E_f is the energy of vacancy formation and C is a constant The generality of the argument for deriving this relation shows that it should be equally valid for metals

In the case of metals Pathak & Vasavada (1970b) have shown that the relation between E_f and the melting temperature Tm is

$$E_f(\mathrm{eV}) = 7{\cdot}63 \times 10^{-4} Tm \qquad \ldots \quad (3)$$

Combining eqs (2) and (3) we get

$$\frac{V}{Tm} = C'K \qquad \ldots \quad (4)$$

where C' is a constant

It was interesting to find that this relation holds also for molten metals. This can be seen from table 1

Table 1 Relation between compressibility K and melting temperature Tm for molten metals

Metal	V/Tm ($\times 10^3$) ($cm^3\ mole^{-1}\ K^{-1}$)	K ($\times 10^{12}$) ($cm^2\ dyne^{-1}$)	V/KTm ($\times 10^{-7}$)
Na	63.9	21	304
K	135.3	40	338
Rb	179 1	49	365
Cs	231.0	67	344
Cu	5 26	1.45	362
Ag	8 31	1.86	446
Zn	13.3	2.4	553
Cd	21 9	3 2	683
Pb	30.6	3.5	873
Bi	39.2	4.3	911

In table 1, the values of the compressibilities are taken from Egelstaff & Widom (1970). It can be seen from the table that although the compressibilities vary by a factor of about 50, the values in the last column vary by a factor of about 3

In view of the above arguments we can combine eqs. (1) and (4) for molten metals and get

$$\frac{V\sigma K_F}{Tm} = \text{constant} \qquad \ldots \quad (5)$$

The values of the left hand side are shown in table 2

Table 2. Relation between surface energy σ, melting temperature Tm and Fermi wavelength K_F for molten metals

Metal	σ* (dyne-cm)	K_F $(\times 10^{-8})$ (cm^{-1})	$\frac{V\sigma K_F}{Tm}$ $(\times 10^{-8})$
Na	191	0.90	10.98
K	101	0.73	9.98
Rb	77	0.68	9.38
Cu	1085	1.35	7.71
Ag	785	1.19	7.77
Au	754	1.20	6.91
Zn	824	1.57	17.16
Cd	564	1.40	17.25
Al	915	1.75	17.13
In	340	1.50	18.71
Tl	400	1.46	17.42
Sn	526	1.63	27.68
Pb	444	1.57	21.30
Bi	376	1.61	23.71

*The values of σ in the above table are taken from Flynn (1964).

It is seen from the above table that although $V\sigma K_F/T_m$ remains fairly constant for the different groups of metals, no simple correlation with Z can be found This note is communicated with a hope that it will stimulate further theoretical considerations

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