



Solid State Electronics EC210
AAST – Cairo
Spring 2016

Lec. 10: Hydrogen Potential

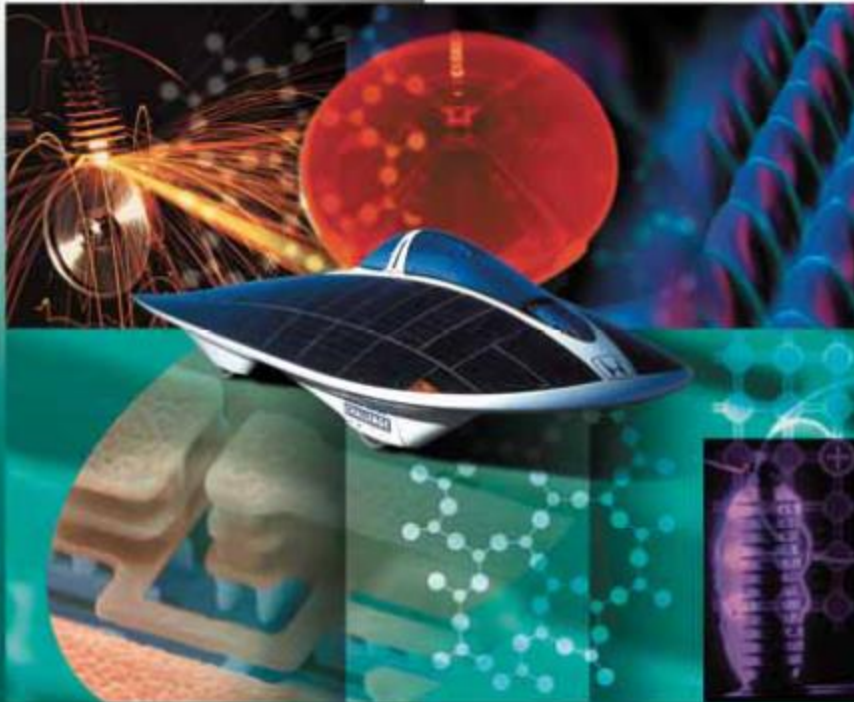
Original Lectures prepared by:
Dr. Amr Bayoumi, Dr. Nadia Rafat

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Principles of Electronic Materials and Devices

Third Edition



S. O. Kasap

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Pages



P. 231-234: Hydrogen Atom

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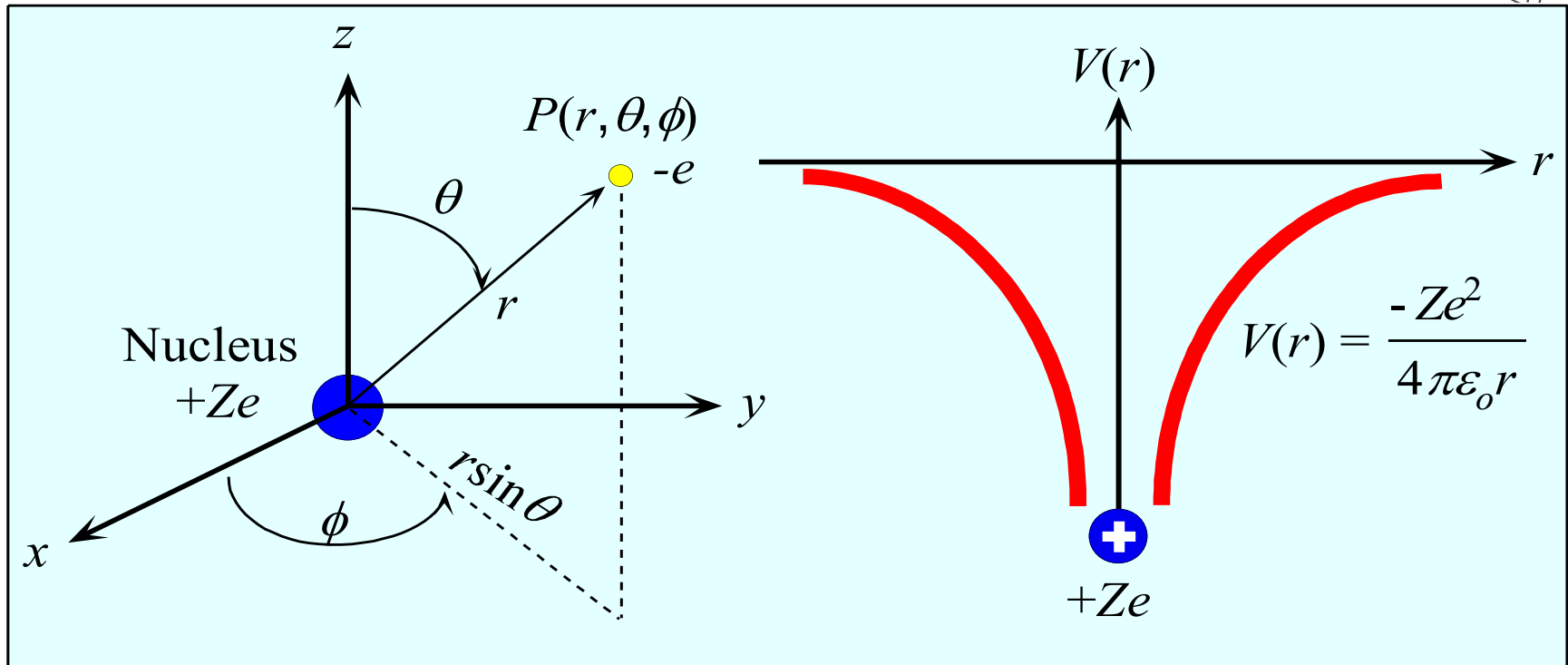
Outline

