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Physics 141A: Solid State Physics

MT2 Review

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Contents

1 Chapter 5: The Periodic Table

- To solve for the dynamics of a quantum mechanical system we need to solve Schroedinger's Equation $\hat{H}\psi = E\psi$ but this is intractable for atoms with a dozen-or-so electrons, let alone solids with 10^{23} particles in them.

- Instead, we try to draw conclusions from simplified models of atoms.

- Recall that an electron in an atom is described by a set of quantum numbers $|n, l, l_z, s_z\rangle$ where

$$\begin{aligned} n &= 1, 2, 3, \cdots \\ l &= 0, 1, \cdots, n-1 \\ l_z &= -l, \cdots, 0, \cdots, l \\ s_z &= \pm\frac{1}{2} \end{aligned}$$

- **Aufbau Principle:**

- **Madelung's Rule:**

- **Effective Nuclear Charge**

- **Ionization Energy**

- **Electron Affinity**

2 Chapter 6: Chemical Bonding

There are a number of different ways atoms bond together to form molecules and materials.

2.1 Ionic Bonding

- Essentially, the complete transfer of one (or more) electron(s) from one atom to another. Eg. $Na + Cl \to Na^{+} + Cl^{-} \to NaCl$
- We define the following:

$$\begin{aligned} \text{Ionization Energy} &= \text{Energy required to remove one electron from a neutral atom} \\ \text{Electron Affinity} &= \text{Energy gain resulting from adding an electron to a neutral atom} \end{aligned}$$

- The energy required to transfer an electron from A to B (when the two atoms are far apart) is

$$\Delta_{A+B\to A^{+}+B^{-}} = (\text{Ionization Energy})_A + (\text{Electron Affinity})_B$$

- However that's not the full story. We also have a **Cohesive Energy** which is a classical result of the coulomb interactions between the two ions as they get closer to each other, which is

$$\text{Cohesive Energy of AB} = \text{Energy gain from } A + B \to A^{+} + B^{-}$$

- Thus,

$$\Delta E_{A+B\to AB} = \Delta E_{A+B\to A^{+}+B^{-}} + \text{ Energy gain from } A^{+} + B^{-}$$

  i.e.

$$\boxed{\Delta E_{A+B\to AB} = (\text{Ionization Energy})_A - (\text{Electron Affinity})_B - (\text{Cohesive Energy of AB})}$$

- **An Ionic Bond forms if $\boldsymbol{\Delta E_{A+B\to AB} < 0}$.**
- <u>Note:</u> Why $\Delta < 0$? Due to our sign convention.
  - Ionization Energy is energy we put into the system, but we denote it as +ve.
  - Electron Affinity is energy that comes out of the system, but we denote it as −ve.
  - Similarly, Cohesive Energy is energy gain so it's energy that comes out of the system. Thus, just like Electron Affinity, we denote it as −ve.
  - So, when electron affinity overpowers ionization energy i.e. more energy comes out than we put in, we have $\Delta E < 0$ and this is Energetically Favorable.

2.2 Covalent Bonding

2.3 Wan der Vaal's forces

2.4 Metallic Bonding

2.5 Hydrogen Bonding