Answer on Question #76573, Chemistry / General Chemistry

Calculate the lattice energy for ZnO crystal by using eq.3.4and born hyber cycle compare distance between two answers

Solution

Table data

$Zn(s) + ½\ O2(g) \rightarrow ZnO\ (s)\ \Delta H_f = -350.5\ kJ/\ mol$

$Zn(s) \rightarrow Zn(g)\ \Delta H_s = 130.4\ kJ/mol$

$Zn\ (g) \rightarrow Zn^+\ \ I(Zn) = 906.3\ KJ/mol$

$Zn^+ \rightarrow Zn^{+2}\ \ I(Zn^+) = 1733\ kJ/mol$

$1/2O_2(g) \rightarrow O\ (g)\ ½\ \Delta H_d = 248.5\ kJ/mol$

$O(g) \rightarrow O^-(g)\ EA(O) = 141\ kJ/mol$

$O^-(g) \rightarrow O^{-2}\ EA(O^-) = -780\ kJ/mol.$

Medelung constant (A) = 1.6411

Born Constant (n) = 8

Internuclear distance (a) = 199 pm = $199 \cdot 10^{-12}$m

1. Find lattice energy of ZnO value according to electrostatic model.

$$\Delta U = N_a A \frac{Z_1 Z_2 e_0^2}{4\pi\varepsilon_0 a}\left(1 - \frac{1}{n}\right)$$

$Z_1 = +2$

$Z_2 = -2$

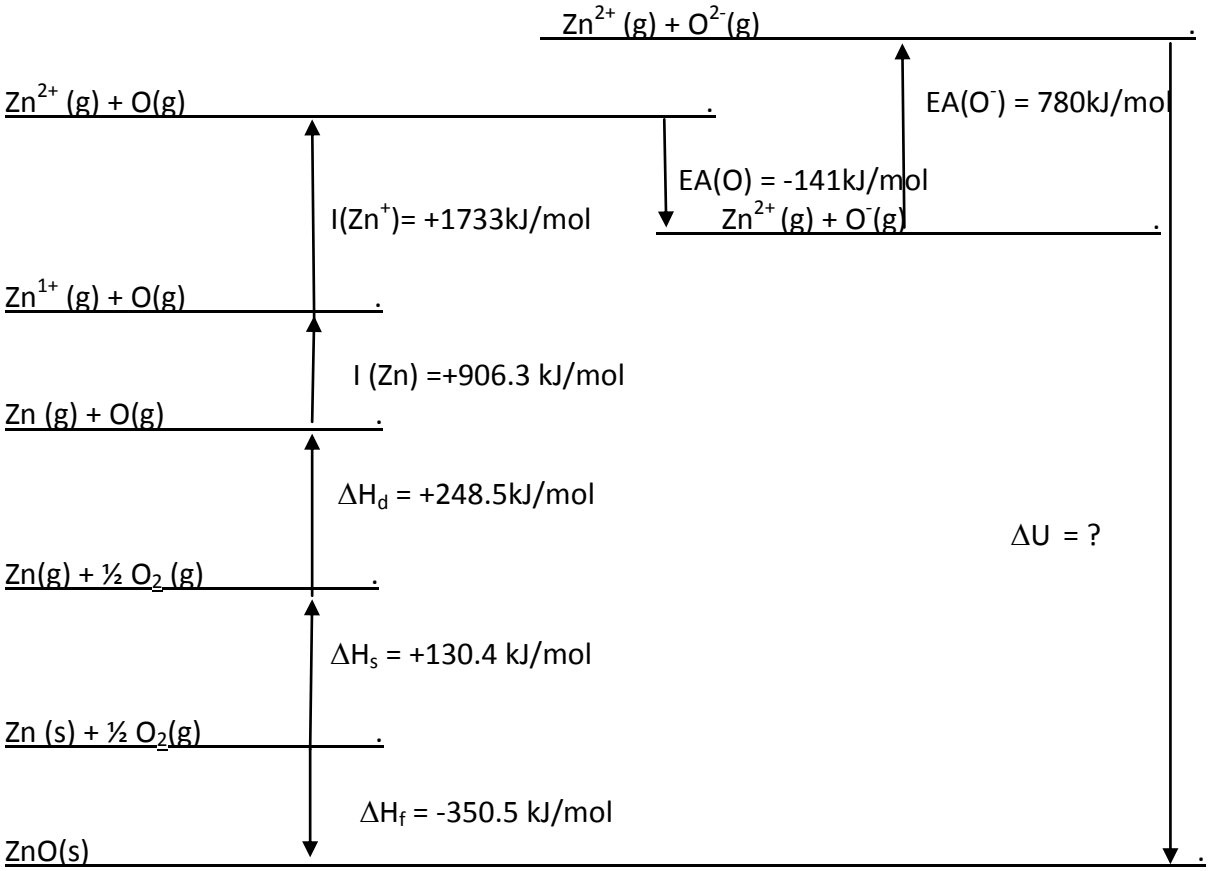
$e_0 = 1.6022 \cdot 10^{-19}\ C$

$\varepsilon_0 = 8.854 \cdot 10^{-12}\ C^2/m$

$$\Delta U = 6.022 \times 10^{23} \times 1.6411 \times \frac{(1.6022 \times 10^{-19})^2 \times 2 \times (-2)}{4 \times 3.14 \times 8.854 \times 10^{-12} \times 199 \times 10^{-12}} \times \left(1 - \frac{1}{8}\right)$$
$$= -4012\ kJ/mol$$

Minus before value of lattice energy of ZnO shows that the energy is expended to break crystal structure.
|-4012kJ/mol| =4012kJ/mol

Find lattice energy of ZnO value according to Born-Haber cycle .



$\Delta U = \Delta H_f (ZnO) - (\Delta H_s + \Delta H_d + I(Zn) + I(Zn^+) + EA(O) + EA(O^-))$

$\Delta U (ZnO) = (-350.5) - (130.4 + 248.5 + 906.3 + 1733 - 141 + 780) = -4007.7$ kJ/mol.

Minus before value of lattice energy of ZnO shows that the energy is expended to break crystal structure. Therefore the value of lattice energy is $|-4007.7 \text{ kJ/mol}| = 4007.7$kJ/mol

We can see that lattice energy calculated according to electrostatic model is 4012kJ/mol and according to Born-Haber cycle is 4007.7 kJ/mol. Both values are very close to each other. The difference is 4012-4007.7= 4.3 (kJ/mol).Therefore both values (obtained from thermochemical cycle and calculated according to electrostatic model) can be used in chemical calculations.