- Energy Levels in Hydrogen
- Overlap of Hydrogen Atom potential and wavefunction
- Band Theory using Hydrogen

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Hydrogen Potential Well



The electron in the hydrogenic atom is attracted by a central force that is always directed towards the positive nucleus. We therefore use spherical coordinates centered at the nucleus to describe the position of the electron.

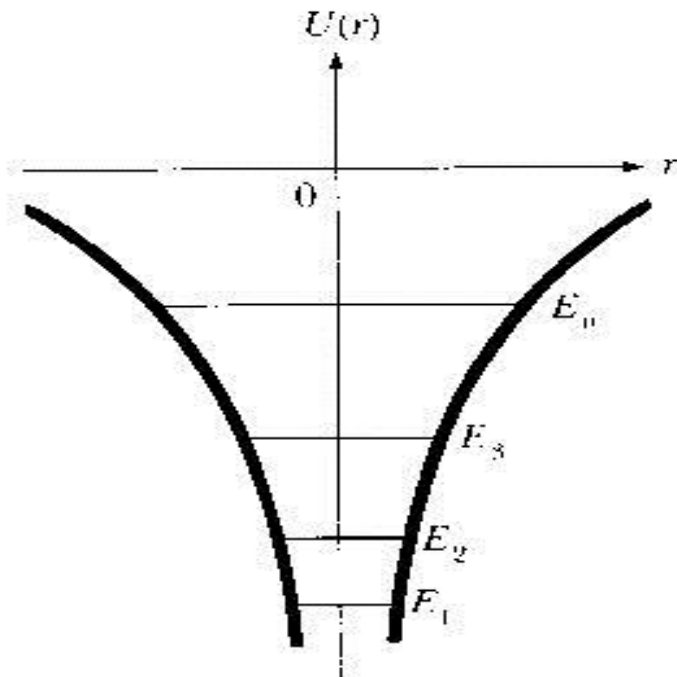
From The *PE* of the electron depends on r only.



Discrete Energy Levels

This is a “Potential Well” where Schrodinger equation has solution inside it (like in 1-D box) and outside it (like in barrier tunneling)

i.e. It has discrete energy levels and finite wavefunctions



$$U(r) = -\frac{1}{4\pi\epsilon_0} \frac{e^2}{r}$$

From P.

