UNIVERSITÄT SIEGEN
FESTKÖRPERPHYSIK

Solid state physics (*winter term 2015/2016*)

Lecturer: Prof. Dr. Ullrich. Pietsch
Exercise tutor: Dr. Ali Abboud (ENC B-024)

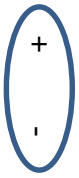
Exercise sheet 3

1. Ionic Crystals

CsCl consists of two simple cubic lattices of Cs and Cl ions displaced by (0.5 0.5 0.5). Madelung constants can be derived by calculating a summation of coulombic interactions, each term in the series indicates all the interactions for a specific ion-ion distance. Derive the first 10 terms (arising from the 10 shortest distances) for determining the Madelung constant of CsCl.

2. Van der Waals bonding

Starting with the equation of an electric field due to an electric dipole (E_{dipole}), show that the binding energy of two neighbored (***energy of interaction***) non-permanent dipoles at a distance **R** varies as $\mathbf{R}^{-6}$, when **R** is much larger than the distance of the two charges of each dipole.



$$\cdots\cdots\cdots\cdots\cdots E_{dipole} = \frac{1}{4\pi\varepsilon_0}\frac{p}{R^3}$$

Hint: An electric field induces a dipole moment $p \sim E_{dipole}$ and the energy of a dipole in a field E is proportional to pE.

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3. Linear ionic crystal

Consider a long line of 2N ions of alternating charges ±q with a repulsive potential energy A/R^n acting only between nearest neighbors.

Show that at equilibrium separation R_0

$$U(R_0) = -\frac{2Nq^2\left(1-\frac{1}{n}\right)ln2}{R_0}$$

Hint: $\ln(1+x) = \sum_{m-1}^{\infty}\frac{(-x)^m}{m}$

Please return on 11/11/2015