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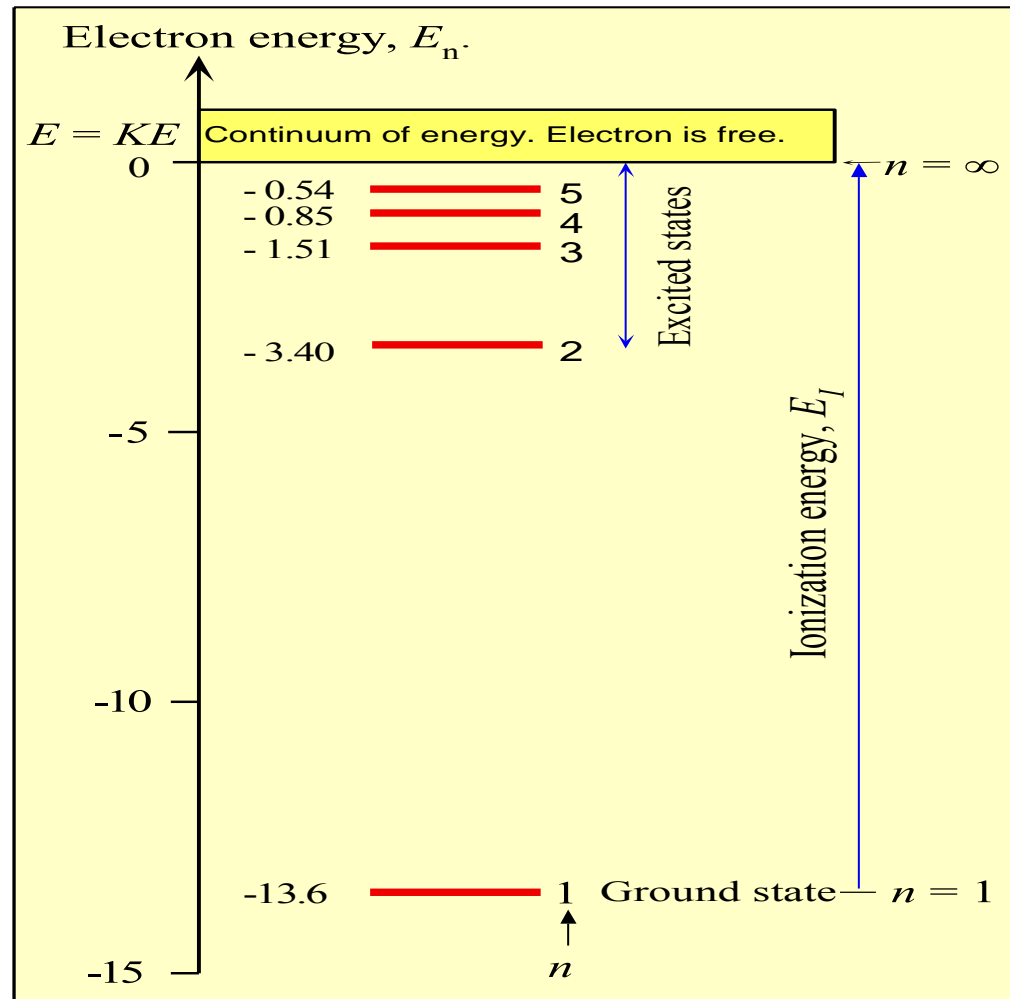


Energy Levels for H-atom:

Depends on *Principal Quantum Number*

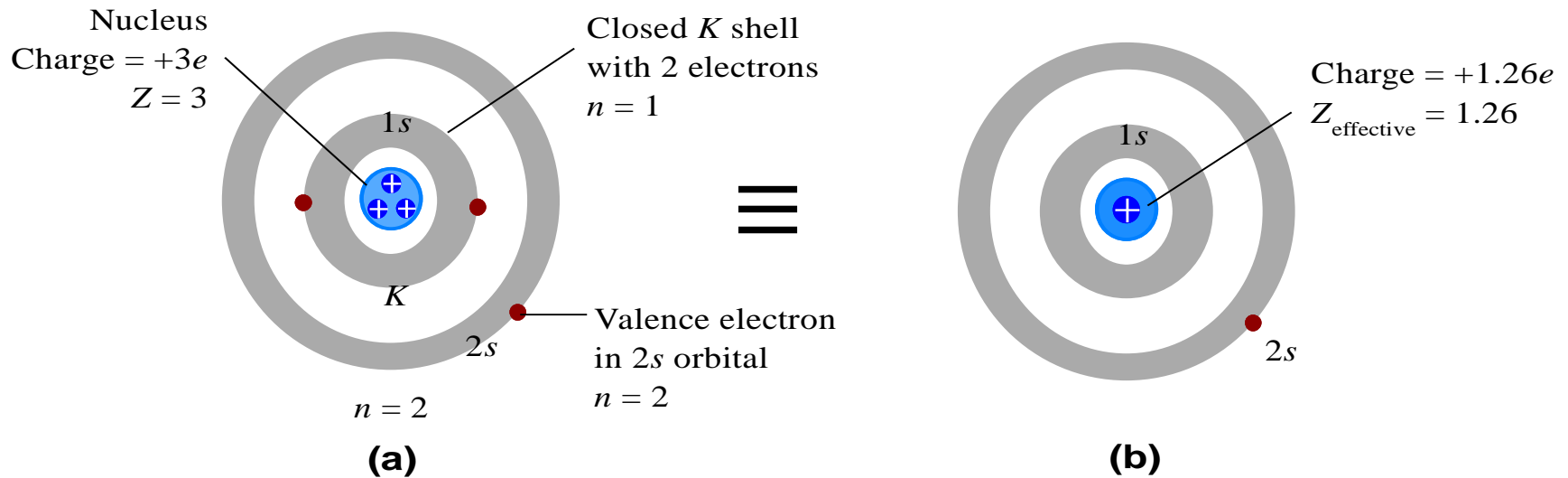
$$E_n = -\frac{Z E_1}{n^2}$$

$$E_1 = \frac{me^4}{8\epsilon_0 h^2}$$



From *Principles of Electronic Mate* The energy of the electron in the hydrogen atom ($Z = 1$)

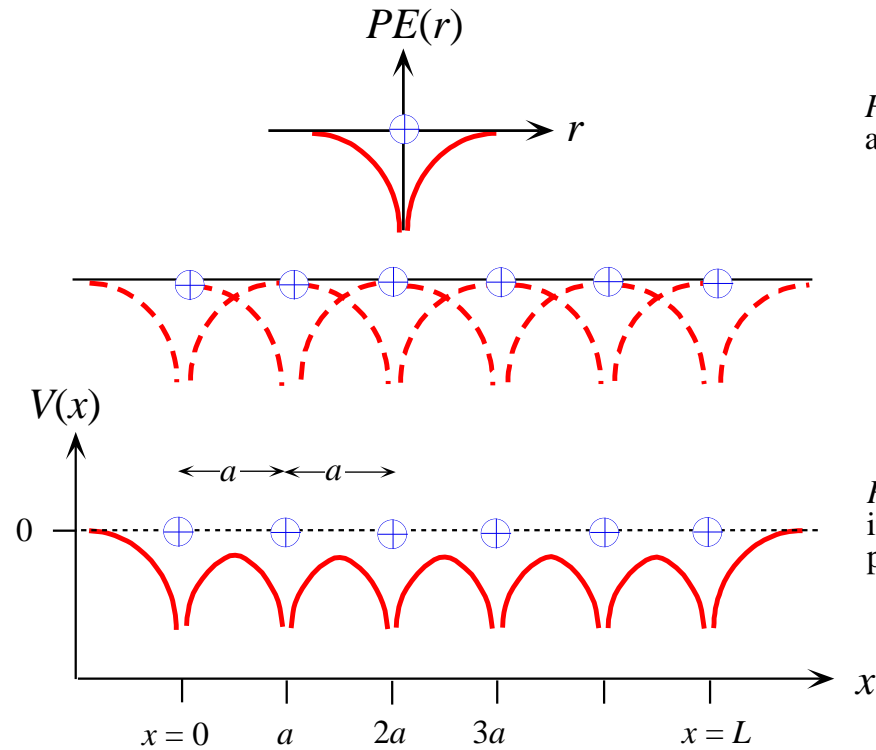
$Z_{\text{Effective}}$: (1.26 for Li)



The Li atom has a nucleus with charge $+3e$, 2 electrons in the K shell, which is closed, and one electron in the 2s orbital.

(b) A simple view of (a) would be one electron in the 2s orbital that sees a single positive charge, $Z=1$

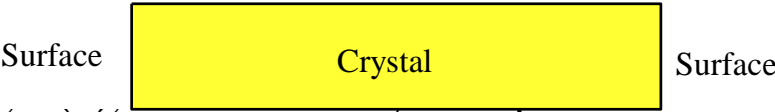
Superposition of Coulomb Potential for N-Atoms



PE of the electron around an isolated atom

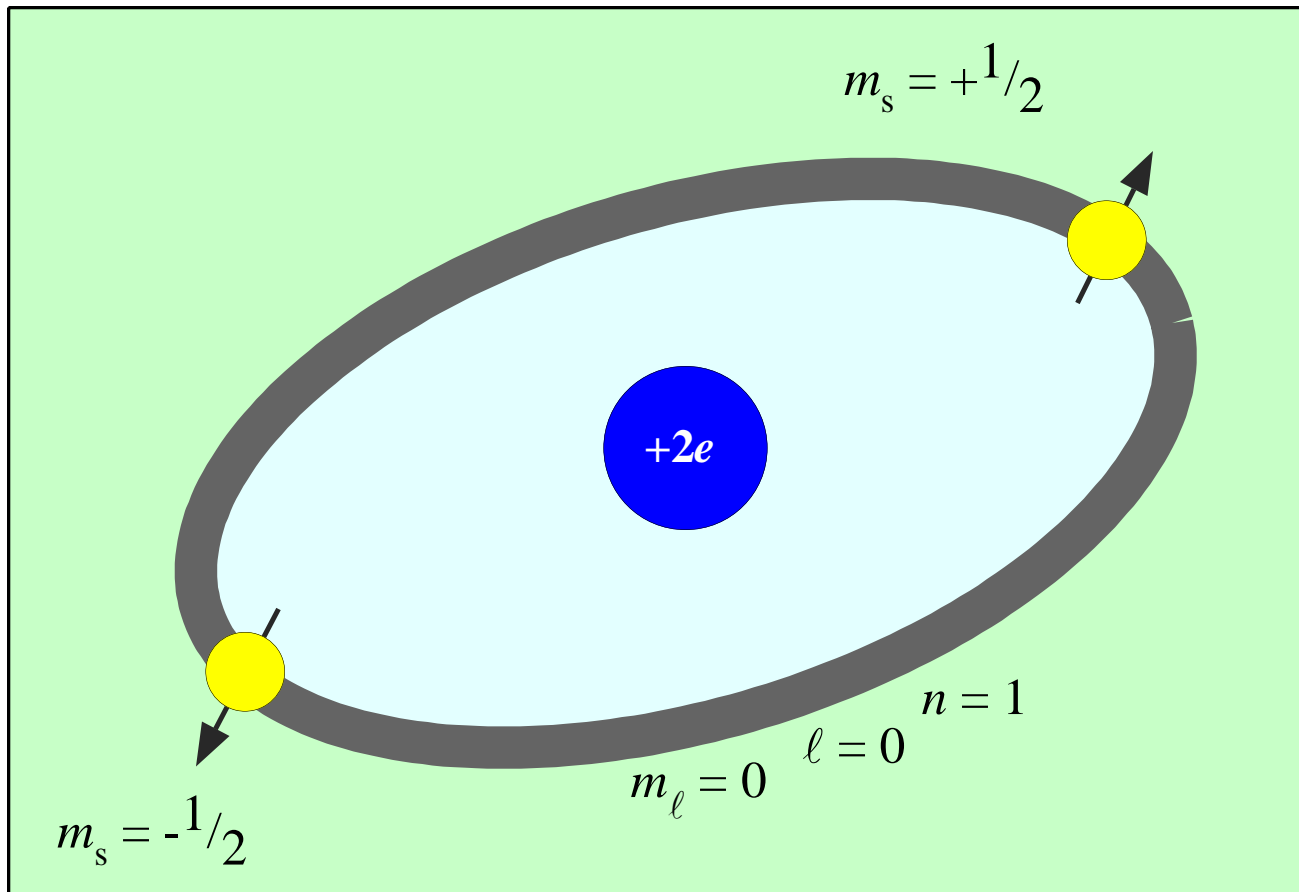
When N atoms are arranged to form the crystal then there is an overlap of individual electron PE functions.

PE of the electron, $V(x)$, inside the crystal is periodic with a period a .

The electron P  periodicity as that of the crystal, a . Far away outside the crystal, by choice, $V = 0$ (the electron is free and $PE = 0$).



Paired Spins



Paired spins in an orbital.



Pauli's Exclusion Principle:

No two electrons can have the same four quantum numbers within the same system

Table 3.3 The four quantum numbers for the hydrogenic atom

n	Principal quantum number	$n = 1, 2, 3, \dots$	Quantizes the electron energy
ℓ	Orbital angular momentum quantum number	$\ell = 0, 1, 2, \dots (n - 1)$	Quantizes the magnitude of orbital angular momentum L
m_ℓ	Magnetic quantum number	$m_\ell = 0, \pm 1, \pm 2, \dots, \pm \ell$	Quantizes the orbital angular momentum component along a magnetic field B_z
m_s	Spin magnetic quantum number	$m_s = \pm \frac{1}{2}$	Quantizes the spin angular momentum component along a magnetic field B_z

From